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Qualitative Evaluation of Financial Instruments for Renewable Heat

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Executive Summary

In 2007 the European Council committed itself to the goal that 20 percent of EU energy use in 2020 should come from renewable sources. This target applies to all energy use, and therefore to the three broad economic activities for which energy is used: electricity generation, heating, and transportation.

The European Commission's recent "climate action and renewable energy package" includes a proposal for how this target would be shared across Member States. It sets a target for the UK of 15 percent renewable energy by 2020. Although many European countries, including the UK, have relatively well-developed policies designed specifically to promote renewable electricity, and have recently implemented policies to increase the use of renewable energy for transportation, there are very few policies in place to promote the use of renewable energy for heat.

This report, commissioned by the UK Department for Business, Enterprise and Regulatory Reform (BERR), considers a range of policy options that could be used to provide financial support to renewable heat technologies to increase their use across the economy. A companion research effort, undertaken by Enviros Consulting, assesses the barriers to investment in and use of renewable heat technologies from the supply side and the demand side.

UK Heat Market Characteristics

The "market" for heat differs from the market for electricity. Most heat is not produced by a third party and sold on to distributors and then the final customer. Instead, the vast majority of heat is consumed where it is produced, and in most cases the producer and consumer are not economically distinct. The heat supply chain therefore includes fuel and equipment suppliers and some service providers, but there is only a limited "market" for heat as a product or service in its own right. More than half (55 percent) of heat is consumed by the residential sector, another 30 percent is used in industry, and the remaining 15 percent is used by the commercial and public sectors. Most heat is for space heating of buildings, with heating of hot water and industrial process heating (which typically requires special equipment and high temperatures) also significant (BERR 2008b).

In addition to variation across the different consumer demand segments, another important factor affecting the nature of heat use is the fuel (or other form of energy) used to generate heat. Most heat is produced by burning natural gas, but electricity and oil use are also significant, and other fuels are also used. These forms of energy can differ in the quality of heat they can provide, as well as in the greenhouse gas emissions and other environmental impacts of this heat.

At present, renewable heat accounts less than one percent of heat demand. The share has declined in recent years. In many cases generating heat from renewable sources is costly relative to non-renewable alternatives. In addition, the government has recognised various barriers to the use and growth of renewable heat, which affect both the supply of renewable heat and demand for it. These include uncertainties about technology costs and potentials, about the reliability of supply chains, as well as the disruption associated with researching and adopting new technologies.[1]

Current Policy Landscape

Various existing policies already provide direct and indirect financial support to renewable heat technologies, but there is no existing policy explicitly designed to achieve a renewable heat target. Policies such as the EU Emissions Trading Scheme (EU ETS), the Climate Change Levy (CCL) and the Carbon Reduction Commitment (CRC) provide incentives for renewable heat by increasing the cost of using non-renewable forms of energy for heating. These policies are not applied consistently across all fuels or fuel users. Moreover, the costs imposed by these policies on non-renewable energy use (which generally amount to less than £10 per megawatt-hour, depending on the fuel used), is expected to be too low to result in levels of renewable heat sufficient to make a significant contribution to the UK's renewable energy targets. The recent banding of the Renewables Obligation (RO) for renewable electricity provides some incentives to invest in combined heat and power (CHP) running on renewable energy, but will only encourage the use of renewable heat insofar as it is not more profitable to use the renewable resource to generate electricity alone. The Carbon Emissions Reduction Commitment (or CERT, which was previously the Energy Efficiency Commitment, or EEC) recognises renewable heat technologies, but typically these are a more costly way for energy suppliers to comply with their obligations than other measures, such as insulation or energy-efficient light-bulbs. Finally, there are a number of grants programs (e.g. the Low Carbon Buildings Programme), tax credits (Enhanced Capital Allowances), and other policies that offer direct or indirect support to renewable heat technologies, among others—but none of these is designed specifically to promote renewable heat, and the incentives typically only apply to selected types of heat consumer.

Existing policies therefore provide inconsistent support for renewable heat across sectors and across fuel "counterfactuals" (the fuel or energy source that would otherwise be used for heat). The level of support provided by these policies also is lower than would be required to contribute significantly to the overall UK renewable energy target or a potential renewable heat "sub-target". Finally none of these policies—nor the combination of them—can be expected to achieve the targets in the least expensive way possible.

This report considers a range of policies that could be used to increase the level of financial support provided for renewable heat. We review a "long list" of policies and evaluate them against a set of criteria to assess whether to consider their design in more detail. The evaluation criteria include:

1. **Feasibility**: Is the administrative burden of the policy acceptable? How complicated is the policy to set up and run? Are there legal barriers to its implementation? Are there other barriers to public acceptance of the policy?

2. **Effectiveness in delivering renewable heat**: The primary goal of the policy is to deliver renewable heat, and therefore the ability of the policy to provide incentives across all

[1] A study undertaken by Enviros Consulting (2008) in parallel to this one considers the supply and demand side barriers to the use of renewable heat in some detail.

sectors, fuel counterfactuals, and technologies is critical. Extent of coverage and the level of incentives provided to renewable heat are important considerations in this regard. It is also important to consider the certainty of delivery under the policy and the extent to which commitments made by the policy are credible.

3. **Cost effectiveness**: Cost effectiveness refers to the policy's ability to deliver a given level of renewable heat at the lowest possible cost, taking as given the commitment to attain a given level of renewable heat. It does not imply any cost-benefit assessment of the renewable heat target, nor does it consider whether the renewable heat target is a cost-effective means of achieving other policy objectives. We also consider the difference between short-term and long-term cost-effectiveness, where the latter reflects the potential benefits of accelerating technological improvements to result in lower costs over the lifetime of a policy.

4. **CO_2 emissions reductions**: One oft-cited motivation for policies to promote renewable energy technologies is that they can help address the threat of climate change. The extent to which the adoption of renewable heat technologies actually does reduce emissions of CO_2 depends on the emissions intensity of the fuel or energy source that would otherwise be used to generate heat (the fuel counterfactual). It also depends on the interaction of any new policy with existing policies—thus where emissions are already capped by the EU ETS, use of renewable heat will only have CO_2 emissions benefits if overall caps are subsequently adjusted to reflect the use of renewable heat.

5. **Distributional considerations**: Policies to promote renewable heat may be costly, and these costs will be borne by different segments of the economy. The costs may be borne by all taxpayers, by energy consumers, by non-renewable energy suppliers, and others. Any benefits of the policy will be split between renewable heat suppliers / producers and consumers. A very important consideration is the extent to which those that bear the costs of the policy will pay more than the actual resource costs of the policy—resulting in a transfer to renewable heat beneficiaries. Such transfers have been important in shaping recent discussions about the design of the RO as well as of the EU ETS.

Policies for Evaluation

- **"Upstream" Expansion of EU ETS**. This policy would introduce a common CO_2 price to all users of fossil fuels that do not currently face one under the EU ETS, by covering fuel *suppliers* under the EU ETS, and not just the direct *emitters* of CO_2. This would address some of the unevenness of incentives for renewable heat but would be administratively and legally difficult and is unlikely to lead to financial incentives high enough to deliver renewable heat in the UK at the desired levels.
- **"Downstream" Expansion of EU ETS**. This would extend the EU ETS to cover smaller emitters—possibly even down to the level of the household. Either the administrative costs associated with such an approach are likely to be very high, or the overall coverage of heat use is likely to be small. In addition, the level of incentive provided is unlikely to be sufficient to meet UK renewable heat targets.
- **Expansion or other modification of CRC**. The CRC is designed to cover energy use by large organisations, and therefore would not reach the majority of heat use. Moreover, an important factor influencing the original design of the CRC has been that administrative

and compliance costs should be kept to a minimum. Modifying the policy to cover more organisations or to provide substantially greater incentives for renewable heat would increase costs and seems unlikely to lead to significant levels of renewable heat without major modifications.

- **More direct price instrument to affect non-renewable energy prices.** Expansion of the EU ETS and CRC would not provide incentives for the cost-effective uptake of renewable heat, and would be unlikely to achieve the target levels of renewable heat. It would be possible to develop other price instruments (or to modify existing ones) to shift demand away from non-renewable energy sources and more directly incentivise renewable heat. Although such measures would be cost-effective, they may not be feasible, and are likely to have undesirable distributional implications.
- **Grants and other forms of up-front credit**. Many renewable heat technologies have high up-front costs relative to non-renewable alternatives, and therefore would benefit from some form of up-front support. However, some renewable heat technologies that are expected to be important if the UK is to meet its potential targets—notably heat from biomass-derived fuels—would require some form of *ongoing* support, because the variable cost of fuel is higher than that of non-renewable alternatives. Providing grants that were high enough to defray both up-front and ongoing costs could leave the scheme open to abuse, compromising effectiveness and cost-effectiveness. On top of this, the necessary scale of a grants program could be large, in which case the administrative burden would be substantial. It is not clear whether economies of scale associated with a single centralised body to oversee grant funding would outweigh the potential benefits of a more competitive framework under other policy options.
- **"Renewable Heat Obligation" (RHO)**. Under an RHO, the Government would set a target for renewable heat and impose upon energy and fuel suppliers individual obligations that would contribute to meeting the target. The scheme would involve a system of tradable green certificates. Renewable heat users, their designated agents, or companies in the renewable heat supply chain would be eligible to receive certificates if they produced evidence of renewable heat use. Market participants could sell certificates to suppliers to earn revenues to offset their costs. The value of certificates would fluctuate with the market price, similar to the RO or EU ETS. Under an RHO, the obligation could be set to meet any given target, essentially guaranteeing effectiveness, albeit at very uncertain cost. The policy would be expected to be cost effective because all forms of renewable heat would receive the same level of incentives, although overall costs could be increased as a result of the uncertainty associated with the variable certificate price.[2] The scheme would involve significant administrative effort for monitoring, reporting and verification, and market infrastructure. In addition, there would be a potential for significant transfers of wealth from energy consumers to heat producers (some of whom would themselves be heat consumers because of the prevalence of on-site heat generation). Some policy design options (such as "banding") could be used to reduce such transfers, but these also could reduce overall scheme cost-effectiveness.
- **"Renewable Heat Incentive" (RHI)**. The RHI would be similar in some respects to a "feed-in tariff" system for supporting renewable electricity, in that producers of

[2] High levels of uncertainty could mean that potential investors in renewable heat would demand a risk premium that would represent a real cost of the policy relative to policies with less uncertain returns for investors.

renewable heat would be entitled to receive a fixed level of support for their output. Responsibility for providing the financial support to renewable heat could rest either with energy / fuel suppliers or with electricity / gas distribution companies. Mechanisms would need to be in place to ensure that cost burdens were distributed fairly. In this and other respects, an RHI would have much in common with an RHO. Both types of scheme would need to rely on records of renewable heat output that could be used to secure financial support. The overall effectiveness of an RHI would be uncertain, because there would be no guarantee that the level of incentive would meet a given target. The policy would, however, be cost-effective and could be less costly than an RHO because of reduced uncertainty. Distributional implications also would be similar to those of an RHO.

§ **"Hybrid" Renewable Heat Obligation**. A hybrid scheme would combine features of an RHO and RHI by limiting the volatility of the certificate price in some way. This could include setting a buy-out price ceiling (or floor) or linking to other schemes—including the existing RO. A hybrid scheme could be attractive given the uncertainties surrounding the feasibility of UK renewables targets, but by design would compromise on the effectiveness of renewable heat delivery. A combined RHO-RO scheme in theory could prove more cost-effective than two separate schemes, because of the potential for directing renewable energy inputs where they would most efficiently contribute to achieving overall UK renewable energy targets. However, in practice, a linked scheme could prove complicated because of the need to set "exchange rates" or similar parameters to govern the relationship between heat and electrical energy. The attractiveness of such a scheme in terms of cost-effectiveness is therefore very uncertain.

A simplified summary of these evaluations are presented in tabular format in Table ES-1 on the next page.

Having reviewed the long list of policies, we select three for more detailed discussion – the RHO, the RHI, or a hybrid scheme. The remainder of the report considers a number of detailed design issues related to the implementation of these three options.

Table ES-1 Summary of Evaluations of Policy Long-List

Policy	Feasibility	Effectiveness	Cost-effectiveness	CO2	Distributional
Emissions trading and taxation					
Expansion of EU ETS -- upstream	OO	–	–	–	OO
Expansion of EU ETS -- downstream	O	OO	OO	OO	–
Direct price instruments	OO	P	P P	P	OO
Expansion of CRC	O	OO	O	OO	–
Modification of CRC recycling	–	O	O	O	–
Investment support: grants, loans, and other credits					
Large-scale programme	–	P	–	P	–
Targeted	P P	O	P	O	–
Renewable heat obligation — no up-front crediting, no differentiation of renewable heat support					
RHO with tradable certificates	OO	P	(P)	P	OO
RHI with fixed-price subsidy	O	O	–	O	O
"Hybrid" RHO with safety-valve	O	–	(P)	–	O
"Hybrid" RHO with RO link	O	–	(P)	–	O
Renewable heat obligation — up-front crediting, no differentiation of renewable heat support					
RHO with tradable certificates	OO	P	P	P	OO
RHI with fixed-price subsidy	O	(P)	P P	(P)	O
"Hybrid" RHO with safety-valve	O	–	P	–	O
"Hybrid" RHO with RO link	O	–	P P	–	O
Renewable heat obligation — up-front crediting, differentiation of renewable heat support					
RHO with tradable certificates	OO	P	(P)	P	O
RHI with fixed-price subsidy	O(O)	(P)	P	(P)	–
"Hybrid" RHO with safety-valve	O(O)	–	(P)	–	–
"Hybrid" RHO with RO link	O(O)	–	P	–	–

Note: **As with any summary table, distilling the extended discussion within this report into illustrative rankings or scorings requires substantial simplification, and therefore the table should not be relied upon without reference to the more complete discussion in this report.**

Renewable Heat Obligation

Target setting: In keeping with existing quantity-based schemes in the energy sector (such as the CERT, RO, and RTFO), an RHO would impose an obligation to purchase and surrender renewable heat certificates on suppliers of energy used for non-renewable heat. It seems likely that only suppliers above a certain size threshold would face an obligation, although this could result in competitive distortions and perverse incentives, because there are a large number of smaller suppliers of so-called non-net-bound fuels. Exempting these smaller suppliers from the obligation would not mean that their customers would have no incentive to use renewable heat technologies, however, nor would it mean that such suppliers would not bear any costs as a result of the scheme. In fact, because renewable heat may be relatively less expensive for non-net-bound consumers, the distributional impacts of renewable heat policies may disproportionately affect non-net-bound suppliers, who would face significant erosion of their customer base.

Target-setting probably would need to account for differences in the share of each energy source that is used to generate heat (for example, most natural gas is used for heating, but only some electricity). For the same reason it also may be appropriate to differentiate obligations according to the consumer segment being supplied.

Selection of measures: An RHO would provide incentives to choose the most cost-effective way of meeting the renewable heat target provided it applied in the same way to all forms of renewable heat output. There is some risk that energy suppliers would be reluctant to fund measures among their own customers, because doing so would reduce their sales of conventional energy. This concern seems not to have had a major impact on the functioning of the CERT or its predecessor, however.

A potential distributional concern arises under the RHO if the policy awards the same level of support to all forms of renewable heat: consumers could end up paying more to low-cost renewable heat measures than would be necessary to incentivise them to produce. Uniform support also means that emerging technologies may be neglected relative to more established technologies, which in theory may reduce the long-term efficiency of the scheme. One way of addressing these concerns would be to differentiate the level of support offered to each MWh of renewable heat depending on the technology, customer segment, fuel counterfactual, or all three. There is a risk that such differentiation would compromise the cost-effectiveness of the policy, however—particularly because there is significant uncertainty about the actual costs of renewable heat technologies, and also because it would be difficult to ensure the accuracy of differentiation if customer segment and fuel counterfactual were to be taken into account.

Measurement of heat output: Any renewable heat support scheme designed to incentivise actual heat output must have some way of measuring or estimating that heat output. For large heat users, direct measurement of heat would be possible and is already the norm. However, the evidence that we have been able to review suggests that for most small consumers the direct measurement of heat output would be expensive and therefore infeasible. For some heat technologies, a viable alternative would be to measure renewable energy input and combine this with assumptions about average energy efficiency of heating equipment. For other technologies, the only feasible approach may be to “deem” the renewable heat output based on standardised formulae that take into account various aspects of the technology, the heat consumer, and external factors such as weather. Our preliminary assessment is that an RHO would have to rely on a combination of different monitoring methods, varying by technology, size of heat load, and market segment. Different rules would govern the type of supporting evidence required to qualify for renewable heat certificates from different measures.

Supply chain relationships: A key challenge for an RHO scheme is to find administrative, contracting, and other institutional arrangements to minimise administrative costs and risks to consumers and participants in the supply chain. It seems very likely that most consumers will be unwilling to take upon themselves the administrative requirements necessary to demonstrate eligibility to receive renewable heat certificates. Similarly, most consumers—even large ones—will not wish to bear the risk of volatile certificate revenues to offset the higher costs of getting their heat from renewable sources. Even renewable heat equipment manufacturers and fuel suppliers may be reluctant to bear these costs and risks if they are uncertain about the liquidity of the certificate market and the potential revenue stream it will provide. Energy suppliers therefore are likely to have to offer to consumers and companies in the supply chain contractual terms that protect them from such risks. The arrangements could be similar to those observed under CERT / EEC.[3]

For technologies with significant up-front and installation costs, this would mean energy suppliers would need to provide up-front payments to equipment suppliers and installers. In effect, obligated suppliers would need to establish their own grants programs for capital-intensive renewable heat measures. For biomass heat, which also has ongoing ***variable*** costs in excess of conventional heating costs, obligated energy suppliers would need to defray consumers' higher variable costs as well.

Depending on the way certificates were awarded, this could expose obligated energy suppliers to potentially unfair competitive pressure from independent renewable fuel suppliers. For example, if obligated suppliers paid the up-front costs of a biomass boiler, they would need to be assured that they would be entitled to any certificates produced by burning renewable fuels in that boiler—otherwise their investment would not provide the return (in the form of certificates) that justified it in the first place, and therefore the investment would never be made. It could be difficult to design a scheme that ensures that obligated suppliers receive certificates associated with their capital investments and that at the same time allows biomass fuel suppliers to qualify independently for certificates.

Timing of support: The above considerations suggest that the secondary market in certificates may not be particularly liquid. One way of improving the liquidity of the secondary market would be to encourage the participation of equipment manufacturers and independent installers by awarding certificates up-front. This could be accomplished by deeming in advance the level of heat output expected from certain technologies. This would codify within scheme rules some of the grant-like features of the contractual arrangements described above—although recipients of deemed certificates would still be exposed to certificate price risk. Biomass would still present special concerns, because there would be a need to determine what share of the certificate award should go towards the up-front cost, and

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3 Australia's MRET policy also provides a model for contractual relationships among consumers, renewables providers, and obligated suppliers.

what share should be reserved for the supply of biomass fuel itself. These shares would need to be applied universally to avoid competitive distortions—so that, for example, any supplier of biomass fuel would receive only one half (say) of the certificates associated with the heat produced from that fuel; the other half would go to the original equipment manufacturer or its designated agent.

Up-front Renewable Heat Incentive

Target setting: The obligation to pay for renewable heat output could be placed on energy suppliers (as in the RHO described above) or on energy distribution network operators (DNOs). In either case (and particularly for energy suppliers) it is likely that there would need to be some "balancing mechanism" to ensure that the burden was distributed fairly among the obligated parties (and, ultimately, their customers). One alternative to such a balancing mechanism would be to establish a central purchasing authority that would collect funding from the relevant suppliers or DNOs, and be solely responsible for distributing the funds to eligible measures.

An important advantage of an RHI compared to an RHO would be that it would avoid the potentially high costs associated with an inflexible fixed target and uncertain renewables costs. In theory, it also would eliminate the uncertainty associated with a volatile certificate price, making it possible for investors to demand a lower risk premium for renewable heat investments. In practice, because the amount of renewable heat actually delivered by the policy would be uncertain, the RHI could be subject to government review that would adjust incentive levels once new information became available. Therefore the difference between the RHO and RHI in this regard is likely to be less than the theoretical difference between pure price and pure quantity instruments. There would be a benefit to ensuring that procedures for adjusting incentive levels were set out in advance as clearly as possible, to minimise the uncertainty for investors. It would also be important to consider any perverse incentives that could be created as a result of changes to incentive levels—for example, if existing projects were only eligible for the previously-offered level of support, it would encourage delay of projects.

Like an RHO, an RHI could differentiate between different technologies—and/or consumers and fuel counterfactuals.

Selection of measures: As with an RHO, an RHI would offer incentives to invest in cost-effective forms of renewable heat by offering the same level of support to all measures. This would raise similar concerns about distributional implications ("excessive" payments to certain measures) and long-term efficiency.

In addition, under an RHI, the obligated party (whether energy supplier or DNO) would have limited (if any) incentive to ensure that renewable heat was actually delivered, as they would face no explicit obligation. If suppliers were required to pay only for measures undertaken by their own customers, this would create further disincentives for promoting renewable heat.

As noted, a potential benefit of an RHI is that the risk premium demanded by investors could be lower—this could lead the RHI to deliver more capital-intensive renewable heat projects than a comparable RHO.

Measurement of heat output: Under an RHI monitoring requirements would be very similar to those under an RHO. Each producer / consumer would need to be able to provide some record of its supply / use of renewable heat, and of the quantity used. The information required for such records would essentially be the same as the evidence required to qualify for the award of a renewable heat certificate under an RHO.

Supply chain relationships: As discussed above, the obligation imposed on energy suppliers under an RHO would force them to come to contractual terms that would tend to minimise the risks and costs borne by all parties in the supply chain, including consumers. Thus obligated suppliers might find that they would need to offset up-front costs of equipment manufacturers even if they did not receive certificates up-front. This would not be the case under the RHI. The absence of any binding obligation to procure renewable heat under an RHI would mean that renewable heat suppliers would need to cover these costs themselves and enter into contracts with consumers and other suppliers accordingly. It could be necessary for an RHI to formalise these contractual terms in the policy itself. Thus if equipment manufacturers or installers did not have the credit or could not bear the delivery risks associated with payment for actual heat delivered (or, in the case of biomass, if fuel suppliers were not willing or able to cover up-front costs with expected future RHI payments), the RHI would need to offer up-front payments.

Timing of support: For the above reasons, deeming of project output and up-front award of incentives may be more necessary under an RHI than an RHO.

Hybrid Scheme

A hybrid scheme could offer a way to mitigate some of the risks and uncertainties (of high costs or of under-delivery) associated with either an RHO or an RHI. Linking an RHO to the RO appears to be an attractive option in theory, because it would make it possible to allow market forces to provide the incentives to allocate resources in the way that met overall UK renewables targets (and not just those for heat) at lowest cost. However, the existing features of the RO (notably banding) and complications associated with renewables that can be used for or qualify as either renewable heat or renewable electricity mean that the resulting market for renewables certificates would still be heavily influenced by policy decisions. The likelihood that targets would be achieved at reduced cost, relative to separate policies, is therefore very difficult to assess.

Summary Conclusions and Areas for Further Research

This report sets out a wide range of design issues associated with policies to provide financial incentives to support renewable heat. We find that policies that can provide support for renewable heat output, such as an RHO or RHI, are likely to be better than other alternatives, but that these policies will need to treat different technologies and different sectors in different ways. In particular, we find that the type and extent of monitoring and the timing of support will need to vary to ensure that administrative costs are not disproportionate, to reduce exposure to risk, and to facilitate the development of markets and supply chains.

The report provides qualitative evaluations of these policies but highlights various qualitative and quantitative uncertainties. A key qualitative uncertainty is whether supplier relationships and contractual arrangements will be developed that will facilitate broad participation in the market for renewable heat or heat certificates. Under an RHO energy suppliers would in effect be compelled to develop such arrangements, or risk failing to meet their targets. It is not clear whether other parties in the supply chain would participate independently in a certificate market, however. Up-front crediting could facilitate such participation, and also seems to be a pre-requisite for an RHI.

Perhaps the central quantitative uncertainty relates to the potential for the delivery of renewable heat in the UK and the likely cost of its delivery. Because of the significant uncertainties associated with renewable heat, it seems desirable for any policy to include design features that reduce the risk of very high costs.

Other topics for which further quantification would be helpful include:

- assessment of the relative importance of different sectors, measures, and fuel counterfactuals, to determine which design policy features are likely to be most significant;
- estimates of the extent of "overpayment" (or "rents") for individual types of renewable heat technologies;
- analysis of impacts on non-renewable fuel suppliers and their customers;
- cost of reducing / overcoming the potential barriers to the supply of and demand for renewable heat.

Some of these topics are addressed in forthcoming reports (by NERA and by Enviros Consulting). Others may require additional research.

1. Introduction and Background

The EU "climate action and renewable energy package" recently presented targets for renewable energy for each EU Member State to fulfil the previously announced overall EU target to source 20 percent of all EU energy from renewable sources by 2020. The package proposes a 15 percent UK target for renewable energy. In contrast, current levels are around 1.3 percent of total energy, forecast to rise to around 5 percent with currently implemented policy measures. Much of this increase is in the electricity generation sector, with some increase also forecast in transport. By contrast, the use of renewables in the heat sector is forecast to rise no higher than 1 percent under "business as usual".

In the 2007 Energy White Paper, Government announced it would:

> "conduct further work into the policy options available to reduce the carbon impact of heat and its use in order to determine a strategy for heat. The work will look at the full range of policy options, including the range of existing policy mechanisms such as the EU ETS." (p. 91)

In this context, BERR has commissioned NERA to evaluate options for financial instruments to promote renewable heat. This report is the output of Phase I of that work, providing a qualitative evaluation of a "long-list" of policies, as well as a more detailed assessment of a short-list of three policy approaches. Phase II of the project will provide quantitative estimates of the short-listed policies.

In this project we have not undertaken to evaluate the cost-effectiveness of renewable heat as a method to achieve emissions reductions, improvement in energy security, or other energy policy objectives. For the purposes of this project, we therefore have taken the objective of increasing renewable heat supply as given, and the analysis is confined to options for the achievement of this aim.

The short time available for this research means that this study relies on published sources only. We have not attempted to interview renewables industry representatives, energy or heating equipment suppliers, government officials, consumer bodies, or other stakeholders. We highlight major areas of uncertainty throughout the report.

1.1. Previous Studies of Instruments to Promote Renewable Heat

There is no agreement in previous studies about the best way to promote renewable heat. The Biomass Task Force (Defra, 2005) strongly rejected a heat obligation system of tradable certificates, proposing instead a large-scale capital grants scheme. By contrast, Ernst & Young (2007b) identified tradable certificates for measured output as the most promising approach for large-scale renewable heat projects, and reserved the use of grants for the household sector (accompanied by an expanded role for renewable heat in the CERT). An earlier study by ILEX (2003) also proposed a renewable heat obligation with tradable certificates, but argued that it should be complemented by tax breaks and subsidised loans for capital equipment. Meanwhile, the Renewable Energy Association (REA, 2008) recently argued that government-run grants scheme were not sufficient, and instead proposed that renewable heat and microgeneration of electricity in the household sector would be best encouraged by a system of subsidised loans using property values as security.

The wide range of conclusions reflects the substantial uncertainty or disagreement about the characteristics of renewables as they could be applied in the UK heat markets. Fundamental uncertainties include data on the cost and potential for renewable heat, and information about the supply- and demand-side barriers faced by renewable heat projects.

1.2. Structure of This Report

This report is structured as follows. The next section provides an overview of aspects of the UK heat market and renewable heat that are relevant to the consideration of financial instruments. This is followed by a brief overview of current policies that have an impact on renewable heat in section 3, while section 4 outlines the approach to evaluation, including the evaluation criteria agreed with the Steering Group. It also provides an overview of the policies selected for evaluation.

The next three sections evaluate a range of candidate instruments to promote renewable heat, grouped under three broad headings. Section 5 evaluates approaches that would increase the cost of using non-renewable fuels. Section 6 considers options for investment support through capital grants or subsidised loans.

Section 7 evaluates options for a range of different designs for a “Renewable Heat Obligation” (RHO), based on providing subsidies per unit of renewable heat produced. The options considered include quantity-based as well as price-based financial instruments, and this discussion forms the bulk of this report.

Section 8 concludes with a summary of the evaluations and overall conclusions about the three groups of policies.

2. Background on UK Heat Markets and Renewable Heat

This section provides an overview of aspects of UK heat markets and renewable heat supply. It does not aim to give a comprehensive overview, but to indicate some of the salient features of heat markets that are relevant to the subsequent policy evaluation.[4]

2.1. Heat Market Characteristics

2.1.1. Sectors and fuels

Heat markets can be characterised according to two main dimensions. First, demand varies by sector, with a conventional split into four categories:

- Domestic sector, consisting of residential dwellings.
- Commercial sector, including offices, warehouses, and factory buildings.
- Public sector, including officers, hospitals, leisure centres, universities, etc.
- Industrial sector, dominated by process heating.

BERR (2008b) estimates that of the final heat demand in the UK in 2005, 54 percent was in the domestic sector, 30 per cent was in the industrial sector, and the remaining 16 per cent was in the public and commercial sectors.

Heat markets also can be split by the fuel consumed. In the household sector, the large majority (81 percent) of households use natural gas for heating, with the remainder relatively evenly split between electricity and various non net-bound fuels dominated by heating oil. Around one-third of total household electricity consumption is used for heating purposes (BERR 2007c).

The split between fuels depends in large part on the division between houses on and off the gas grid. AEA (2007b) estimates that some 4.4 million households are off the grid. These are likely to be the properties with the most potential for the use of renewables in this sector. In contrast, the industrial sector produces heat using a wider mix of fuels. BERR (2008b) estimates that 47 per cent of heat is from natural gas, 26 per cent from oil, 19 per cent from electricity, and the remainder from other fuels.

The use of different fuels means that the CO_2 emissions associated with different heating systems vary significantly. For example, heating by natural gas emits only about half as much CO_2 per MWh heat as does electric heating, while non net-bound fuels emit less than electricity but also vary significantly between heating oil, coal, and liquid petroleum gas.

2.1.2. Technologies and suppliers of heat

An important difference between electricity and heat markets is that heat is not a traded commodity. Heat is difficult to transport, and its generation therefore needs to take place at or close to the point of final consumption. Excepting a few cases of community heating, the

[4] This section draws on AEA (2007b), BERR (2007c) and BERR (2008b), to which the reader is referred for a fuller review of UK heat markets and the potential for renewable heat.

UK heat market is structured as a combination of markets inputs (electricity and fuels); markets for conversion equipment (central heating systems, boilers, CHP, etc.); and markets for various ancillary services (installation, maintenance, etc.). As a consequence, there is no comparable regulatory structure for heat as there is for electricity; nor is there a single well-established supply chain corresponding to that of generation, transmission, distribution, and retail supply of electricity.

The most immediate analogy to electricity is the suppliers of fuels used for heating. This includes the six large electricity and gas suppliers active in the domestic sector, as well as some smaller and more numerous suppliers in the business sector. Suppliers are much smaller in the non net-bound sector. For example, AEA (2007a) indicates that there are some 700 coal merchants, of which only a dozen supply more than 75 GWh of energy per year; at least 25 different LPG suppliers; and a very large number of suppliers of heating oil.

Another consequence of the on-site generation of heat is that the size of individual heating systems varies significantly. Large CHP boilers serving industry can have a capacity of several hundred MW, boilers in the commercial sector range between less than one to several MW, while domestic boilers for individual homes are in the region of 10-20 kW depending on application.

2.2. Renewable Heat Technologies and Supply

There is also significant variation in the characteristics of technologies used for the supply of renewable heat. Broad categories of renewable heat include:

§ biomass heat, ranging from small boilers to combined heat and power;

§ solar hot water heaters;

§ ground source and air source heat pumps;

§ biogas from anaerobic digestion; and

§ deep geothermal heat.

These technologies vary on several dimensions, including their feasibility and economic size and their cost. A useful comparison for the purposes of comparing policy instruments are the costs in the 2008 CERT illustrative mix. This indicates a cost of around £450 for cavity wall insulation, one of the higher-cost measures actually undertaken in the EEC/CERT, while the cost of solar thermal is estimated at around £3,700, wood pellet boilers at around £7,500, and ground source heat pumps at £10,500-12,000 (Defra 2008). In addition, costs are very uncertain, and estimates such as Ernst & Young (2007a), Pöyry (2008), AEA (2007b), EEE (2005) and Element Energy (2008) together give a wide range for possible costs.

2.2.1. Cost structure: fixed and variable cost

The cost structure of renewable heat generation also places demands on support mechanisms. For many renewable heat technologies capital costs constitute a high proportion of total costs. The cost structure is particularly front-loaded for solar thermal and ground-source heat pumps, but the use of biomass also may lead to significant installation and equipment costs compared to more conventional boilers. Moreover, in many cases conversion to renewable technologies is characterised by high capital costs relative to the *continued* use of fossil fuel-fired heating (even where this involves the replacement of existing equipment). This is particularly relevant in the residential sector, where access to capital may be either rationed or expensive, and where discount rates for energy appliances may be high (see section 2.4.2).

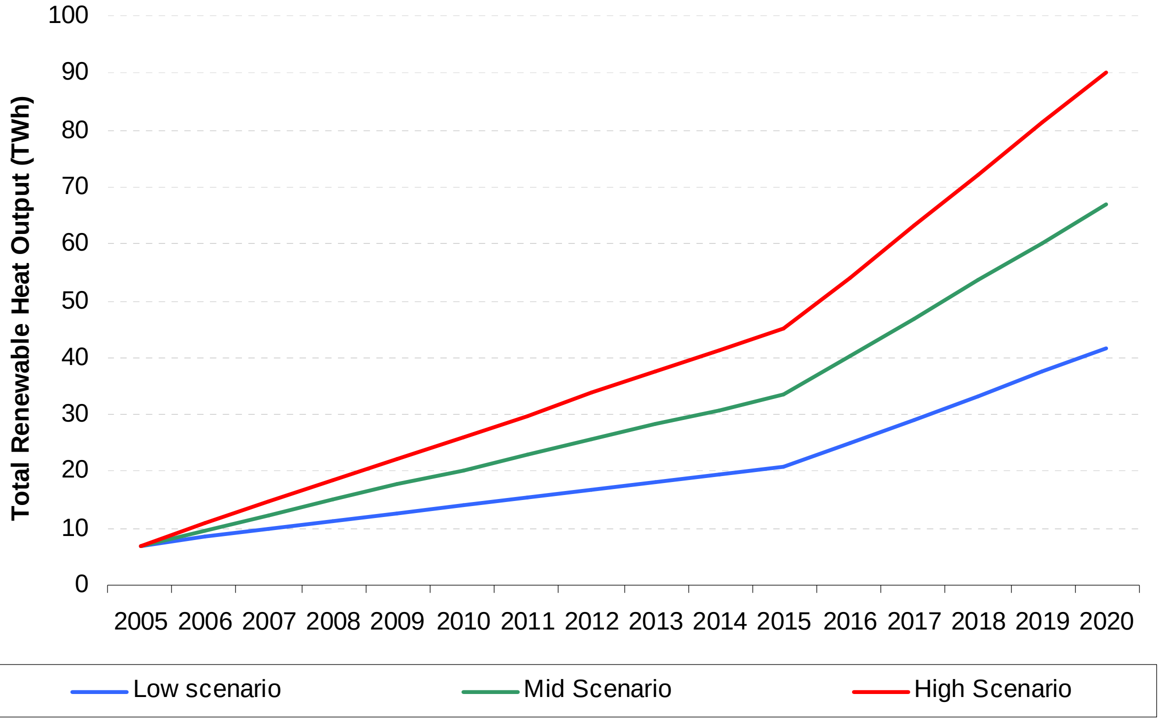
For larger installations biomass is the most likely technology and variable cost is an important element of the total long-term marginal cost. There is an important difference between heat and electricity in this regard. In much of renewable electricity generation (notably, wind and hydropower), variable cost is very low and operators have an incentive to maximise output from generating plants (almost) regardless of subsequent support levels of prices of electricity. By contrast, biomass has an ongoing variable cost that constitutes a significant proportion of total long-term marginal cost. There is a risk that, if support ceases, boilers or CHP plants originally relying on biomass may be better off reverting to the use of cheaper fossil fuels.

A particularly stark example of high up-front costs is the case of community heating. For example, BERR (2008b) cites a “conservative” number for capital investment requirements of £50 billion to supply 5.6-6.6 million via community heating (implying a cost of around £10,000 per household). However, UK-relevant estimates for the large-scale use of community heating are by necessity highly speculative.

2.3. Current Levels of Renewable Heat and UK Targets

Renewable heat currently makes up less than 1 percent of UK total heat demand and has been declining from its peak in 1994. By contrast, we have been asked for this project to consider illustrative scenarios for renewable heat resulting in numbers of substantially higher proportions between 5 and 12 percent of total heat demand in 2020. Figure 2.1 illustrates implied trajectories of these targets, with total heat supply increasing from current levels of less than 7 TWh to between 42-90 TWh in 2020. These numbers take into account significant improvements in energy efficiency which help reduce the absolute amount of renewable heat required to meet a given percentage target.

Figure 2.1
BERR Scenarios of Total Renewable Heat Output (TWh)



***Source**: Data provided by BERR*

These scenarios translate into a significant impact on UK heat markets. For illustration, if renewable heat were deployed proportionate to current consumption, the implied increase of the "mid" scenario would require between 1.5 and 2 million additional households using renewable heat for a substantial majority of their heating needs by 2020.

To meet these targets, much of the growth in renewable heat will by necessity need to come from retrofitting renewable heat in existing buildings. This is both because new build will constitute a small proportion of total floor area in 2020, and because new buildings demand significantly lower amounts of heat per area than does the existing building stock.

2.4. Barriers to the Use of Renewable Heat

In general terms, a "barrier" is something that prevents the maximum uptake of renewable heat. This may be because it reduces or delays the installation of capacity, or a factor which prevents or delays installed capacity running at full output.

The issue of barriers is considered in a separate and concurrent project undertaken by Enviros Consulting. However, we briefly discuss generic supply- and demand-side barriers below as they are relevant to the subsequent evaluation of different financial support mechanisms. The scope of this report is limited to financial instruments. We thus do not consider other instruments such as direct regulation, voluntary agreements, information measures, and other measures that may be able to overcome some barriers. However, the ability of different financial instrument to overcome barriers also may vary, and we briefly outline some of the main aspects relevant to subsequent evaluations below.

2.4.1. Supply-side barriers

Based on a tentative classification provided by Enviros, supply side barriers can be grouped into four categories:

- **Fuel chain**. Consistent and sufficient supply of biomass of good quality to the right specifications (e.g., moisture content), without high transport costs or delays in delivery.

- **Supplier/ equipment maintenance base**. Including problems with: equipment models fit for purpose and reliable; compliance with air regulations; limited stocks, import availability, or manufacturing capacity; space in buildings for boilers, fuel storage, etc.

- **Technology**. Infrastructure including transportation, wood chipping, storage and handling facilities, etc.

- **Infrastructure development**. Availability of UK companies able to design, install and maintain equipment; good geographic coverage of required services; training and awareness among architects, engineers, plumbers, etc.

Other aspects may include planning regimes, absence of certification, and various other detailed issues.

The most relevant aspect of supply-side barriers for the purposes of considering financial instruments is that overcoming many of the barriers depends on investment. Building infrastructure, training of installers, conversion to energy crop cultivation, and many other aspects of supply chain development is associated with up-front costs that can be recouped only if the demand side of the market develops sufficiently. In most markets, sufficient demand and rising prices will encourage investment and entry to the supply chain, and there is no *a priori* reason to believe this would not be the case with the renewable heat supply chain. However, if development of the demand side is uncertain, supply chain development may be delayed or partial.

Supply costs also may be subject to returns to scale or innovation effects. One motivation commonly cited for policy intervention to support renewable energy is to achieve lower future costs of currently "immature" technologies. It is not clear to what extent this is applicable to the major groups of renewable heat technologies. Many renewable heat technologies have been used on a large scale in other countries, including solar thermal, ground- and air-source heat pumps, and biomass CHP and residential boilers. Also, technology costs are likely to depend largely on worldwide deployment rates rather than on UK developments. Nonetheless, there may be reason to believe that the costs of supplying heat would fall with increased deployment because of learning and scale effects in the development of supply chain elements.

2.4.2. Demand-side barriers

Demand-side barriers refer to factors that may prevent uptake even where reliable supply of relevant technologies is readily available. Such barriers have been discussed primarily in relation to energy efficiency, where a common motivation for policy intervention is the observation that some energy consumers do not undertake efficiency improvements even where it *appears* from available information that it would be financially advantageous for them to do so. In this context, barriers are the various issues that give rise to the apparent discrepancy between behaviour and financial incentives.[5]

Measures to increase the use of renewable heat bear many similarities to energy efficiency policy, including investment in changes to energy infrastructure. Similar barriers therefore may arise and be of relevance to the evaluation of the effectiveness of different financial instruments. Barriers often cited in the literature include:[6]

§ ***Basic financial barriers.*** These include the potentially higher (up-front) costs of products and the interest rates available to consumers.

§ ***Hidden costs.*** These include "transaction costs" associated with finding reputable providers, time costs of disruption or cessation of business activity, and the costs of differences in quality of product or service—all of which may reduce the net benefit derived from measures.

§ ***Lack of information.*** If consumers do not know their level of heating requirements, what renewable technologies are available for heating, or the cost of different options, they are unlikely to consider investment in renewable heat.

§ ***Risks and uncertainty.*** Uncertainty about future energy prices may deter consumers from investing since they cannot be assured of future costs; consumers also may not be certain whether their tenure at a property will be sufficiently long for future savings to repay an initial outlay. In addition, consumers may be wary of the risk associated with new (or unfamiliar) products or services.

§ ***Poorly aligned incentives.*** The most commonly cited barrier of this kind is the "landlord-tenant split", whereby landlords under-invest in energy infrastructure because tenants pay energy bills. It also includes organisational splits of energy capital expenditure and ongoing energy costs over separate budgets or departments. Similar misalignments can occur in the building industry and among property developers, often due in part to asymmetries of information. For example, there is some suggestion that energy costs may not be fully reflected in building values or rents, resulting in an inability to recoup investment costs. Failure to incorporate environmental or other externalities (such as energy security) into energy markets also is included here.

§ ***Psychological / sociological barriers.*** This category refers to a range of less tangible barriers that may explain consumer behaviour that does not conform to perfect "economic rationality". These may include inertia in decision-making (which may be due to loss-aversion and concerns about regret), the use of rules-of-thumb rather than more complicated full optimisation, and preferences that depend on the behaviour of others.

§ ***Regulatory barriers.*** Finally, there are aspects of the energy market and its regulatory framework that could make it more difficult for households to benefit from or consider

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5 See NERA (2006b) and NERA (2007b) for discussions of barriers to energy efficiency in the SME and household sectors, respectively.

6 This discussion is largely a summary of the discussion in NERA (2007b)

energy efficiency. Examples include limits on the types of “contracts” offered to households by suppliers, assignment of responsibility for metering, and treatment of distributed generation.

- Technologies are relatively established; used in other countries; but nonetheless unfamiliar to UK consumers.

- Lack of information and distrust of technologies may be particularly relevant

2.4.3. Implications of barriers for policy evaluation

These barriers span a wide range of different costs and other phenomena and have several implications for policy evaluation. First, *size* of a measure affects how administrative and related costs affect project finance. Projects have associated with them not only costs from purchases (of equipment, fuel, or installation services), but also the cost of time spent. Examples may include the cost of finding information about technologies or support schemes, applications for grants or other financial support, or the cost of finding an installer or waiting for installation. For a large project, these activities are likely to be small compared to the overall cost of the project under consideration. By contrast, for small projects the cost of time input can rapidly become large relative to the value at stake in making different choices. Adding uncertainty to this can reinforce this effect: if the cost differentials between (potentially unfamiliar) renewable heat projects and (well-known) fossil fuel-fired heating systems are small, or are *perceived* to be small, the investment in time to find information and compare options may be an important factor in deterring the uptake of projects. The change to a renewable heat technology therefore may have to offer significant financial or other (perceived) advantages to enter into the set of options considered in the household sector.

Second, the *cost structure* of a measure becomes important. Many of the above barriers or hidden and missing costs identified in the context of energy efficiency relate to failures to undertake projects which require initial outlay but where benefits are deferred. Where such barriers exist, even relatively modest up-front costs may be a deterrent to the uptake of renewable heat, even if total lifetime cost appears relatively attractive when barriers are not taken into account.

Third, the *combination* of financial support with other policies may matter. For example, measures that combine the provision of financial support with information or marketing – or with incentives for their provision – may be better able to achieve the uptake of measures for a given level of subsidy. Similarly, measures that achieve economies of scale in project appraisal and other time costs may have lower cost for a given amount of renewable heat capacity installed.

Fourth, there may be more intangible *behavioural* issues that affect the efficacy of policy intervention. To the extent behavioural barriers are significant, policy effectiveness may depend not only on the strength of financial incentives provided, but also on other factors; for example, the effectiveness of a given level of financial incentive may depend how incentives are “framed”; which institutional mechanisms are used to create incentives; or on the simultaneous provision of information, regulatory requirements, or other factors that affect barriers. Much of UK energy efficiency policy has been designed with these considerations in mind, and in some cases regulatory intervention has been motivated principally by such considerations.[7]

There is some controversy about what constitutes a genuine behavioural "barrier" and what is best regarded as a cost incurred by market participants. The information costs to small participants are a case in point. On the one hand, the "hassle" or time devoted should be accounted for as a cost in standard cost-benefit analysis. On the other hand, there is survey evidence suggests that the actual time costs are small compared to the potential benefits, and that the "perception gap" between actual costs and beliefs about costs is difficult to reconcile just by accounting for the cost of time.

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[7] For example, the Energy Efficiency Commitment / Carbon Emissions Reduction Target is designed to use energy suppliers' contact with customers to overcome barriers, while the Carbon Reduction Commitment has as a key aim to focus management attention on energy use through the use of monitoring and reporting requirements (with financial incentives arguably placed in a subsidiary role).

3. Current Policies Affecting Renewable Heat

In this section we provide an overview of how current or planned policies interact with markets for renewable heat. This is intended both to provide an overview of the current support available for renewable heat, and a brief description of policies that may form the basis of expanded policies to promote renewable heat.

3.1.1. The EU Emissions Trading Scheme

The EU ETS results in an increased cost of energy derived from the combustion of fossil fuels, including grid electricity. Renewable energy, by contrast, does not incur this cost as it incurs no obligation to surrender allowances under the EU ETS. Consumers of energy covered by the EU ETS (including electricity) therefore have an increased financial incentive to turn to renewable sources for heat generation.

The incentive is faced directly by installations covered by the EU ETS, which account for a large share of total industrial heat demand (which in turn is around 30 percent of total demand). It also applies to electricity consumers, who face the cost of emissions allowances passed through to prices. However, the EU ETS does not cover the direct emissions from fuels at scales below 20 MW, and incentives for renewables therefore are not consistent across all heat consumers.

3.1.2. The Carbon Reduction Commitment

The Carbon Reduction Commitment is a cap and trade program for emissions from organisations in the large non-energy intensive sector. The financial incentive provided for renewables in this scheme are difficult to assess. Although the CRC is a cap-and-trade program, it does not provide financial incentives in the way typically associated with emissions trading. Revenue from an allowance auction is recycled, eliminating much of the cost of emissions, although this is reinstated in part by making the amount received back contingent on a league table of emissions reductions. For an individual organisation, however, the marginal cost of emissions is hard to predict, and may deviate from the price of allowances.

The focus of the CRC is on “behavioural” rather than financial incentives. The hope is that the CRC administrative requirements as well as reputational effects of the league table will increase management attention to energy use. This in turn may lead to the uptake of emissions reduction measures that are in fact cost-effective but which may not previously have been undertaken, notably through the improvement of energy efficiency.

The combination of an absence of direct financial incentives and the focus on behavioural incentives for measures that will reduce energy costs and save money overall mean that the incentives for renewables are very uncertain. If, as various models indicate, energy-saving measures are available that will reduce emissions while also reducing costs, it is unlikely that a significant quantity of measures involving renewable heat (which are likely to involve increased costs) will result from the CRC.

3.1.3. Carbon Emissions Reduction Target

The Carbon Emissions Reduction Target (CERT, previously known as the Energy Efficiency Commitment, or EEC) is a credit-based emissions trading programme in the residential sector, focussing on energy efficiency measures.

The CERT requires electricity and gas supply companies to achieve a specified quantity of energy savings among UK households within a given compliance period. Savings can be achieved by undertaking measures that affect household energy consumption. Ofgem, which administers the scheme, determines whether particular activities are eligible to count towards suppliers' obligations, and also calculates the energy savings associated with each measure. To date, the scheme has been dominated by cavity wall insulation, although there also have been measures affecting other insulation, lighting, and appliances. From 2008, the CERT includes among its eligible measures some microgeneration measures as well as biomass community heating and CHP. Despite this expansion of the scope of the policy, however, the bulk of measures installed under the CERT are likely to remain energy efficiency measures, rather than renewables.

To reduce the administrative burden of the scheme, the calculation of emissions reductions arising from measures under the CERT is highly standardised. Reductions are "deemed" using standardised calculation methodologies based on average UK conditions, and the calculation leaves out many household-specific factors that may affect the emissions arising from a given measure (e.g., number of inhabitants, income, past consumption, etc.). Additionally, the full life-time savings attributable to a measure are credited up-front (adjusted for some discounting of future benefits), which is one of the reasons why long-lived measures such as cavity wall insulation have proven attractive to suppliers. The result of using a life-time and deemed approach is to drastically reduce the monitoring and administrative requirements, compared to a scheme where savings from each measure undertaken would be individually estimated or measured.

The CERT also awards some flexibility to participants under the scheme. Suppliers can trade either obligations or savings, although in practice this has been rare. Instead, the most important flexibility is the ability of suppliers to undertake measures among any UK households (rather than just their own customers) and to contract with third parties to undertake energy efficiency measures on their behalf. In practice, suppliers carry out only a small proportion of energy savings measures themselves, but instead offer installers and others in the energy efficiency supply chain financial subsidy in return for documentation allowing them to claim the EEC "credits" attributable to the subsidised measures. The suppliers thus effectively run a procurement and grants scheme, supporting various types of measures according to the most cost-effective opportunities available to them.

3.1.4. Climate Change Levy

The climate change levy is a tax on the use of energy in the industrial, commercial, and public sectors. The rates of the levy vary depending on the fuel used, and it is broadly similar to a carbon tax of around £10 / tCO_2.

The levy does not apply to all energy use. Notably, energy use in the household sector, power generation, transport, and certain specialised industrial processes are exempted. Also exempted is energy intensive industry that has entered into voluntary Climate Change Agreements to reduce energy use to negotiated target levels. Further, fuel used in good quality CHP schemes and electricity generated from renewable sources also are not required to pay the levy.

The CCL encourages renewable energy by lowering its cost relative to the use of fossil fuels. The cost advantage depends on the fuel; for example, gas use is taxed as 0.15 p / kWh and electricity at 0.44 p / kWh. These levels are lower than the numbers typically cited for the relative cost disadvantage of many renewable heat technologies. For example, the analysis presented in BERR (2008b) indicated that a support of £10 / MWh, corresponding to 1 p / kWh would likely be required, while many technologies in Ernst & Young (2007a) would imply higher levels of subsidy requirements.

3.1.5. Grants schemes

Several grants programmes are in place to contribute towards the installation of renewable heat technologies. The main programmes are the following:

§ ***Low Carbon Buildings Programme (formally Community and Household Capital Grants and Clear Skies).*** This programme offers grants for microgeneration, including both electricity and renewable heating. Phase 1 of the programme was launched in April 2006, will run for three years, with a budget of approximately £36 million, and is open to householders, public, not for profit and commercial organisations across the UK. The microgeneration technologies covered include ground source heat pumps, bio-energy and renewable CHP. Phase 2 of the programme will make grants available to public sector buildings and charitable bodies with funds currently committed up to mid-2009.

§ ***Scottish Community and Householder Renewables Initiative in Scotland and Environment and Renewable Energy Fund in Northern Ireland.*** The Scotland initiative includes grants to support community and household renewables schemes. The average grant for community projects is 50 per cent with a maximum capital grant of £100,000. For householders, funding is set at 30 per cent of the installed cost up to £4,000 for a single measure. The grants support technologies such as solar heating and ground, water and air heat pumps. The Northern Ireland fund provides grants for householders, with the level of the grants depending on the technology. For example, the maximum grant for ground source heat pumps is £1,500 subject to an overall 50 per cent limit.

§ ***Enhanced capital allowances.*** Enhanced capital allowances are tax incentives for companies that pay income or corporation tax, reducing tax bills and improving cash flows by allowing companies to claim 100 per cent first-year allowances against the taxable profits during the period of investment in energy-saving technology. Capital allowances are available for energy efficiency, low-emission cars and water conservation. There are currently 14 eligible technology groups for energy, including several renewable heat technologies such as heat pumps for space heating and solar thermal systems.

§ ***Bio-energy Capital Grants Scheme.*** This support the installation of biomass-fuelled heat and combined heat and power projects in the industrial, commercial and community sectors in England. Application for Round 3 of the scheme (now closed), run by Defra, took place between December 2006 and March 2007. The grant rate was up to 40 per cent of the difference in cost compared to a fossil fuel alternative, with minimum to maximum single award limits of £25,000 to £1 million. Defra intends to run further rounds of the scheme.

In addition to the above schemes, which provide support directly to equipment used in the production of renewable heat, there are additional existing policies that contribute support to the supply chain for renewable fuels that may be used to product for heat.

§ ***Energy Crops Scheme.*** The Defra scheme that run until 2007 provided grants to establish two energy crops: short-rotation coppice and miscanthus. Natural England is administering the 2007 to 2013 Energy Crops Scheme, which is jointly funded by the EU and UK government. The establishment grants for the two energy crops in England will be based on 40 per cent of the actual establishment cost.

§ ***Other support schemes for the biomass supply chain***. Relevant initiatives include Defra the Bio-energy Infrastructure Scheme, the Biomass Heat Accelerator project run by the Carbon Trust, and various initiatives by Regional Development Agencies and the Forestry Commission.

These various initiatives offer targeted support for a number of applications relevant to renewable heat. However, their cumulative impact is small compared to the scale of the targets discussed above.

3.1.6. Renewables obligation

The renewables obligation also provides support that indirectly encourages some use of renewable heat. Notably, electricity generation from biomass-fired CHP gets 33 percent higher support (2 ROCs) than does electricity generation without simultaneous generation of heat (1.5 ROCs). However, the support for heat is indirect only, and heat output is not explicitly rewarded. The RO therefore provides incentives to maximise electricity but not heat output—provided that the CHP plant remains classified as “good quality”.

The RO also may have more indirect effects on the viability and uptake of renewable heat. On the one hand, the obligation could contribute to the development of a biomass supply chain, making the supply of biomass for heat generation more feasible. On the other hand, the use of biomass for electricity generation represents a competing use for biomass resources, as discussed above.

4. Approach to Policy Evaluation and Evaluation Criteria

We discuss below the evaluation criteria used in this study and provide an overview of the policies considered.

4.1. Evaluation Criteria

The evaluation of financial instruments considered in this report has been undertaken using evaluation criteria agreed with the project Steering Group. The evaluation criteria can be summarised under the following headings:

- feasibility of implementation;
- effectiveness in achieving an increase in renewable heat;
- cost-effectiveness per MWh of renewable heat;
- impact on CO_2 emissions;
- distributional impact and equity; and
- impact on other policy goals.

We discuss the evaluation criteria in more detail below.

4.1.1. Feasibility of implementation

Policies are evaluated with respect to the feasibility of their implementation. This is broadly understood to include a range of considerations including the practical administrative feasibility, administrative complexity, legal feasibility, and public and political acceptability of measures.

Practical feasibility is reduced by policies that create complex administrative burdens, for example, through reliance on expensive metering technologies, onerous reporting requirements, or rules lacking in transparency. Market-based environmental regulation typically relies on the creation of financial incentives for quantities that are not currently traded in markets, and which therefore may not be subject to existing property rights or easily measured. (For example, credit-based systems may require an assessment of whether particular projects are “additional” to counterfactual baseline developments; cap-and-trade programmes require precise rules about the reporting of the capped quantity and systems for accounting for allowances; per-unit subsidies require the measurement of the supported quantity; and grants require judgement about whether projects qualify for support.) In many cases, the information requirements and administrative procedures associated with such regulation therefore give rise to a trade-off between creating efficient price signals, on the one hand, and avoiding undue administrative complexity, on the other. If rules are too complex or burdensome, the efficiency or effectiveness of the instruments may be limited (see discussion below).

Instruments also may face challenges of public acceptability. This may arise if there are local adverse effects of renewable heat (e.g., local pollution), or if infrastructure required for its delivery is thought to be invasive (e.g., on grounds of aesthetics or through disruption caused). Public acceptability also may be reduced to the extent renewable heat adversely affects desirable attributes of heat delivery (e.g., reliability, interruptibility, or flexibility), or if its use otherwise required significant changes to public behaviour. In our evaluation we consider chiefly whether these issues vary between different financial instruments; although, as noted, we do not aim to evaluate the acceptability of increasing renewable heat *per se*.

Some measures also may face legal hurdles. Much of energy and climate policy is governed by EU directives, and the feasibility of some approaches may depend on their consistency with these requirements. Also, financial support typically is subject to EU State Aid approval. Some approaches may require changes to primary legislation, which may put limitations on the feasible timescales for the introduction of instruments.

4.1.2. Effectiveness in achieving an increase in renewable heat

As noted, the impetus for the current project is the desire to achieve a contribution from the heat sector to the overall UK renewable energy target for 2020. An important evaluation criterion therefore is the ability of financial instruments to achieve a sufficient increase in the overall amount of heat generated from renewable energy sources. For this project, NERA has been asked to evaluate the effectiveness *with respect to the renewable heat target*. Emissions reductions and other relevant policy objectives are assessed separately and accounted for in the overall evaluation where agreed with the Steering Group but do not form the basis for judging the "effectiveness" of instruments.

The effectiveness of policy will depend immediately on its *coverage* of heat use where renewable heat technologies could be used. As noted above, heat markets can be broadly segmented into sectors (industrial, commercial, public, and household), and further by the characteristics of current use of non-renewable energy (by fuel, net-bound vs. non net-bound, or use of electricity). Instruments can differ in their applicability to these different segments, with different total coverage as a result. Conversely, it may be less important to cover heat market segments where the use of renewables is difficult to achieve.

Effectiveness also depends on the ability of the policy to elicit a response from covered heat consumers, often referred to as the "uptake" of measures to deploy renewable heat. At a basic level, this depends on the strength of the incentive and the resulting relative cost of renewable heat and alternative heat sources. While many instruments can be designed to provide an arbitrarily strong financial incentive, others may be constrained in this regard. For example, links to other environmental markets may mean that prices of certificates or permits are determined by factors extraneous to the heat market or even outside UK policy control. Uptake also needs to be evaluated with respect to the barriers discussed in section 2.4. Another constraint on the feasible level of incentive may be distributional considerations, particularly if the same financial incentive is provided in undifferentiated form to all consumers, or to all technologies.

Evaluations also need to take account of the uncertainty about effectiveness. One aspect of this is whether policies provide financial instruments by fixing quantities or by fixing the level of the financial incentive. With a price instrument (which could take the form of a tax, or a feed-in subsidy) the level of the financial incentive can be determined directly, but the resulting quantity of renewable heat depends on market actors' responses to these price signals and cannot be precisely known. Government therefore may face a risk that the level of response is lower than expected and falls short of targets.

Conversely, a quantity instrument leads to a situation where the overall target is under direct political control but the level of resulting subsidy or financial incentive is uncertain. While this can reduce risk to government, as we discuss below the resulting risk to parties affected by the policy may have implications for the cost-effectiveness of achieving a given target. It also may indirectly affect effectiveness, if the risk is so substantial that it deters investment required to increase the use of renewable heat.

Similar considerations apply more generally to situations where there may be doubt about policy credibility. A key aspect of this is the continuation of support in future years. Also, changes to policy may carry a penalty by reducing the credibility of commitment by government. Untested approaches to financial support therefore may be less effective to the extent they lead to a greater risk of "getting it wrong" and thus of subsequent revision.

A final consideration is that effectiveness should be evaluated with respect to *additional* renewable heat resulting from the policy. As discussed above, various incentives for renewable heat are created through existing and planned energy and climate policy instruments, and some uptake is expected as part of the "business as usual" scenario where no additional financial incentives are put into place. The additionality, and thus genuine effectiveness, of a particular financial instrument thus will depend on its interaction with other policies.

4.1.3. Cost-effectiveness per MWh renewable heat

Cost-effectiveness is evaluated in this report only with respect to the renewable heat produced. NERA has not made an attempt to assess whether achieving a given level of renewable heat is cost effective in a wider sense, or is a cost-effective method to achieve other policy objectives.

The cost-effectiveness of the measures undertaken in response to a financial instrument to promote renewable heat depends in large part on achieving *consistency* of incentives across different opportunities for renewable heat supply. This includes consistency on a per-unit basis across different sectors, renewable heat technologies, as well as the fuels displaced by renewables. Thus there is a link to coverage, as policies that fail to encompass particular sectors or fuels may fail to include cost-effective opportunities for renewable heat deployment.

Cost-effectiveness depends not only on the cost of measures, but also on the administrative and any "hidden and missing" costs. In some cases, the administrative cost to government and participants – including any time costs – can be a substantial proportion of overall cost. Moreover, depending on circumstances, there may be a trade-off between ensuring consistent marginal incentives and avoiding undue administrative overheads as well as hidden and missing costs. All of these factors affect the true cost-effectiveness of achieving a given level of renewable heat through a particular instrument.

Wider cost-effectiveness may depend not only on the appropriate selection of measures for renewable heat, but also on achieving efficient use of inputs into renewable heat relative to other uses of those inputs. A case in point is the use of biomass, demand for which is generated through policies to encourage the use of renewable energy in electricity generation and transport. It therefore may be important to consider to what extent policies are amenable to achieving consistent financial incentives for the use of biomass energy across different support mechanisms.

The risk and uncertainty considerations noted above also may affect cost-effectiveness. Many renewable heat technologies have substantial up-front costs and will be undertaken only with sufficient certainty that these will be recouped. Alternatively, where explicit financing arrangements are in place, uncertainty in the level of future financial support may translate into a higher cost of capital or discount rates. This may affect cost-effectiveness as well as the rate of uptake of renewable heat technologies, as financial instruments that entail a higher risk (with potential for higher cost of capital) may skew decisions away from long-term projects that may otherwise be cost-effective.

Cost-effectiveness also may depend on returns to scale, in two main ways. First, there may be returns to scale for a given set of technology characteristics. For example, district heating is likely to require a minimum number of users to make investment in central heat generation and distribution infrastructure profitable; the widespread adoption of biomass heating may require the development of a supply chain of minimum scale and reliability; or public acceptability may depend on the rate of adoption. Second, the scale of deployment may affect cost-effectiveness over time by encouraging learning and innovation. One motivation for the support of renewable energy is to bring down the long-term cost of technologies, and either through the encouragement of innovation or through other “learning-by-doing” (including innovation in contracting, institutional learning, etc.).

4.1.4. Impact on CO_2 emissions

The reduction of CO_2 emissions is a key underlying motivation for policy to promote renewable energy. The emissions reductions achieved can differ substantially for a given amount of renewable heat depending on the alternative heat source that is displaced. In general, electric heating is more emissions intensive than coal- or oil-fired heating, while gas-fired heating have lower emissions still. However, the precise emissions reductions depend also on other characteristics, notably the efficiency of the displaced heating system.

It also is relevant to consider whether the emissions being displaced are subject to constraints. Notably, a substantial proportion of emissions associated with heat generation in industry and the large non-energy intensive sector will be covered by either the EU ETS or the CRC. In these sectors, the increased use of renewable heat will not lead to net emissions reduction benefits for a given cap level. The achievement of emissions reductions through separate support for renewable heat therefore would depend on tightening the emissions caps in these programmes by a corresponding amount.

4.1.5. Distributional impact and equity

Distributional impacts of policies depend on two main factors. First, achieving the increased use of renewable heat will entail a higher total resource cost. The distributional effects of a financial instrument thus depend on which party pays this cost.

Second, policies that put a value on renewable heat typically create transfer payments or “scarcity rents” when recipients of financial support receive payments in excess of their costs.[8] These rents can be earned if the same level of subsidy is paid for heat projects of differing cost – e.g., through a single level of incentive payment for all heat generated, or through a certificate system including eligible technologies of differing marginal cost. It also may be the result of higher prices (e.g., brought about through other price instruments, or through the pass-through of opportunity costs) in a situation of different costs. While such rents are a "normal" feature of markets where prices are set by marginal cost, they may be controversial where scarcity and markets are created through policy intervention. On the other hand, addressing such distributional concerns may pose a trade-off with cost-effectiveness if modifications to reduce infra-marginal rents (e.g., through the differentiation of support to different policies) cause more expensive projects to be undertaken in lieu of ones of lower cost.

The distribution of both costs and scarcity rents depend in large part on how renewable energy is financed. Where support is financed through general government revenues the distributional effects would mirror the effects of the economy's overall tax system. If payments are borne by parties within the energy markets (e.g., through an obligation on suppliers, or through other energy charges), then distribution depends on market interactions, including how costs incurred upstream are passed through to downstream users. Moreover, depending on how obligations are structured (e.g., by customer, or by MWh supplied), the ***marginal*** cost of supply may differ, with different impacts on pass-through for a given resource cost.

One of the key distributional objectives of government energy policy is the reduction of fuel poverty. In the context of financial instrument for renewable heat this amounts broadly to a concern about rising energy prices faced by those for whom energy costs already are a large share of income. Instruments thus may differ in their impact on fuel poverty both if the total subsidy (including scarcity rents) differs, and if the pass-through of costs varies between policies.

4.1.6. Impact on other policy goals

In addition to the reduction of CO_2 emissions and ensuring the affordability of energy for households, energy policy also includes the objectives of energy security and the promotion of competitiveness through the use of competitive markets. We evaluate these policy objectives only as they vary between different policy approaches.

Discussions of energy security often centre on the issue of avoiding dependence on unreliable sources of energy (e.g., imports from politically volatile regions) or, in the case of electricity, on ensuring adequate capacity and other aspects of wider system reliability. Renewable heat may contribute to energy security where renewable energy sources are more reliable than the fossil fuels and electricity displaced. However, it is unclear that there is any straightforward relationship between energy security and renewable energy. Specifically, it is not clear that

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[8] These transfers sometimes are referred to as "deadweight costs". This is distinct from the meaning of this concept, more commonly referred to as "deadweight loss", in welfare economics. Deadweight loss refers to a reduction in total *social* surplus arising from allocative inefficiency in markets (e.g., reduced *combined* consumer and producer surplus arising through deviations of prices from marginal cost through market power, externalities, or taxes). By contrast, scarcity rents are transfer payments that need not reduce overall combined consumer and producer surplus. To avoid ambiguity, we refer to subsidy payments in excess of cost as "scarcity rents" or "infra-marginal rents".

fuel diversity achieved through increased use of renewables (as opposed to diversity in fuel sources) in and of itself contributes to energy security; nor that renewable energy need means an avoidance of reliance on imports, either on average or at the margin; nor indeed that the absolute level of imports by necessity is related to security. Moreover, the relationship between energy security and renewables is complicated by several factors. If the achievement of targets for renewable energy is uncertain, this may translate to uncertainty about the need for investment in conventional energy supply, with implications for energy security. Many of these considerations are likely to be more relevant to electricity than heat markets.

The impact of renewable heat on competitiveness is largely analogous to the impact on fuel poverty, in that it depends on the impact on prices. Meanwhile, if financial instruments were not to be consistent with the functioning of competitive energy markets, this would be an important topic for evaluation.

4.2. Policy Categories and Long List of Policies

The remainder of this report consists of an application of the above criteria to the following policy categories and specific instruments:

- **Policies that increase the cost of fossil fuels.** The attractiveness of renewable heat depends on the cost of the relevant fossil fuel alternative. Measures which raise the cost of fossil fuels therefore can be used to promote the uptake of renewables. We discuss options that involve expanding or modifying existing emissions trading policies (including the EU ETS and the proposed CRC), as well as other price instruments.
- **Grant schemes for renewable heat investment.** Policies of this type can be categorised by funding mechanism; in theory these could include tax incentives, capital grants, and guaranteed/subsidised loans.
- **Renewable Heat Obligation.** This policy option would create a market that would provide support for renewable heat output (as opposed to investment), through the creation of renewable heat certificates or similar instruments.
- **Renewable Heat Incentive.** This also would provide support for renewable heat output (for example, per MWh produced), but with a fixed level of support—similar to so-called “feed-in tariffs” in the electricity sector.
- **Hybrid approaches.** These would combine elements of the heat obligation and its tradable certificates with features that could fix or constrain the level of subsidy received.

5. Policies Raising the Cost of Fossil Fuel Use

This group of instruments rely not on subsidies for renewable heat, but on increasing the cost of conventional technologies for heat generation. This framework for policy is consistent with an “externalities” approach to supporting renewables, whereby renewable energy sources are made more attractive by increasing the cost of non-renewable energy to account for potential social costs not reflected in market prices.

In the context of environmental policy, there are two main approaches in this regard: quantity-based instruments (such as emissions trading) and price instruments (which could include taxes). We consider the following approaches:

- Expansion of the EU ETS to additional emissions sources or through “upstream” coverage;
- Expansion of the CRC to additional energy users, or modification of the scheme to provide greater incentives for renewable heat; and
- More direct price instruments applied to non-renewable energy use.

5.1. Expansion of the EU ETS

5.1.1. Description / design options

The EU ETS could be extended to include additional heat sources in two main ways:

First, it would be possible to extend downstream coverage by opting in additional UK emissions sources to the scheme. This would require operators of these installations to hold permits to emit CO_2 and to surrender allowances corresponding to emissions on an annual basis. The cost of heat produced by burning fossil fuels would increase by the cost of the allowances required to cover the associated emissions.

Second, it would be possible to extend coverage “upstream”. This would require fuel suppliers to hold allowances corresponding to the emissions created when their product is burned by customers. Incentives for end-users would be created by the pass-through of emissions costs to fuel prices, and thus would appear similar to an increase in fuel prices or a tax on fuel use. The combination of upstream and downstream trading (often referred to as a “hybrid” approach) is the route taken in the US.

5.1.2. Evaluation

5.1.2.1. Feasibility

The inclusion of additional downstream facilities would be legally feasible. Such an “opt-in” of heat installations has been done in other Member States in Phases I and II of the EU ETS; for example, some countries with significant community heating sectors have opted in numerous CHP installations.

However, additional downstream coverage may be difficult because of EU-wide momentum towards removing small emitters from the scope of the EU ETS. For example, the recent proposals by the European Commission for the future of the EU ETS contained provisions to allow Member States to remove installations with less than 10 ktCO_2 per year.

Additional upstream coverage would likely require changes to the Emissions Trading Directive. Although the Directive currently is under review, such extensions have not been part of these discussions and are not included in the draft proposal proposed by the European Commission. The scope for further amendments would likely be very small, as the schedule for current proposed revisions is unusually tight for EU-wide directives.

Upstream coverage also would pose challenges for "fuel accounting". For example, it would be necessary to separately account for fuel supplied to installations whose emissions were covered directly by the scheme, and fuel supplied to facilities currently not covered. Failure to do so would risk either "double regulation" or "double counting" of emissions.[9]

5.1.2.2. Effectiveness

It is unlikely that additional coverage in the EU ETS would produce a significant increase in the amount of renewable heat.

Expansion of the EU ETS downstream (to progressively smaller emitters) is not likely to be practically feasible, because of the administrative costs such expansion would impose on participants. Estimates from a survey commissioned by the Environment Agency suggest that for small emitters the administrative costs of participation are high, and that by implication these costs outweigh the potential social benefits of inclusion for some sources currently included (AEA 2006). The potential to increase coverage would be limited further by the fact that many of the larger organisations that otherwise would be candidates for inclusion already would be included in the CRC. Between these considerations, the feasible cost-effective extension of downstream EU ETS coverage would be very limited.

An upstream expansion of the EU ETS could achieve more complete coverage. The EU ETS currently covers much of the energy use in the industrial sector, which in turn corresponds to 30 percent of total heat demand. Much of the remaining 70 percent thus could be included through upstream expansion of the EU ETS.[10]

The effect of upstream coverage on renewable heat would depend on the cost differential rising fuel prices created between renewable and other heat sources. Assuming full pass-through to downstream users, current Phase II prices of €20-€25/tCO_2 would lead to price increases in the region of £3.5/MWh for natural gas, £4.5 / MWh for heating oil, and £6 / MWh for coal. Most forecasts of allowance prices in the post-2012 period are higher than current prices, in the region of €35/tCO_2. At this allowance price fuel prices could rise by £6 , £7 and £9 per MWh for gas, oil and coal, respectively.

Judging by some cost estimates in Ernst & Young (2007a) and the recent heat Call for Evidence (BERR, 2008b), this level of additional advantage could be sufficient to make some

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9 See Sorrell (2006) for a more detailed discussion of these issues.

10 Coverage would be less than 70 percent as some 15 percent of total heating is from electricity, which already is covered by the EU ETS. Also, coverage would depend on whether commercial and public sector organisations in the CRC were exempted from upstream coverage of fuel use. On the other hand, not all of industry currently is in the EU ETS.

renewable heat technologies cost-competitive with fossil fuel-based heat, especially for the more carbon-intensive non-net-bound fuels. For heating provided by natural gas, however, the incentives are unlikely to be sufficient to switch to renewable heat. Many renewable heat technologies would remain more expensive compared even to the more emissions-intensive fuels.

Thus the magnitude of consumer response is difficult to gauge. On the one hand, mechanisms to raise the price of fossil fuels have been successful in creating large-scale deployment of renewables in some countries. Notably, significant and rapid increases in the use of renewables for heating in Sweden have been achieved in large part through high taxes on energy (currently corresponding to around £75 (€100) per tonne CO_2). However, it is difficult to compare conditions across countries, as both heating needs, pre-existing infrastructure (notably, community heating), and the biomass supply chain conditions are very different from those in the UK. It also is difficult to conclude from the experience with this very high level of incentive what the implications of a smaller incentive would be for UK energy markets.

However, there is reason to believe that the overall response would be modest. It is unclear that the cost estimates from the previous analyses cited above fully account for the total cost of switching to renewable heat, including the cost of installation and various “hidden and missing” costs. Moreover, even to the extent that the relative cost of technologies is changed to make renewable heat cost-effective compared to some fossil fuel-fired options, it is uncertain to what extent this would lead to consumer response. This depends to a large extent on the degree to which the inertia with respect to energy technology choices discussed in section 2.4 – including behavioural “barriers” and implied high discount rates – constrain the response to an altered financial situation. This remains difficult to evaluate, particularly in the heat market where there is little experience with policy intervention.

The best available evidence base may be the experience with energy efficiency. Although there is disagreement about how to interpret the evidence, many studies and the models underlying much of UK policy in the area indicate that pools of measures go either unnoticed or are otherwise untapped, even where there are apparent financial gains to consumers. This issue may be particularly relevant for measures involving longer-term investment, and for measures in the residential and commercial sectors. (Conversely, the energy-intensive sector that is most likely to respond to financial incentives already is covered by the EU ETS.)

5.1.2.3. Cost-effectiveness of heat measures undertaken

Downstream expansion of the EU ETS is unlikely to be cost-effective, chiefly because of the high administrative costs noted above. By contrast, an upstream expansion appears relatively attractive from the point of view of administrative cost. The number of fuel suppliers is very small relative to the number of fuel consumers and the aggregate direct administrative burden created is therefore small.

Like many market-based measures that rely on individual decision making in response to price signals, there would be a time burden associated with the appraisal of options for heating. However, the additional burden created by changing relative prices is unlikely to be of consequence. Expanding the set of potentially cost-effective measures available to consumers (by making renewable technologies more attractive) would not normally be considered a "cost". By contrast to approaches which are contingent on certification of measures, the measurement of heat output, application processes, etc., measures that serve to change relative prices are administratively light-touch for government, producers, and consumers.

It is less clear that the heat options taken up under an expanded EU ETS would be cost-effective *from the point of view of increasing renewable heat* (although it would be cost-effective from the point of view of CO_2 emissions reductions). The incentive created would vary by the CO_2 content of fuels, and the incentive created per unit of heat would therefore also vary. Thus there would be instances where renewable heat with a higher cost per unit of heat generated, but replacing emissions-intensive fuels, would be undertaken in lieu of cheaper measures replacing lower-emitting fuels.

The quantitative significance of this on overall cost-effectiveness of heat measures undertaken is difficult to gauge. In the residential sector it is likely that supply-side barriers (notably, space constraints) as well as other cost considerations anyway make the non net-bound sector the most attractive for renewable heat. The deviation of upstream EU ETS coverage from a situation with a uniform additional cost per unit energy from fossil fuels therefore may not be large in this sector. In the commercial and public sectors the cost disadvantage of replacing gas compared to replacing other fuels may be lower, and the "distortion" created by raising gas prices less than other fuels therefore more significant. However, this is somewhat speculative, as information on opportunities for renewable heat in this sector is very thin.

5.1.2.4. Impact on CO_2 emissions

The total amount of CO_2 reductions *through use of renewable heat* resulting from an expansion of the EU ETS would depend on the amount of fossil fuels that were replaced by renewables. As noted, these would likely be very small for a downstream expansion, but could be larger – although still likely modest compared to targets, and also uncertain – for an upstream expansion. However, as is the intention of the EU ETS, the CO_2 savings achieved per unit of renewable heat would be maximised.

Of course, *overall* CO_2 reductions in the EU ETS (rather than reductions achieved through renewable heat specifically) depend solely on the EU ETS cap, the stringency of which can be set through policy.

5.1.2.5. Distributional impact

UK climate policy to date has avoided imposing significant additional charges on energy prices, in part because of concern about the distributional implications. The higher numbers quoted above imply price increases of around 15-20 percent for gas, and up to 90 percent for coal. Government estimates imply that significantly smaller increases in average fuel bills could lead to significant increases in fuel poverty. Without some offsetting mechanism, the increase in cost therefore would be contrary to some key distributional objectives.

The net distributional consequences of a cap-and-trade program depend on the allocation of allowances. In most upstream proposals, allowances are purchased by fuel suppliers. Government therefore could choose either to auction allowances (which would imply a net transfer to the Treasury, similar to a tax), or to allocate them for free to other parties.[11] If auction revenues were recycled or allowances awarded to the parties affected by the price increase, this could offset in part the distributional consequences of the price increase. However, there are practical limitations to doing this without also undermining the incentives the upstream expansion would be intended to create.

5.1.2.6. Impact on other policy goals

We have identified no major impact on other policy goals of an expansion of the EU ETS along the lines described above.

5.2. Direct Price Instruments Applied to Non-Renewable Heat Use

5.2.1. Description and design options

As the above discussion indicates, relying on upstream EU ETS coverage imposes some limitations on the structure of changes to fuel prices. Apart from difficulties of implementation, these include:

- Levels of price increases depend on the overall EU ETS and other factors outside UK policy control.
- The relative level of price increases for different fuels depends on their CO_2 content, which may not lead to the maximum increase in the use of renewables.

The main alternative method of increasing fossil fuel prices would be to rely on some other more direct price instrument. One current example of such an instrument is the CCL, as discussed in section 3.1.4.

5.2.2. Evaluation

Many of the advantages and disadvantages of a more direct price instrument applied to fossil energy sources are similar to those of an upstream expansion of the EU ETS. We briefly evaluate below some of the ways in which such an approach would differ.

5.2.2.1. Feasibility

Given that an expansion of taxes is not under consideration as a significant tool for energy policy (see e.g., BERR, 2007d), it is not clear that there is another pricing mechanism that could be used.

5.2.2.2. Cost-effectiveness of heat measures undertaken

A price instrument could be highly cost-effective. The administrative burden would be small compared to the more involved policy approaches relying on grants schemes or certificates of heat output. The main potential cost would be the deadweight loss arising from reduced energy consumption; however, to the extent the renewables targets are motivated by

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[11] In current US upstream proposals, free allocation is provided to many different parties, including ones not directly regulated under the cap-and-trade programme, such as retail electricity suppliers or States.

externalities arising from such consumption it is unclear to what extent this would be a true social cost.

In addition, if the policy were intended to raise the cost only of non-renewable energy used for *heating*, then there would be administrative costs associated with distinguishing such energy use from other energy uses. Making this distinction would be likely to reduce the overall cost of the policy per unit of renewable heat delivered—because otherwise a significant proportion of the cost increases would simply make the cost of electricity use, for example, more expensive.

Compared to emissions trading, a price instrument could be made more effective for the promotion of renewables as there would be no requirement to link the incentive levels to the emissions characteristics of fuels.

5.2.2.3. Effectiveness

The effectiveness of a price instrument would depend on what levels of price increases would be feasible given the expected costs and distributional impacts

As noted, if significant fossil fuel price impacts were feasible, experience from other countries suggest that they can be an effective tool for the increased use of renewables – again with the caveat that comparisons between countries are difficult without also accounting for other aspects of energy markets and policy.

5.2.2.4. Impact on CO_2

The same considerations as in the case of an upstream expansion of the EU ETS would apply, although for a given overall cost, the effect on CO_2 would be expected to be less than in the case of the EU ETS, because the EU ETS directly targets CO_2, whereas a generic non-renewable heat price instrument would not.

5.2.2.5. Distributional

In the case of a direct price instrument, the UK government would have control over the level of the price signal, in contrast to the case with the expansion of the EU ETS. The overall level of incentive therefore could be made significantly higher—with corresponding implications for overall cost, overall delivery of renewable energy and distributional impacts.

An important consideration for the use of a direct price instrument is that it would affect prices for non-renewable energy *at the margin*, and therefore could result in substantial rents relative to other policies. This is because the full cost difference between the marginal or target-meeting unit of renewable heat would need to be applied to the price of every unit of non-renewable energy sold. Under other policies, only a fraction of this cost-difference would be applied to the price of each unit of energy sold.

5.2.2.6. Other policy objectives

We have identified no major effects on other policy objectives.

5.3. Expansion / Modification of the CRC

5.3.1. Description and design options

The CRC could be changed in two main ways to encourage the uptake of renewable heat. First, it would be possible to expand coverage. As noted, the current threshold for the CRC is set to 6,000 MWh of half-hourly metered electricity per year. Coverage could be increased either by using a different electricity consumption threshold or by specifying particular additional categories of energy users to be included.

Second, it would be possible to tailor the scheme to provide stronger incentives for the uptake of renewables; notably, it would be possible to include a "renewable heat bonus" in the calculation of revenue recycling (as noted, the current approach is to base recycling on changes in emissions since the start of the scheme). For example, some proportion of recycling could be made contingent on the adoption of renewable heat technologies.

We do not consider either of these options a likely candidate for the achievement of UK renewable heat targets, but provide a brief evaluation of the features of these policy options below.

5.3.2. Evaluation

5.3.2.1. Feasibility

In principle, there would be no major administrative obstacles to expanding CRC coverage. Although there are difficulties associated with issues such as identifying participants, setting up administrative structures, implementing the allowance auction, etc., most of these are associated with setting up the scheme in the first instance and would not be significantly increased by expanding its scope.

The feasibility of changing the CRC design nonetheless is likely to be limited by public and political acceptance. The relevant design features, including the threshold and the revenue recycling rules have been the outcome of extensive analysis, stakeholder consultation, and negotiation. Moreover, since its first inception, the CRC was designed primarily with an eye to energy efficiency, and the acceptability of the scheme has been tied in large part to the possibility that administrative and other costs incurred by participants could be offset by savings on energy expenditure. Major changes to the recycling mechanism or other features that would likely be necessary to direct significant financial subsidy towards renewable heat therefore would entail a major departure from previous motivations for the policy.

5.3.2.2. Effectiveness

CRC coverage is bounded by EU ETS and CCA coverage of large energy consumers, and expansion therefore would entail the inclusion of additional commercial- and public-sector organisations with lower energy consumption than the 6,000 MWh threshold. The total energy use of these organisations is modest. Total commercial and public sector heat use accounts for only 16 percent of heat demand, and much of the sector already is included in the CRC. The scope for increased coverage thus is small relative to the overall heat sector.

Also, without significant changes to scheme design the CRC is unlikely to be an effective way to promote the uptake of renewable heat. As outlined in section 3.1.2, the current design provides only limited financial incentives for renewables, as financial incentives may be uncoupled from allowance prices through the recycling mechanism, with uncertain effects on the net incentives faced by individual organisations. If participants in the CRC do face sufficient financial incentives to reduce their energy use and emissions intensity, it seems likely that their initial efforts will focus on energy efficiency, which appears to offer net savings, rather than renewables, which do not.

Finally, while some analyses have suggested that the reputational effects of the CRC could be very important, they are of uncertain magnitude and it is unclear that they would extend to the use of the more expensive emissions reduction options available in the sector, among which renewable heat is likely to be found. Overall, these incentives appear insufficient to promote the proportional increase in renewable heat use implied by UK targets (even within the commercial / public sector).

In theory, the recycling mechanism could provide a potentially flexible tool for the creation of additional financial incentives for renewable heat. However, as discussed above the prospect for changes at this stage of scheme development is small.

5.3.2.3. Cost-effectiveness of heat measures undertaken

The limited coverage of the heat market represented even by a significantly expanded CRC also would limit the ability to ensure the cost-effective deployment of renewable heat measures across the entire heat market. Without explicit links between the financial incentives provided to different heat market segments, the marginal cost of measures is likely to differ. Ensuring consistency of with instruments that may be used in other sectors would be particularly difficult to achieve in the case of the CRC recycling mechanism, as the financial incentives created are non-transparent.

The cost-effectiveness of expanding the scope of the CRC also would be limited by the relatively high administrative costs that attach to the cap-and-trade approach. The CRC has been designed to be "light-touch" compared to other cap-and-trade schemes, and significantly less onerous than requirements under the EU ETS. However, with the inclusion of smaller participants the time and other costs associated with scheme participants could rise to a significant proportion of the potential for energy savings, or even of total energy expenditure for smaller organisations.[12]

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[12] The costs of participation in the CRC have been explicitly modelled at a relatively high resolution of sectors and energy consumption size bands, and this analysis was part of the process of defining the current threshold of annual electricity consumption of £6,000 MWh. However, the criterion used to define the threshold was that participants should be able to break even given a level of energy savings indicated by models that are achievable within the target group. This criterion is unlikely to be tenable for measures for renewable heat, which generally would entail a net cost increase. Previous cost-benefit analyses of the CRC inclusion threshold therefore may not be informative for the threshold of a scheme aiming to encourage renewable heat.

5.3.2.4. Impact on CO_2 emissions

The CO_2 emissions arising within the CRC depend on the overall cap, which is a variable under direct policy control.[13] Changes to scheme design to encourage renewable heat therefore could result in no additional emissions reduction unless the cap also were adjusted. As noted, the emissions reductions attributable to increased used of renewable heat would likely be small.

5.3.2.5. Distributional impact

The distributional impacts of either expansion or changes to recycling within the CRC would be small. The covered organisations are ones for which energy use is a small proportion of total expenditure, and the scheme is designed to be revenue neutral as a whole. Moreover, as the financial opportunity costs are limited by the recycling mechanism, the impact on product prices is likely also to be limited. The main distributional impacts therefore are between CRC organisations. Modifications to reward renewable heat would lead to redistribution toward organisations able and willing to make use of renewable heat technologies.

5.3.2.6. Other policy goals

We have identified no major implications of an expansion / modification of the CRC for other policy goals.

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13 Although the scheme features a buy-out provision, this has been designed to ensure that corresponding emissions take place from emissions sources within the EU ETS.

6. Grants for Renewable Heat Investment

6.1.1. Description and design options

The previous chapter discussed policies that would encourage renewable heat by increasing the cost of using fossil fuels. A second broad policy approach would be to offer direct financial support to renewable heat that would offset part or all of the initial investment cost of renewable heat measures. We do not consider the source of this funding. We briefly discuss design options for such support, focussing on the following parameters:

§ Funding mechanism;

§ Eligibility criteria; and

§ Project selection criteria and administration.

We include in this policy category a form of "procurement auction" that would solicit tenders to provide renewable heat and award them with support, based on the attractiveness of the proposal—both in terms of cost and other factors.

6.1.1.1. Funding mechanism

The main funding mechanisms for investment support programmes are:[14]

§ *Capital grants,* which provide a payment directly towards investment cost. This is the approach of the Low Carbon Buildings Programme and is the most common form of direct investment support.

§ *Subsidised loans*, which are offered on terms that would not be available through commercially provided project finance. This is the approach of the Carbon Trust SME loans scheme and the Salix programme for the public sector. In these cases, the recipient pays no interest, and the cost of capital is funded instead through the energy savings of the project. This mechanism has been used in several countries to support renewables, including as a complement to the German feed-in tariff for renewable electricity.

§ *Guaranteed loans* typically are used for larger projects, to support commercialisation and in some cases demonstration. By providing government guarantee, or by offering a lower interest rate, the cost of capital is reduced and project finance improved. For example, the current US budget includes guaranteed loans of $38.5bn for "innovative energy projects" that reduce GHG emissions.

6.1.1.2. Funding level and differentiation

The level of funding provided may depend on the objectives of the scheme. One approach is to aim to offset the cost of the subsidised technology relative to its most relevant counterfactual. Alternatively, support can aim to support the one-off costs of conversion from one technology to another (e.g., from direct electric to central heating). The grants

[14] Investment support is provided elsewhere through tax relief or credits, which allow investment costs to be offset against taxes that otherwise would be payable. An example is the Enhanced Capital Allowances scheme, which accelerates the rate at which capital allowances can be written off against taxable profits. Such funding mechanisms are outside the scope of our analysis.

scheme also may be operating alongside other incentives, and thus be designed to shoulder only part of the additional burden associated with the investment. The funding level also may be adjusted in response to uptake.

There also is a question of how grants for different technologies (and potentially different projects) should be differentiated. In theory funding could be differentiated by technology, by the customer installing it, by the counterfactual heat source, over time, and/or based on the amount of the technology already installed. The appropriate form of differentiation would depend on whether the objective were to support emerging technologies, achieve large-scale deployment of proven technologies, maximise renewable heat output, or reduce CO_2 emissions most cost-effectively.

6.1.1.3. Eligibility and project selection

Investment support may operate at all stages of technology development and diffusion, from research and development, demonstration, commercialisation, or increased deployment. Correspondingly, the support may have different motivations, ranging from potential "spill-over" or other externalities from research; to scale effects, acceleration of diffusion, or "infant industry" arguments for demonstration and commercialisation; and pollution or other externalities in the case of large-scale deployment. The purpose of the scheme thus sets the overall parameters for the eligibility.

Eligibility also depends on the scale of projects. For smaller projects eligibility typically is based on stylised criteria that minimise the administrative cost, such as a pre-specified list of technologies. In this case, the level of support typically also is standardised for each type, or may vary only with easily observable parameters (e.g., the size of the equipment, or the number of households served). The selection of projects deemed to be eligible may be on a "first come, first served" basis, or determined through a random draw or other rules.

For larger projects, applications may be more detailed, and eligibility may be determined on a case-by-case basis, based on more general guidelines. Projects also may be more involved, e.g., selection may be on the basis of formal tenders that may require both objective and subjective evaluations.

6.1.1.4. Tendering for large-scale projects

It would also be possible to design the system for awarding support around requests for tenders, with awards given via a selection process involving an auction or other similar procurement procedure. This could entail several differences from the type of grants scheme described above. First, the level of support could be endogenously determined as the outcome of an auctioning process, rather than determined in advance. Second, it would be possible to differentiate support further through the auctioning process than would be possible in a grants programme without tendering. In addition to a cut-off point for the maximum price that would be paid for a given technology band, support could be differentiated *within* technology categories by awarding winning tenderers a level of support equal to their bids.

A range of other design considerations would arise for a tendering system. One aspect is auction design and participation. It is likely that only large organisations would be prepared to participate in auctions, and it would be necessary to consider which sectors or types of projects should be eligible for support through ordinary grants and which through tendering. Another key design issue is to consider the likelihood that proposed projects are in fact undertaken. (We discuss these issues in more detail in the evaluation section below.)

It also would be necessary to consider the denomination of a tender for renewable heat. Within a standard grants scheme the most likely denomination would be capacity. However, it would also be possible for project tenderers to request support not simply to defray capital costs for new capacity, but for actual renewable output. This latter policy design would offer support in return for each unit of recorded output of renewable heat, and thus would require arrangements for heat monitoring and certification. This would make it similar in many respects to certain forms of the Renewable Heat Incentive discussed in section 8.

6.1.2. Evaluation

6.1.2.1. Feasibility

The administration of grants schemes can be complex and existing grants schemes have recently been criticised. One difficulty is to match supply and demand, ensuring both that the funds allocated are sufficient to meet demand and that grant take-up is sufficient to result in the disbursement of funds and deployment of renewable heat. Grants for larger-scale projects may give rise to other sources of complexity. With larger sums at stake rules for eligibility and selection of projects may need to be tightened. It would likely be necessary to run separate grants schemes for different segments of the heat market, reflecting different scale of grants and size of equipment.

There is little UK experience with grants schemes of the size that would be necessary to deliver the targets for renewable heat, and most of the current experience is with programmes in the household sector. As noted, UK renewable heat targets may require conversion to renewable heat by 1.5-2 million households and a large number of organisations in the industrial, commercial, and public sectors. Although there would be perhaps ten years in which to administer the grants, this scale of grant administration would be very significant. For comparison, around 4,000 grants have been paid and another 7,000 allocated in the first two years of the LCBP. One example outside the household sector was the funding of large-scale renewable electricity projects during the 1990s through the tendering mechanism established by the Non-Fossil Fuel Obligation. We discuss some of the lessons from the experience with this policy below.

In addition to potential concerns about administrative feasibility, grants schemes raise questions about political acceptability and commitment. If grants were to be the main financial support mechanism for the achievement of renewable heat targets, the ultimate source of funding would need to be allocated a significant budgetary commitment until 2020.

6.1.2.2. Effectiveness

The effectiveness of a grants scheme would depend on the feasibility of running a large-scale programme. As noted, this depends both on administrative issues and political factors.

Grants schemes also need to be able to overcome the problem of achieving uptake. The support of investment may be an effective way to stimulate increased uptake of renewable heat. Many technologies are characterised by high up-front installation and equipment costs, particularly in the household and commercial sectors. Moreover, many of the relevant barriers in the commercial sector (cash flow accounting and split incentives, high hurdle rates and low priority for energy projects, etc.) and household sector (high implicit discount rates, insufficient inclusion of energy benefits in house values, etc.) are ones which would be most effectively overcome through up-front rather than ongoing support. In these sectors, the structure of up-front support therefore is likely to be effective.

It may be particularly difficult to use up-front grants support to encourage the adoption of biomass heating. Biomass is likely to constitute a large proportion of any substantial expansion of renewable heat, and unlike many other renewable energy technologies for which grants have been used (especially solar, wind, and hydro microgeneration) its use entails a significant ongoing cost. If (as seems likely) the price of pellets, wood chips, or other relevant fuels were higher than the relevant fossil alternative, the up-front support would have to be significantly in excess of the net installation and equipment cost in order to make conversion to renewable heat technologies financially attractive. Even with high levels of initial subsidy, consumers may be unwilling to commit to a technology with higher ongoing costs. The likely future prices and availability of biomass are highly uncertain, and it is therefore difficult to gauge the significance of this barrier. Moreover, providing excess support for equipment without any requirement to use the equipment would be at risk of leading to abuse.

Uptake also depends on other factors that influence technology diffusion, including the trust in new technologies and public and professional awareness about renewable heat technologies. A grants programme is largely "passive" in this regard, and would not necessarily include provisions to address some of the barriers associated with lack of trust and awareness. It may be possible to supplement such a programme with marketing and other activities, and a very large-scale programme may be more visible. There is a parallel in this regard to the approach taken for household energy efficiency. The EEC / CERT operates in large part as an investment support programme, with grants and other support offered by energy suppliers. One of the motivations for this arrangement is not only that suppliers have the ability to comply using whatever arrangement they find most effective (whether through grants, loans or otherwise), but also that the information they have about consumers (e.g., about demographics or energy consumption patterns) as well as their pre-existing relationship may make them better able to ensure the uptake of measures.

Effectiveness may be reduced by the inability of ensuring long-term support. Grants programmes often are time limited by design or institutional necessity (notably, budget periods). This has been a concern with past and current grants schemes, including in the transition from the Clear Skies programme to the LCBP. Where support is offered up-front the risk of discontinuation of support need not adversely affect uptake by producers or consumers. However, it is likely to be detrimental to overcoming supply-side barriers to the large-scale deployment of renewable heat. In particular, the development of the supply chain – including the cultivation of crops and handling facilities for biomass, the training of installers for a range of technologies, the development of certification, etc. – will require investment by a range of private sector parties in the anticipation of future increases in demand that would allow the recuperation of initial outlays. The uncertain renewal of grants schemes may be a significant obstacle to such investment.[15]

The use of auctioning would raise additional questions for effectiveness. One problem with the Non-Fossil Fuel Obligation (NFFO) was that only a small proportion of accepted and winning projects were in fact undertaken. The chief reason for this was that the approval and auction format provided winning tenderers with a (valuable) option to undertake a projects if future conditions proved favourable, but no obligation to deliver renewable electricity if conditions were less favourable. This mechanism in turn affected bidding, leading to a high proportion of bids for non-performing projects. While some of these issues were particular to the NFFO design, it is a general problem of this form of procurement that it is difficult to achieve a guarantee that pledged projects will materialise, thus undermining effectiveness. The overall impact of these considerations on effectiveness would depend also on what proportion of support channelled through a grants programme were offered through a tendering process. In the case of renewable heat this may be relatively small, as only large-scale projects would likely find it feasible to undertake the necessary administrative effort, and much of the potential for renewable heat is likely to be at a smaller scale.

6.1.2.3. Cost-effectiveness of heat measures undertaken

We would expect a renewable heat target to be achieved at the lowest cost when consistent marginal incentives are available for all methods of generating heat. This would be difficult to achieve through a grant scheme that awarded funding per unit capacity, as there is no guarantee that similar capacity investments would result in similar renewable heat production counting towards the ultimate renewable energy target. One way to improve cost-effectiveness would be to vary the level of support offered by the expected lifetime heat output from different projects; for example, grants could vary not only by technology and capacity, but also if there were reason to believe that load factors or efficiency would differ. In effect, the likely output from a project would be “deemed” up-front, and more support would be awarded to projects with higher likely output (we discuss deeming in more detail below). This approach would not be without difficulties, however. The administrative burden to demonstrate expected heat output could be significant, with high costs and a deterrent effect on uptake. It is unclear how good an estimate of lifetime output could be achieved at acceptable levels of administrative cost and complexity, particularly in heterogeneous sectors where equipment load profiles may vary significantly (this may be particularly relevant in industry). Moreover, there is significant uncertainty about the true cost (including hidden and missing cost) of different renewable heat technologies, making such targeting or differentiation difficult.

This is an illustration of the general problem of ensuring the cost-effective production of heat with instruments where the level of support received is decoupled from the level of output. The capital investment undertaken may not be that which would lead to the highest level of

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[15] The German subsidy scheme for solar panels offers an example of similar difficulties. Nast et al. (2007) report that: “the subsidy rate for solar systems was suddenly cut in 2001 as a result of budget shortages. [Five years later t]he market for solar collectors has not yet completely recovered from the resulting 40% drop in sales.”

renewable heat delivered. Also, the subsidy of capacity may lead to over-investment. In both cases, the cost effectiveness for each unit of output therefore also may be lower.[16]

The magnitude of impact of these factors on cost-effectiveness is difficult to gauge. Concerns about cost-effectiveness may be particularly high where ongoing or variable costs are significant (notably for biomass and possibly for heat pumps) and there is therefore a risk of reversion to the use of fossil fuels. It also is likely to differ depending on the scale of projects. In larger installations in the industrial, commercial, and public sectors, metering may be feasible and policy instruments that reward output rather than investment therefore may perform better. For smaller heat loads in the household and SME sectors, however, metering may be prohibitively expensive anyway, and it is not clear that grants would incur a significant cost-effectiveness disadvantage relative to other approaches relying on “deemed” savings. We discuss these issues further in section 7.1.5.

As noted above, there is little experience with a grants programme on the scale that would be required to achieve renewable heat targets. The associated administrative costs therefore also are very uncertain, but they are likely to be substantial. Direct administrative costs associated with the policy approach include the time costs to prospective project developers finding out about scheme rules and completing the application process, as well as the cost to the scheme administration of appraisal of eligibility, project selection, and administration of funds. Experience suggests that complex rules or requirements on applicants can have a significant negative impact on take-up.[17]

However, it is unclear that these administrative costs – although likely to be substantial – can be escaped in any policy that relies on the appraisal of individual projects. They are likely to attach to systems such as feed-in support or and tradable quotas as well, depending on their design. One way to reduce administrative cost could be to involve a system of intermediaries acting on behalf of project developers, especially where projects are small in the SME and household sectors. We discuss this in more detail in sections of Chapter 7.

The use of auctioning for large-scale projects could increase cost-effectiveness. A grants programme will need to ration support in some way, whether on a first-come, first served basis, through administrative requirements, or through some other principle. Auctioning could provide a more efficient method for rationing scarce grant funding, by identifying and offering support to the least-cost projects. This would depend on achieving an efficient auction design with a close correspondence of bids to the actual marginal cost of projects.[18]

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16 This has led to problems for such schemes in the case of renewable electricity, where it has been difficult to ensure that wind farms and other renewable generation technologies were sited and designed to maximise the output per unit subsidy. The difficulties of the early Californian support systems for windpower often are cited as an example of this problem.

17 For example, the introduction of the requirement that applicants apply for planning permission prior to making an application for the LCBP may have been an important contributing factor to the drop in applications following the suspension and re-launch of the programme in 2007

18 The efficiency of the auction is a function of its ability to ensure that the most cost-effective projects receive funding. This is not the same as the ability to reduce inframarginal rents through price discrimination. It has been argued that the use of procurement auctions has the potential to reduce such rents by paying projects only the amount that they bid. In fact, there is some doubt that a “pay as bid” auction would in fact reduce such rents, because bidders would be expected to adjust their bids to match that of the most expensive winning bid—rather than simply bidding their own marginal cost. Such bid behaviour would not necessarily affect the *efficiency* of the auction, however.

6.1.2.3.1. Dynamic cost-effectiveness

Despite the difficulties of relying solely on grants, grants schemes have several attractive features, especially their potential to overcome barriers by providing up-front payments. Even if it were concluded they were not suitable as the main instrument to promote renewable heat, they may play a role alongside other financial instruments, or in particular segments of the market.

Grants may be used to contribute to the development of technologies that currently are not cost-effective or mature. As noted, the cost-effective deployment of currently least-cost technologies typically depends on the provision of consistent and technology-neutral incentives across technologies. On the other hand – as illustrated in recent discussions about "banding" and other reforms to the Renewables Obligation – this can give rise to a tension with ***dynamic*** cost-effectiveness, which may depend on supporting the development of currently immature technologies or supply chains. To the extent this can be achieved through policy intervention, it may require more targeted support.

One role of grants therefore may be to support technologies that currently are unlikely to be taken up, in the expectation that adoption would lead to lower costs. The relevance of this for the 2020 renewable heat targets is difficult to assess, however. For one, it is not clear that the renewable heat technologies that are likely to be used to satisfy the target would be accurately characterised as new technologies in need of additional research. Rather, many of them are mature technologies whose current costs do not compare favourably with more conventional forms of heat. In addition, reduced manufacturing costs are likely to depend primarily on world-wide growth in technologies, and may not be influenced much by UK policy. On the other hand, as noted in section 2.4.1, the cost of installation and of developing local supply chains could be affected by the UK policy environment. Such benefits would have to be balanced against the risk that attempts to "pick winners" results in costly support for technologies that fail to develop into cost-effective and mature methods to produce renewable heat.

Another potential for grants could be to overcome particular barriers that may be identified. For example, they may take some risk out of capital investment in situations where supply chains for biomass or other inputs are not yet established and reliable. This use of grants has precedents in other countries; for example, Sweden has used a combined regime of energy taxation and highly specific grants for conversion from direct-fired electric heating, as well as the use of ground-source heat pumps and other measures.

If grants are to be used alongside other instruments it would be important to consider how compatible they are likely to be. For example, it is likely that a CERT-type system of certificates for deemed output (especially if combined with lifetime crediting) and a grant programme may be overlapping rather than complementary. On the other hand, grants may be a good complement to instruments which primarily affect the relative cost of renewable heat and fossil technologies, including the instruments discussed in the previous section.

6.1.2.4. Impact on CO_2 emissions

The CO_2 impact of a grants scheme would depend on the amount of renewable heat that could be deployed through this mechanism. As noted, there is little experience on which to judge this, although as discussed in the previous section, there is some reason to believe that grants alone may not be as effective as other policies or in combination with other policies.

Like all instruments whose primary objective is to promote renewable heat, there is a potential tension between maximising renewable heat delivery and promoting CO_2 reductions. It would be possible to increase the level of CO_2 reductions by varying the level and eligibility for grants, depending on the expected CO_2 savings of a policy. However, it would be necessary to analyse to what extent this would conflict with the effectiveness of the programme. The significance of this issue is difficult to judge without modelling the CO_2 benefits of measures promoted by grants relative to those implemented under other policies.

6.1.2.5. Distributional impact

The distributional impacts of a grants programme ultimately would depend largely on the source of funding, which we have not considered here. At a high level, grants would constitute a net transfer of funds to energy market participants—including consumers and producers. It is difficult to assess the implications of such a policy in more detail without specifying the source of grant funding, however.

For example, patterns of uptake may affect groups differently. This has been a concern in the case of the EEC/CERT, where measures often entail a net benefit (in the form of greater comfort and lower future energy expenditure) to recipients of measures, but impose costs on energy suppliers that must be recouped from other customers. If energy suppliers were made to provide the funds for a grant scheme, this could have implications for those in fuel poverty source.

The distributional impact also would depend on the extent of infra-marginal rents resulting from the grants scheme. This relates in part to the ***additionality*** of the projects undertaken, i.e., to what extent grants are paid to projects that would have been undertaken without support—or at a lower level of support.[19] Any grants scheme aiming to achieve high uptake would likely have to offer levels of support that would exceed the cost of many projects, resulting in a net transfer beyond the resource cost of the renewable heat used.

The use of auctioning potentially could reduce rents for projects that are of sufficient size to be amenable to this method of project selection. If bidders are offered support "as bid", and if there is a correspondence between bids and actual marginal cost, then the rents could be significantly reduced compared to a situation where all projects were paid the same. However, as noted above, there is some doubt as to whether there would be a correspondence between bids and actual marginal cost, and there may be only a small proportion of potential renewable heat projects that would be of sufficient size to participate in tendering.

As we discuss below, the issue of providing support in excess of costs for some projects is not specific to grants. It is a general consequence of standardised support levels, and may not be any more of a concern for grants than for other instruments. One the one hand, grants may

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19 Some data indicate that there is renewable heat potential that currently is cost-effective compared to *current* heat generation. For example, the recent Call for Evidence (BERR, 2008b) indicates that several measures entailing conversion from electric heating to renewable heat may be cost-effective. However, it also is not clear to what extent such estimates account for full installation cost or hidden and missing costs.

be more amenable than some instruments to the differentiation of support. On the other hand, the problem of asymmetric (and incomplete) information about the costs of projects may be more substantial where support is offered not through energy market participants but through a central government agency.

6.1.2.6. Impact on other policy goals

We have identified no major impacts of grants on other policy objectives.

7. Renewable Heat Obligation with Tradable Certificates

The next three chapters consider renewable heat support policies that provide direct incentives for renewable heat output. These policies differ from those discussed above because they focus more directly on the actual renewable heat delivered, rather than on providing support for renewable heat *capacity* or on discouraging the use of non-renewable fuels. Policies providing direct support to renewables output have been used in many countries in the electricity sector, and Box 7.1 outlines some of their key features.

Box 7.1
Support Mechanisms for Renewable Electricity

A range of different mechanisms exist to provide per-unit support to renewable electricity, through one of three main mechanisms:[20]

- **Price instruments: feed-in tariffs** (FITs), which offer a pre-determined subsidy for each unit of electricity produced from eligible renewable generation. Such schemes typically are based on a *purchase obligation* on electricity suppliers to accept any electricity offered from registered renewable sources at a premium price. Feed-in tariffs currently are in use in several EU Member States, including Denmark, France, Germany, Ireland, and Spain.
- **Quantity instruments: tradable green certificate** (TGC) schemes are the main alternative approach to FITs. TGC schemes create a new market, in which demand is driven by an obligation on some party to hold and surrender certificates, and supply driven by the possibility of receiving a TGC in exchange for a unit of eligible renewable electricity. By making certificates tradable, the "renewable" attribute of electricity thus can be bought and sold separately from the underlying electricity, and the financial support to renewable generation thus varies with the market clearing price. EU Member States with TGC schemes include Belgium, Italy, Sweden, and the UK Renewables Obligation bears many features of a TGC scheme.
- **"Hybrid" instruments:** TGC schemes and other quantity instruments can be formulated to incorporate features of price-based instruments. TGC schemes can impose a price ceiling in the form of a commitment by the regulator to sell an unlimited number of certificates at a pre-specified price (a "buy-out"). In the Renewables Obligation, the buy-out is complemented by a "smear-back" that allows the price received by suppliers of certificates to fluctuate in response to scarcity and distance to target. Auctions, too, can be given "hybrid" elements, notably by not accepting bids above a price ceiling. In this way, the quantity supplied as well as the level of support is endogenously determined in the auction.

This chapter considers options for a tradable certificate scheme for renewable heat in the form of a "renewable heat obligation" ("RHO"). This would be similar in overall structure to tradable green certificate schemes that are in use in various countries to support electricity, as well as the UK's own Renewables Obligation (RO) for electricity and the UK's Renewable Transport Fuel Obligation (RTFO) for transport fuels.[21] The remainder of the chapter discusses basic design options for an RHO, and then evaluates the policy according to the

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[20] In addition to these mechanisms, there are other instruments used in some jurisdictions. Price support sometimes is offered through a production tax credit, an approach primarily used in the US. Auctioning or tendering procedures also have been used as an alternative to the certificate-based or feed-in approaches, with the Non-Fossil Fuel Obligation an example of this approach. Renewable electricity also has been supported by a range of other policies, including auctions for capacity rather than electricity delivered; support for demonstration projects; funding of research and development; favourable grid access; and subsidised or guaranteed loans.

[21] Both the RO and RTFO are quantity instruments that incorporate a "buy-out" option, which modifies the functioning of each scheme. We postpone discussion of buy-out and other "hybrid" provisions to Chapter 9.

evaluation criteria. (More detailed discussion of policy design and how such a scheme would work in practice are the focus of Chapter 11.)

7.1. Description and design options

We discuss below the following design parameters:

- sources of funding and allocation of obligations;
- defining qualifying activities;
- denomination of targets;
- differentiation of support;
- monitoring, reporting, and verification;
- certification and enforcement; and
- additional market design options

In addition to these high-level parameters, it is likely that the design and functioning of an RHO would need to account for detailed considerations arising in different market segments. This seems particularly important for two design parameters – the monitoring of heat output, and the detailed institutional arrangements for crediting and accounting of certificates. We defer consideration of these to the more detailed discussion of policy design in Chapter 11

7.1.1. Sources of funding and allocation of obligations

TGC schemes in the electricity sector have imposed certificate obligations on parties at different points in the supply chain, including end-users (Sweden), retail suppliers (the Renewables Obligation), distribution companies (Germany), and grid operators (Italy).

The supply chain for heat in the UK differs in important ways from the supply of electricity. As noted in section 2.1.2, the heat market consists of a combination of fuel and electricity suppliers and heat infrastructure and service providers. An important consideration for an RHO is that the obligation to purchase certificates falls on a party of sufficient size to handle administrative and cash-flow requirements, and which also is able to recoup the cost of purchasing certificates. In practice, it seems likely that the parties most able to meet these criteria in the UK heat market would be the suppliers of fuel and electricity currently used for heating. This would include gas and electricity suppliers, and could be extended to suppliers of non net-bound fuels including coal, heating oil, and liquid petroleum gas.

7.1.2. Defining qualifying projects

The policy design needs to define which activities and projects would be eligible to receive RHO certificates, either in advance or through a process of certification. This aspect of policy design includes specifying the technologies, sectors, size and commissioning dates of projects or equipment that will be recognised by the policy. Various other issues are likely to arise as well. For example, there may be concern that providing support to existing sources of renewable heat could give rise to so-called “windfall gains” to such facilities. Conversely, it may be necessary to consider transition arrangements to “grandfather” support for any facilities that have been constructed on the expectation of previous support that would be discontinued following the introduction of the RHO. These considerations may not be a major administrative issue in the case of renewable heat as there has been little ongoing previous support.[22]

It also would be necessary to consider whether there should be a time limit for the support received. The rationale for such provisions (which are a feature of several TGC schemes for electricity) is that it may prevent undue windfall gains. This concern may be particularly relevant for technologies with high up-front but low subsequent variable costs (e.g., solar power). However, it is likely to have drawbacks when some of the eligible technologies have a significant variable cost component, and especially if this cost may be higher than the cost of reverting to the use of fossil fuel.

In the case of renewable heat, variable cost is a significant proportion of long-term marginal cost for a number of technologies that are likely to constitute a significant proportion of the potential for renewable heat (including biomass and heat pump technologies). Especially where fossil fuel-fired heating systems have been retained (for backup or otherwise), or if the renewable heat equipment could be used with fossil fuels (e.g., use of solid fuels other than biomass in boilers), this may cause reversion from renewables to fossil fuel heat upon cessation of certificate eligibility. Even if the support period exceeded the payback period, time limitations thus may have adverse consequences for the attainment of the policy goal.

7.1.3. Denomination and time profile of targets

7.1.3.1. Denomination of targets

The main contenders for the denomination of an RHO scheme would be energy or CO_2 emissions. There are precedents for using an emissions-based denomination in TGC schemes; for example, the Wallonian tradable green certificate scheme for electricity denominates certificates in terms of CO_2, while the CERT is an example of a “white” certificate scheme for energy efficiency denominated in CO_2 terms. In the case of electricity the difference anyway may be largely one of accounting rather than substance, as the relevant medium- to long-term counterfactual supply (long-to medium-term marginal electricity generation technologies) is the same for all renewable generation technologies.

For heat markets, by contrast, there could be substantial difference between an energy and CO_2 denomination. As noted in section 2.1.1, the emissions characteristics of existing heat supply differ widely, and the financial support offered for their replacement by renewable heat therefore also would differ substantially. The choice of denomination therefore could be of importance, and would depend on the balance of aims of the scheme.

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22 It would be necessary to consider how an RHO would interact with existing policies, notably the CERT and any continuing grants programmes. The most likely solution to the potential problem of “double crediting” would be to remove renewable heat projects from CERT and grants coverage and use the new certificate scheme as the main mechanism for the promotion of these technologies.

7.1.3.2. Time profile of overall target

Setting the overall target for a quantity-based RHO would depend on forming a view on total heat demand as well as the potential for heat supply and the associated cost. As discussed, current data fit for this purpose appear to be very uncertain. Targets also can be expressed in relative or absolute terms, and the implied stringency may differ to the extent total heat demand was uncertain.

Most existing tradable certificate schemes have aimed to provide potential investors and operators with some certainty of continued support by positing a final target at a future date. Common practice is then to define in advance the step-wise increments to the quota that are necessary to reach this level, effectively defining a trajectory for the overall target. This may be particularly important for a successful RHO, as long-term surety of support would likely be necessary for the development of UK supply chains for renewable heat technologies and fuels. Also, the lifetime of many renewable heat investments is likely to span long time periods of 15-20 years, which further adds to the importance of long-term commitment.

7.1.4. Differentiation of support

An RHO offers some possibility to vary the level of support by technology, which would have two main motivations. First, there may be a desire to ensure that technologies that currently are not cost-effective nonetheless are deployed. The motivation would be that they contributed to technological and supply chain development, similar to the motivation for "targeted" grants discussed in section 6.1.2.3. One justification for such a policy could be to promote longer-term cost-effectiveness by encouraging innovation and development, even if this occurred at the expense of higher costs or lower deployment in the nearer term.

The second main motivation for differentiation of support would be to avoid a large transfer of wealth from consumers to suppliers of relatively low cost renewable heat technologies. Such a transfer would occur if all renewable heat production received the same level of support, even though some sources of renewable heat were much less expensive than other sources that were also required to meet the targets. In this case, certificate prices would rise to the level required to support the relatively expensive renewable heat sources, leading to substantial "infra-marginal rents" for the inexpensive sources. Available evidence suggests that the cost of renewable heat is highly variable across technologies, sectors, customer segments, and existing heat sources, and the issue of infra-marginal rents therefore appears, ***a priori***, to be a relevant concern. If the level of support provided to inexpensive sources of renewable heat differed from that offered to more expensive source, it could alleviate some of this concern.

Differentiating support with in an RHO scheme is complicated by the fact that the price level of certificates – and therefore the level of support per MWh – is not politically determined by emerges in the certificate market. Nonetheless, it is possible to control the ***relative*** support of different projects by offering different number of certificates per MWh to different technologies. This is the basis for the "banding" arrangements under development in the Renewables Obligation.

At the same time, banding has potential drawbacks in the context of renewable heat. There is considerable uncertainty about costs and potential for different classes of projects and thus limited information on which bands and degrees of differentiation could be determined.[23] It also is not clear to what extent the cost differences between projects can be usefully segmented into categories. There is some reason to believe that cost differences may be just as great *within* technology categories as they are between categories—and in some cases the differences within technology categories may be greater, because of the importance of the cost of the fuel or energy source that would otherwise be used to provide heat. If the variations in level of support do not reflect the actual cost differences between different categories, there is a risk of providing differing levels of support for projects with similar cost. This would risk exacerbating concerns about infra-marginal rents, and is likely to reduce the overall cost-effectiveness of the policy. The significance of these risks is an empirical question which this project has not sought to address. In general, however, the risk of compromising cost-effectiveness is greater if the certificate price uncertain, as this would make attempts to provide different levels of support through banding more imprecise.

7.1.5. Heat monitoring, reporting and verification

Ensuring compliance requires monitoring, reporting, and verification (MRV) protocols and associated certification processes for renewable heat output. In contrast to electricity, heat output typically is not metered (outside some district heating schemes and in some larger commercial and industrial settings). This poses a challenge for the RHO approach, as sufficiently reliable monitoring is required for certification and issuance of certificates.

There are three main approaches that may be taken to heat monitoring: direct heat metering, metering of inputs (e.g. biomass or electricity use), and "deeming" of outputs from projects without direct measurement of either inputs or outputs but through estimation of easily observable equipment characteristics (e.g., equipment capacity). It is likely that different approaches to metering would be required for different heat market segments and technologies. The main considerations are how the costs of metering equipment compare to overall project costs, and at what frequency metering data (whether input or output) could be reported without incurring undue administrative cost. For small heat loads, in particular, it seems likely that cost constraints would mean that deeming (which requires much less information) would be preferable. The drawback is that deeming is less precise, which could undermine cost-effectiveness and potentially lead to abuse of the system.

In addition to tailoring monitoring to the size and other characteristics of different heat market segments, it also may be desirable to make reporting and other administrative requirements light-touch. Many renewable heat projects would be very small and could be rendered unattractive if administrative requirements were too onerous. At the same time, large projects (such as industrial biomass CHP, large biomass boilers, or community heating projects), may be able to bear the cost burden of greater safeguards to ensure that accurate data are generated and supplied for MRV purposes.

A precedent for the use of "deeming" is found in the Australian Mandatory Renewable Energy Target (MRET) policy, which is a tradable green certificates scheme and the main support mechanism for renewable energy in Australia. The MRET combines support for

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23 By contrast, differentiation in the RO was introduced after the policy had been in place for several years, and also benefited from information gained through experience with the Non-Fossil Fuel Obligation.

large-scale electricity generation and small-scale projects on the household level witin a single system. In addition to the use of deeming, it includes various other administrative arrangements intended to allow for the effective participation of small producers. We describe the provisions in the MRET in more detail in Box 7.2.

Box 7.2
Administrative arrangements in the Australian MRET program

The Australian MRET is a tradable certificate scheme that includes most forms of grid-connected electricity generation from renewables, as well as microgeneration of electricity and small renewable heat installations. The administrative arrangements under the MRET include provisions aiming to allow the effective participation of "small generation units" (SGUs) for small-scale electricity generation as well as solar heating in the household sector. Although ownership of certificates rests with the owner of the relevant equipment, the typical arrangement for SGUs and solar heat is that a "Representative Agent" (typically, the equipment installer) takes on the right to the certificates in return for an inducement payable to the consumer (typically, an equipment discount). Representative Agents then also undertake the administration associated with scheme participation, including monitoring, reporting, and verification activities as well as certificate trading. The MRET also takes a "deeming" approach to the measurement of output from SGUs and solar heat, estimating output up-front rather than through ongoing metering and avoiding administrative effort and cost associated with ongoing monitoring and reporting. (A reporting requirement applies if Agents hold certificates corresponding to electricity or heat output of 250 MWh or more.) These arrangements are combined with up-front crediting, providing certificates for up to 15 years up-front, depending on the size and type of technology.

Data from the Australian Office of the Renewable Energy Regulator indicate that at around 45 registered agents are active in this market (ORER, 2008). In addition to taking on the right to the stream of certificates from deemed projects, Registered Agents also purchase certificates and act as intermediaries between small producers of certificates and the larger energy companies that have obligations under the MRET. These arrangements (alongside favourable project economics) appear to have been successful in encouraging the use of solar heat. By the end of 2006, certificates corresponding to 3.6 TWh, or one-fifth of total RECs, had been created from 137,000 deemed projects, of which 133,000 were solar water heaters accounting for 3.5 TWh (ORER, 2006).

The MRET system has significant similarity with the arrangements under the CERT. Like in the MRET, CERT credits future emissions reductions up-front, although the CERT crediting period spans the full lifetime of the measure and often is significantly longer than the periods in MRET. One difference is that the CERT has no formal certificate system. Instead, the energy suppliers on whom obligations are imposed contract with a large range of different "third parties who in turn carry out installation, marketing, and other aspects of measures. Suppliers' demonstrate their compliance through the documentation trail created through this "vertical trading".[24]

7.1.6. Administration, certification and enforcement

7.1.6.1. Certification and timing of support

If deeming were used for a significant share of projects to be supported by the RHO, this would give rise to important questions about the timing of certificate awards. Unlike output or input metering, deeming is an *ex ante* methodology, and it would be possible to award certificates *before* the heat is actually generated. In addition to imposing lighter administrative requirements, therefore, deeming also makes it possible to provide up-front support to capital intensive projects, thus reducing the risk of investing in them. This approach is taken for small-scale projects in the Australian MRET policy (see Box 7.2)

Whether it would be desirable to provide up-front support is a key design question, and one that requires careful analysis prior to the implementation of an RHO scheme. A key rationale of up-front crediting would be to enable consumers to switch to renewable heat technologies without incurring large additional up-front costs relative to conventional heating technologies. The predominance in the heat market of decentralised heat production at the point of use means that relative to the electricity sector, there may be fewer opportunities for projects financed by investors willing to commit to large up-front costs in return for future revenues from certificates. Many prospective renewable heat consumers are likely to be the producers of their own heat, and may be unwilling to incur large up-front costs in hope of receiving future government support. It is not clear to what extent existing equipment or fuel suppliers would be willing to take such risks. Such arrangements would represent a significant departure from current contractual arrangements for the supply of heating equipment and fuels.

Depending on the role of different market participants (fossil fuel suppliers, renewable heat equipment suppliers, and heat consumers) an RHO may make it necessary for parties who do not normally engage in investment appraisals under uncertainty to undertake such appraisals. Up-front crediting could help overcome some of these problems, and reduce the risk that future certificate revenue would fall short of the additional cost of renewable heat. Analysing these issues further would be an important area for further investigation. A general observation is that different crediting arrangements may be required for different sectors and sizes of heat projects, depending on their appetite for and ability to cope with different levels of risk.

It also may be necessary to vary crediting arrangements by technology. A potential problem with awarding certificates corresponding to the deemed lifetime output of a project up-front is that there may be a risk that technologies are not used as intended. This is particularly relevant in the case of biomass, where there is an ongoing cost over and above that of fossil technologies. There could be a risk that consumers make use of up-front support for capital equipment for biomass use, subsequently do not use it, or use it to burn fossil fuels. We have

[24] See NERA (2006) for a discussion.

not investigated how significant a risk this may be, but it would require careful consideration. One potential solution could be that certain technologies would receive certificates up-front for their entire lifetime output, whereas others would receive a fraction of this amount, related to the expected relationship of fixed capital expenditure to variable costs of heat production.

7.1.6.2. Compliance periods and enforcement

It also requires monitoring of the certificate accounts of obligated parties, who must meet their individual targets for certificates. Oversight of these provisions requires suitable authority vested in a scheme regulator. In the case of schemes for renewable electricity it is common for the electricity market regulator to also manage TGC schemes, but in some cases system operators have been given this authority. In the case of heat markets, there is no immediately analogous body. However, if obligations were imposed on fuel suppliers it may be possible to use similar regulatory powers (e.g., licensing provision for electricity and gas supply) as a basis for the legal framework.

In most existing green certificate schemes compliance is required on a yearly basis, although longer compliance periods have been used in some cases. Longer compliance periods can help mitigate fluctuations in the supply and demand for renewable heat (e.g., due to weather conditions) that may otherwise lead to a volatile certificate market. Conversely, however, longer compliance periods also may create uncertainty about total supply and make it harder to evaluate the efficiency and effectiveness of the scheme. (An alternative method to avoid volatility is to allow for banking and borrowing, as discussed below.)

Appropriate penalties are needed to ensure compliance by the obligated parties. The penalty can be specified as a fixed fee per certificate not obtained, or it may be linked to some multiple of (fixed or market-determined) certificate prices. It is useful to distinguish penalties that are designed to be dissuasive from "buy-out" or similar provisions in hybrid schemes (discussed in subsequent sections).

7.1.7. Additional market design options

In the absence of liquid derivatives markets, variations in certificate supply and demand could lead to significant price volatility. One way to reduce the price risk associated with such systems is to allow for some form of temporal flexibility in compliance. Many emissions trading schemes allow participants to "bank" allowances, making certificates or allowances generated in one year valid for compliance also in subsequent years. This can help smooth out price fluctuations over time and avoid the development of price spikes. By reducing the risk premium attached to certificates/allowances, temporal flexibility has the potential to lower the overall costs of emissions trading or certificate schemes.

Many existing TGC schemes for electricity provide for some form of restricted banking. Restrictions include limited validity periods of certificates, discounting of the value of previous years' certificates for the purposes of compliance, or stipulations that a certain proportion of certificates surrendered for compliance must be generated within the relevant compliance year.

7.2. Evaluation

7.2.1. Feasibility

Overall, our preliminary conclusion is that the introduction of a tradable certificate scheme for renewable heat could be feasible. However, as the above discussion of design option highlights, there are many outstanding questions. A key proviso is that it is feasible to vary provisions to reflect the heterogeneity of the heat sector – with respect size of loads, characteristics (cost structure and otherwise) of technologies, use of inputs, etc. The actual provisions of the scheme would likely have to vary significantly between different market segments to reflect these differences, including key aspects of scheme operation such as metering / monitoring arrangements; administrative requirements and protocols for reporting and verification; or the time profile of crediting. For small projects and consumers, it is likely that the reporting associated with ongoing monitoring of individual sites would be too onerous. It also would be difficult for energy suppliers to be sure that they would have access to future credits (e.g., if ownership of premises changed). For these reasons, deeming and up-front crediting may be necessary. Arrangements also would have to be flexible enough to allow heat market participants to form contractual relationships to overcome barriers to the use of renewable heat. This includes issues such as allowing consumers to "sign over" the right to certificates to third parties, and possibilities for pre-contracting between parties with an obligation and various heat market participants.

A risk with an RHO scheme is that the arrangements necessary to achieve this flexibility would be complex. A complex scheme could deter uptake of renewable heat, and it also could take time to design and implement. The experience with the Renewables Obligation as well as TGC schemes in several other countries is that tradable certificate schemes often require an iterative procedure of evaluation and modification. This may be even more relevant to the heat sector, where the state of knowledge is considerably less developed than it is for electricity.

A key decision with a quantity-based approach is the setting of the overall target. Information about the potential and cost of renewable heat remains quite limited, as does information about heat demand within particular sectors. A large part of the uncertainty relates to the feasible development of supply infrastructure, industry knowledge, and public attitudes – all of which remain speculative. While further study of the heat sector may improve this, it seems likely that significantly improved information will become available only when renewable heat starts to be deployed on a larger scale. A tradable certificate scheme for heat therefore would face a dilemma between setting targets far in advance to provide certainty and encourage investment commitment, and revising targets periodically to allow for incorporation of new information – at the expense of providing firmer signals to investors.

A more detailed discussion of some of the practical arrangements that would likely be necessary under an RHO is found in Chapter 11.

7.2.2. Effectiveness

An attraction of quantity-based instruments is that they can offer more certainty than other policies about delivering a target amount of renewable heat. Provided provisions are enforced, the amount of heat produced is under direct government control, which provides a good fit with the current UK and EU commitments to increase the share of renewables in the energy mix. This prima facie appraisal needs to be treated with caution, however. There are several reasons why the effectiveness of an RHO may be lower than the above analysis suggests. In particular, if the cost were high, or even if there were a ***risk*** of high cost, it may not be acceptable or otherwise feasible to set stringent targets.

7.2.2.1. Coverage

The feasible target level, and therefore effectiveness of an RHO scheme, would depend in large part on whether it would be feasible to make a large proportion of heat consumers and potential heat projects eligible within the obligation. The discussion in section 7.1.5 highlights that the widest coverage could be achieved by differentiated approaches to MRV, as well as institutional arrangements to enable the participation of small projects, albeit at the price of increased complexity. The experience from the Australian MRET policy appears to be that many of the potential obstacles are surmountable, and that small-scale projects in the household sector can coexist with large-scale projects within a single certificate trading scheme (domestic solar water heaters account for 20 percent of the total certificates awarded under the MRET). Nonetheless, further study of this issue would be required for higher confidence in this conclusion—particularly given the differences between the economics of solar energy in Australia relative to the UK, as well as the scale of the target contemplated in the UK.

7.2.2.2. Uptake

The feasibility of committing to an ambitious overall target also would depend on the extent to which uptake of measures actually could be encouraged from the various covered heat segments. As noted previously, uptake by smaller heat projects is likely to be necessary to reach targets but also challenging to achieve. As outlined in Box 7.2, he Australian MRET certificate trading scheme overcomes this in part by using a system of “Representative Agents”, to whom households sign over their right to certificates in exchange for various forms of inducements for the installation of heat or electricity generation technologies. This includes product rebates, up-front and delayed cash payments, and lower prices for purchased energy.[25] Similar arrangements exist in the EEC/CERT, where suppliers with obligations contract with “third parties” acting on their behalf to offer various structures of payment to final energy users. The most common type of inducement under the EEC has been up-front subsidy of capital measures such as cavity wall insulation, but there also have been innovative approaches such as offering council tax rebates in exchange for undertaking various energy efficiency measures.

The analogy with the EEC is limited by the fact that projects for renewable heat are significantly larger and more capital-intensive than energy efficiency measures (see section 2.2). If heat certificates were awarded only on an ongoing basis, rather than up-front to cover more of a measure’s lifetime, it would be necessary for a party in the certificate supply chain to undertake the financing cost in expectation of a future value stream from certificates. The absence of an up-front payment is likely to be a significant barrier for uptake by households.

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[25] See ORER (2008) and BP (2007)

However, it also may be beyond the financial capacity of renewable heat equipment installers to manage the cash-flow and financing cost of long repayment periods. If these parties were unwilling to bear the associated financial risks, energy suppliers or other obligated parties might be obliged to finance up-front payments in exchange for contracts to receive the future certificates generated with projects.[26] However, it is unclear that this would be consistent with a liquid third-party market in certificates.[27]

If this analysis is correct, it seems likely that scheme effectiveness would be encouraged by issuing certificates for deemed projects at least to some extent up-front, enabling third parties to access the value of certificates reasonably soon after incurring the expenses associated with incentives they would offer to households. Against this, distortions may arise by combining long, up-front crediting lifetimes for "deemed" heat output in a system that also includes continuous crediting for heat projects with input-based or direct metering of heat output. We return to this topic in Chapter 11.

7.2.3. Cost-effectiveness of heat measures undertaken

One of the principal motivations for an RHO would be to create a support system that offered the same subsidy per MWh across all sectors, technologies, and market segments. This should help identify the most cost-effective projects and thus help reach the overall target at least cost.

This theoretical attraction of an RHO may be limited in practice by several factors. First, where deeming is used there would be no guarantee that the actual support offered per MWh would be the same across projects. Support for deemed projects would function in a manner very similar to a grants programme, albeit one financed by energy suppliers or other obligated parties.

The significance of this for cost-effectiveness would depend both on whether the mismatch between up-front deemed output and actual realised output were large, and on what proportion of the total amount of support would be deemed. Unless direct metering were to be used in the household sector, it is likely that deemed projects would account for a significant proportion of total potential for renewable heat. Whether or not the loss in technical cost-effectiveness would be made up for by reduced MRV costs would need to be investigated in more detail.

Larger projects still could receive certificates based on direct monitoring of heat production, which would be more consistent with the advantages that attach to per-unit support. It is likely that the amount of discretion in the design of heating systems, and therefore efficiency gains of rewarding output rather than capacity, is greater for large projects. An analysis of

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[26] Another argument for deeming and up-front crediting goes as follows: The only reason not to give up-front certificate awards is that it may be important to check that long-lived equipment remains in-use via periodic inspections. But suppliers will find it difficult, costly, and inconvenient for customers to ensure that such inspections occur—particularly if a property changes hands. Suppliers need to be assured that they will receive the certificates associated with long-lived capital investments over the course of their working lives. If suppliers are required to make inspections or risk not receiving certificates, this reduces their incentive to invest in long-lived measures. This will reduce the effectiveness and cost-effectiveness of the policy. Therefore, on this line of reasoning, no periodic monitoring of very small measures should be required, in which case there is no longer any reason not to provide lifetime certificates up-front.

[27] For an analysis of similar issues in the context of the EEC, see NERA (2006).

the best arrangements in each market segment would be an important aspect of scheme design.

A second factor that could reduce the (short-term) cost-effectiveness of an RHO below the theoretical maximum is the use of differentiated support levels. As discussed above, motivations for differentiation may be reducing the long-term cost of emerging technologies or supply chains, or distributional considerations, as discussed. It is difficult to gauge what the cost-effectiveness implications of differentiation would be. The less information is available to policy-makers the poorer will be the alignment of marginal cost with "bands" of support; and the greater the risk that inconsistent incentives would undermine cost-effectiveness.

Third, the cost-effectiveness of an RHO may be reduced due to the uncertainty created by the tradable certificate approach. One general criticism of tradable certificate schemes is that future compensation of the use of renewables is uncertain. Compared to instruments that offer a guaranteed level of support, this can result in a higher cost of capital for investment (which reflects a risk premium demanded by investors). This may be a key issue in the choice between a quantity-based approach and one based on pre-determined price support. The issue may be particularly relevant in the heat sector, where small participants may conclude that evaluation of the risks associated with uncertain support is too much of a barrier to rely on certificates for support. We discuss this in greater detail in the evaluation of a fixed financial incentives for heat in Chapter 8.

7.2.4. Impact on CO_2 emissions

As with other policies, the impact on CO_2 emissions would depend chiefly on the amount of renewable heat resulting from the RHO. Without differentiation of support to account for CO_2 effects, the impact would reflect the CO_2 characteristics of renewable heat measures with the lowest cost, not the greatest impact on CO_2 emissions. There is no reason that the resulting emissions reductions would differ systematically from other renewable heat policies not explicitly differentiating between sectors, fuels, or other characteristics.

7.2.5. Distributional impact

Like other policies that rely on funding renewable heat through energy markets, the net distributional effects of an RHO would be to benefit suppliers and consumers of renewable heat and impose additional costs on producers and consumers of fossil fuels and electricity. There is a possibility that the pass-through of costs may differ depending on how obligations are denominated.

In theory, fuel suppliers would be expected to pass through the marginal cost of their obligation to consumers. If the obligation depended on the number of customers, the relevant marginal cost would be the additional obligation incurred when adding another customer. Pass-through therefore would optimally be done on a per-customer basis, similar to an additional fixed charge for all fuel customers. By contrast, if obligations were denominated in terms of the amount of heat delivered (probably using as a proxy the amount of fuel multiplied by a standard factor reflecting the aggregate contribution of that fuel to heat production), then the marginal cost would attach instead to each unit of energy supplied. Pass-through may then take the form of an additional cost per unit of energy, rather than as a fixed cost for all customers, and large consumers would shoulder more of the total cost than would smaller consumers. While these patterns would match suppliers' incentives in a framework of marginal cost pricing, actual supplier pricing strategies may vary from this.

The main distributional issue may be to what extent infra-marginal rents would arise under an undifferentiated system of support. This is difficult to gauge, but the key factors in an RHO system of tradable certificates would be:

- the relative cost of technologies (with higher rents with large differences in marginal cost);
- the relative contribution of higher- and lower-cost technologies to the overall target (with higher rents if low-cost technologies contributed a substantial proportion of certificates);
- the speed at which the supply chain of lower-cost options can be developed and costs of total installation (including technology cost) can be reduced; and
- the risk of high prices in the certificate market, whether because of ambitious targets relative to potential, temporary supply-side bottlenecks, high heat demand, or other causes of scarcity.

A quantitative assessment as well as the judgment of policy-makers would be necessary to determine whether these factors would be a sufficient concern in an RHO system of tradable certificates to warrant the introduction of differentiated support for policies.

A related distributional issue is the extent to which agents / suppliers may be able to price-discriminate between consumers. There is substantial price discrimination in the EEC, where the subsidy offered for measures differs markedly between the Priority Group and others. This reflects in part the higher value to suppliers of Priority Group energy savings and emissions reductions, but also is likely to reflect the different willingness to pay between the two groups. Price discrimination would be more feasible in a system of representative agents (e.g., installers) with more contact with heat consumers than in a system of centrally run grants. The infra-marginal rents from the policy therefore may also be smaller.

7.2.6. Other policy objectives

We have identified no significant impacts of an RHO on other policy objectives such as security of supply, competitiveness, energy market competition, or local pollution.

8. Renewable Heat Incentive with Fixed Support

As noted in the previous chapter, the main alternative to the tradable certificate approach to supporting renewables is an approach that offers a fixed level of financial incentive per unit of renewable energy output. In the electricity sector, such a support mechanism is often referred to as a "feed-in tariff". These typically work by requiring distribution network companies or other parties in the electricity sector to purchase any electricity offered from renewable sources and to do so at a premium price. The premium can either be a fixed premium above the wholesale electricity price, or a fixed total payment per unit of renewable electricity purchased.

The analogous policy in the context of heat would be a fixed payment for each unit of heat generated from eligible renewable sources. Such a support system is referred to a "renewable heat incentive" (RHI) in the Call for Evidence published by BERR in January 2008 and we follow this terminology here. An RHI would have to differ in important respects from feed-in tariffs as used in the electricity sector, because of differences between electricity and heat supply that have been discussed above. The most immediate difference is the absence of a market for traded heat into which a purchase obligation of the type underpinning electricity feed-in tariff systems could be introduced. Whereas all electricity production is metered and (in liberalised markets) sold by generators to another party, heat typically is generated directly by the consumer without being traded on any heat "market". Even where heat is directly traded – e.g., through community heating systems, or in some large-scale CHP off-take agreements – there is no analogy to the open-access transmission and distribution system for electricity.[28]

This means that the feed-in tariff model – where a unit of delivered electricity receives a premium payment directly from an intermediate party in the supply chain, such as a distribution company or energy supplier – cannot be directly applied to the heat sector. It nonetheless is possible to replicate the fixed-support nature of feed-in tariffs by providing a payment for each unit of renewable heat produced. In practice, this would require the maintenance of records that renewable heat had been produced. In many respects these records would resemble a system of ***certificates***. Suppliers, for example, would be obliged to pay a certain price upon being presented with a certificates showing that heat production had been undertaken using qualifying renewable technologies. The chief difference from an RHO is that the price of certificates would not be determined in a market but would be fixed by the scheme regulator. Meanwhile, the quantity of renewable heat (and therefore the number of certificates) certificates would not be determined by the government's target, but by how market participants responded to the fixed price incentive.

[28] Feed-in tariffs have been used to support microgeneration of *electricity* from renewables, notably in Germany. The support typically has been provided for sale of electricity back into the distribution grid. There is no analogy to this in the context of heat.

8.1. Design Options

Because per-unit incentives for renewable heat would need to rely on a system of records or certificates there are several policy design elements of an RHI that would be similar to that of an RHO. We discuss below the following design parameters:

- sources of funding and allocation of obligations;
- defining qualifying activities;
- denomination of targets;
- differentiation of support;
- monitoring, reporting and verification; and
- certification and enforcement.

8.1.1. Sources of funding and allocation of obligations

An RHI would impose an obligation on some party in the heat supply chain to pay an incentive payment for renewable heat upon production of evidence that it had been produced. Similar to what would be required under an RHO, the obligated organisations would need to be sufficiently large to be able to manage the associated administrative costs, and also would need to be able somehow to recoup the cost of providing the subsidy.

As with the RHO, one option would be an obligation on energy suppliers, but there also are other parties that could fulfil this role. One possibility would be to make electricity and gas distribution network operators (DNOs) responsible for the purchase of records of renewable heat production at a fixed price. A significant difference between obligations on suppliers and DNOs is that DNO prices are regulated. It therefore would be necessary to make explicit regulatory arrangements for the recovery of costs through network tariffs.

A complication with an RHI is that it would be necessary to make sure that the party responsible for buying certificates would be clearly identified to avoid confusion and disputes. It also would be necessary to ensure that the subsidies paid were split equitably between organisations, and ultimately between the end-users they serve.

One way to address these issues would be to set up a centralised and regulated purchasing agency financed through contributions from suppliers, DNOs, or other potential obligated parties. This would provide a central point of contact for all renewable heat producers to send their records of production, and also a system for splitting the overall burden (e.g., through a levy on suppliers). The details of these arrangements would require more study.

8.1.2. Defining qualifying activities

In common with other support mechanisms, it would be necessary to decide which renewable heat technologies should be eligible to receive support under an RHI. The principles discussed above would apply, including ensuring that only “additional” projects were eligible; that projects supported through other policies such as the CERT or grants programmes did not benefit from "double crediting"; and that projects supported through past policies continued to receive either grandfathered or equivalent support.

8.1.3. Denomination of targets and level of support

Like in an RHO, the denomination of the unit by which renewable heat qualified for support would influence the level of support received by different types of renewable heat projects (along with any differentiation of support, see below). The main contenders would be support per unit energy or support per unit CO_2 avoided, depending on the aims of the policy.

Unlike an RHO, an RHI could commit to an explicit level of support provided. Provided this commitment were seen as credible, this could provide greater certainty about future revenues from projects. There are several design options in this regard. One option is that the level of support either declines or ceases after some time, as is the case in some renewable electricity feed-in tariffs. The rationale for this typically is that projects are expected to be viable without explicit subsidy after some years. As discussed in the context of an RHO above, however, there is a risk that this would lead to discontinuation of renewables for heating, particularly where the technologies have higher ongoing costs than relevant fossil fuel-fired alternatives.

A difficulty with the fixed-price system implied by the RHI is that the quantity of renewable heat that will be delivered cannot be set in advance. As UK and EU renewables policy is based on quantity targets this poses a potential difficulty, and it would be necessary to consider how to handle potential discrepancies between realised output and politically determined target levels.

One way to respond to this would be to change the level of support in response to the amount of heat output realised (increase the payment if output is low, or increase it if output falls short of the desired level). However, such provisions are associated with several significant potential problems and would have to be done with care so as not to undermine investment incentives. If prices were revised upward it probably would be desirable to make the new level of payment available to *all* projects – including ones already undertaken. Otherwise, there would be considerable risk that investors would delay investment in the anticipation that higher payments would become available in the future.

Reducing payments could be still more problematic. In this case the opposite principle would apply: investment incentives would be best preserved by "grandfathering" support to existing projects, applying the new, lower payments only to projects announced after the revision. If there were a risk that regulators could "claw back" payments by reducing them after investment has been made investors would likely be unwilling to commit funds in the first place.

Revising payments clearly has disadvantages, but if it were thought necessary it would be important to spell out the rules for any future revisions in advance, so as to avoid the creation of uncertainty that would discourage or delay investment.

Another question is whether the payment should be fixed in absolute terms, or whether there should be attempts to vary it depending on the development of costs relative to fossil fuel alternatives to renewable heat. The motivation for such indexing (e.g., to prices of fossil fuels) would be to avoid too high (low) implied effective subsidy for renewable heat, relative to the relevant fossil fuel alternative, in the event that fossil fuel costs were to rise (fall). However, such arrangements are likely to be much more difficult in the case of heat than they would be for electricity. Unlike in electricity markets, where the corresponding arrangement is a "contract for differences" between the wholesale price and a fixed price level, there is no easily observed price or single counterfactual applicable to all heat technologies.

8.1.4. Differentiation of support

An RHI could be differentiated by regulatory decision to offer different prices for renewable heat from different technologies, sectors, counterfactual fuels, or other relevant segments of the heat markets. Compared to an RHO this would be relatively straightforward, as the absolute amount paid would be under direct regulatory control (whereas an RHO could control only the relative support received by different bands, as discussed). As with an RHO, the motivation for differentiation could be to support emerging technologies and / or reduce rents, but these benefits would have to be weighed against the risk of reduced cost-effectiveness resulting if bands were poorly aligned with actual costs.

8.1.5. Heat monitoring, reporting, and verification

Design options for monitoring, reporting and verification arrangements would be similar under an RHI to those of an RHO discussed above. In both types of scheme it would be necessary to rely on a system of certificates or other reporting framework, with attendant need to monitor heat output or some proxy for it. As in an RHO, an RHI would likely need to include a combination of different methods to monitor heat output, as well as different reporting protocols, to correspond to the size and other characteristics of heat projects and consumers.

8.1.6. Administration, certification and enforcement

The case for issuing certificates up-front rather than upon production of renewable heat may be greater under an RHI than under an RHO. As noted above, one motivation for up-front crediting of a significant portion of certificates would be to defray capital costs up-front. Under an RHO, the quota obligation to procure a given number of certificates could provide sufficient inducement to energy suppliers to provide up-front subsidies in the expectation of obtaining future revenue from certificates (although, as noted, the institutional arrangements necessary to achieve this may be difficult to achieve). Under an RHI, by contrast, energy suppliers would have no incentive to undertake this role, as their obligation would be limited to the purchase of renewable heat (or corresponding records of its production) offered to them. It therefore may be necessary to make greater use of up-front crediting that would enable other parties – such as equipment or fuel suppliers – to offer up-front subsidies without needing to take on extensive credit.

On the other hand, the greater certainty about the level of payment, relative to an RHO may mean that it would be possible for a greater number of parties to secure external finance through loans, using the prospective RHI certificate revenue as surety. Investigating the details and feasibility of such arrangements would be an important topic for consultation with stakeholders.

8.2. Evaluation

Many of the aspects of an RHI scheme would be analogous to that of a system of tradable quotas or certificates under an RHO. The evaluation below focuses on those aspects which are likely to differ in the two approaches.

8.2.1.1. Feasibility

Provided that an arrangement could be found for the division of responsibility to purchase RHI certificates, there is no apparent reason that a fixed-price system would be less feasible than the quota-based system of an RHO. The same issues of complexity would arise and there would be difficulties in determining the appropriate level of the price support, analogous to the setting of targets in a quota system.

Ernst & Young (2007b) argued that a quota system would have a better "cultural fit" with other policies and therefore may be more feasible than a fixed-price support mechanism. We are unsure that this is an important consideration. As noted, both an RHO and RHI would rely on certification procedures. They would differ chiefly in the nature of the obligation, and possibly in the contractual and institutional arrangements necessary to enable a wide range of heat market participants to make use of the subsidy. Short of actual linking of schemes, it is not clear that there is any inherent benefit to striving for the same design for instruments in widely differing parts of the energy markets.[29]

As with an RHO, a key issue is whether there would be barriers to the uptake of subsidies under an RHI, notably if administrative arrangements were complex, or if heat consumers were unwilling to incur initial expenses in the expectation of a separate future revenue stream from RHI certificates. Overcoming such barriers would likely depend on achieving the necessary combination of contractual and institutional arrangements, and on up-front crediting of certificates where necessary, as discussed.

8.2.1.2. Effectiveness

8.2.1.2.1. Uncertain quantity with fixed-price support

The effectiveness of an RHI (relative to an RHO) would depend foremost on the level of support offered, i.e., how the level of the payment compared to the prices under a certificate scheme. In the first instance, the different effectiveness of the two types of system would depend on knowledge about the amount of renewable heat that would be associated with a given level of payment. In practice, this is likely to be very uncertain.

Another consideration is that government would bear either the risk that the RHI payment is too low, and that targets therefore would not be met, or that too high a payment resulted in higher supply and therefore cost than desired (and / or in large infra-marginal rents). Given

[29] An additional consideration is the fit between an RHO or RHI with support mechanisms for microgeneration. There could be benefits to having a single mechanism across heat and electricity on a household level, both to reduce administrative complexity and to help achieve an efficient allocation of effort between the different types of renewables.

the uncertainty about costs of renewable heat, this could be a significant concern, particularly if the price of certificates were set far in advance. (As discussed, it also would be difficult to revise payment levels after the start of the policy without risking undermining confidence in the system.)

8.2.1.2.2. Relative effectiveness of quantity and fixed-price systems

In the case of renewable electricity it is a common observation that countries with fixed-price systems (notably, Denmark, Germany, and Spain) have achieved larger volumes of renewable electricity generation than have countries using tradable certificate systems. There is no general agreement on the extent to which this is attributable to the format of the support mechanism, or to what extent it is the result of other differences, notably in the level of subsidy, the length of the period for which support has been offered, the available renewable resource, the provision of support via additional mechanisms (notably, subsidised loans), differences in planning regimes, and different policies concerning grid connection.

Also, it is important to distinguish between pure and hybrid TGC schemes in this regard. Where there is extensive use of a buy-out provision a tradable certificates scheme may share as much in common with feed-in systems as they do with quantity-based regulation. In such situations, low levels of deployment may be more the result of a low buy-out level – corresponding to a low level of feed-in tariff – than of an inherent feature of regulation through tradable certificates. The implications of different systems for effectiveness therefore are far from clear.

8.2.1.3. Cost-effectiveness of heat measures undertaken

Another difference cited between feed-in tariffs and tradable certificate systems for electricity is that the uncertainty of certificate prices creates risks for investors that must be compensated through higher returns. This means that the opportunity cost of capital is higher under quantity-based policies, so that the overall cost of achieving a given policy target is higher. The magnitude of this potential effect depends on how significant a contributor certificate price uncertainty is compared to other sources of revenue uncertainty (notably, fuel prices). It also is likely to relate to factors other than just certificate price levels, including the level of political commitment to the continuation of a policy, the feasibility and likelihood of reaching the overall target, and the political acceptability of rents that may be created from the scheme. For example, if a fixed-price system were more likely to be revised mid-stream than a quota system, the gains from stipulating a fixed level of support may be eroded. Judging the potential additional cost of a quota system over a fixed-price certificate system in the heat sector therefore is difficult.

The process for investment appraisal for many projects in the heat sector also is likely to differ significantly from that of projects in renewable electricity generation. As discussed, although large heat projects may be subject to formal investment appraisal similar to that of large generation assets, with similar considerations arising, these may not account for the majority of the renewable heat delivered under new policies. The process for investment evaluation is likely to be different for smaller projects, in both the commercial and household sectors. Commercial-sector organisations often ration capital using high hurdle rates for investment. Moreover, decisions about heating equipment, which typically forms a very small part of overall expenditure, may not be regarded within a formal investment appraisal framework at all. The effect is likely to be even more pronounced within the household sector, where the various barriers discussed in section 2.4.2 may lead to high discount rates, or the use of "rules of thumb", or to a bias towards known technologies even where alternatives may appear more financially advantageous when viewed through the lens of formal investment appraisal.

It is unclear what impact fixed versus variable levels of support would have in this situation. In any case, it seems likely that a key challenge for both an RHO and an RHI would be to persuade heat users to incur higher initial costs associated with renewable heat by offering potential future revenue from certificates or associated incentive payments. It is possible that the benefits of fixed support become accentuated when "behavioural" barriers to investment decisions are taken into account.

8.2.1.4. Impact on CO_2 emissions

The impact on CO_2 emissions for a given level of renewable heat is not likely to differ under an RHI mechanism compared to an RHO. One theoretical possibility is that an RHI may lead to a different selection of heat projects by making technologies with a higher proportion of up-front costs more viable than they would be under an RHO with similar support levels (because the costs of capital were lower under an RHI). This could affect CO_2 emissions to the extent that it led to the displacement of conventional heating of a different CO_2 intensity.

8.2.1.5. Distributional impact

The distributional impact also is likely to be similar to that of an RHO system. Both systems would include the cost of renewable heat supply in the bills of energy consumers. The cost per MWh of renewable heat delivered would depend on some of the cost of capital considerations discussed above. If there were differentiation of support it is possible that it would be easier to tailor this precisely under an RHI, leading to a smaller transfer from energy consumers to renewable heat users than under an RHO. The other potential way in which a different distributional impact could arise would be if one policy cost substantially more than the other (for a given amount of renewable heat).

It is not clear that an obligation on DNOs would have significantly different distributional consequences from an obligation on suppliers. The cost of using distribution networks is paid by electricity and gas suppliers to the corresponding DNO, and suppliers in turn recover this cost through end-user charges. Under either arrangement, end-users thus would pay the subsidy to renewable heat projects through higher energy bills. Although the precise mechanism for recovery of distribution network charges may differ between suppliers and customer segments, there is no immediate reason to think that the outcome would be very different from that of a direct obligation on suppliers.

8.2.1.6. Other policy objectives

Fixed-price support of the sort implied by an RHI sometimes is characterised as inimical to the principles of liberalised energy markets. Absent concrete examples of potential distortions of competition or the efficient formation of prices, it is difficult to evaluate this charge. All intervention to promote renewable heat by necessity will alter competition in the market to supply heat, but it is not clear why fixing the level of subsidy would constitute a more significant intervention than fixing the quantity of heat to be displaced by renewable heat.

A possible distortion could arise if suppliers in competition with each other had different levels of obligation, with distortions of competition as a result.

9. "Hybrid" Renewable Heat Obligation

The above discussion makes clear that uncertainties about the cost and availability of renewable heat supply mean that any preference for either an RHO or an RHI is not clear-cut. In the case of an RHO there is a risk that costs will be very high for a given target. In the case of an RHI, on the other hand, there is a possibility that targets will not be met (if support is set too low), or may be overshot at high cost (if support is set too high).

Existing UK policies to support renewables – including the RO and the RTFO – address these issues using system with a buy-out provision that caps the total cost. In the language of the economics literature, such provisions constitute a "hybrid" approach between the regulation of quantities vs. regulation of prices.[30] The theoretical rationale for a hybrid approach is that it can provide a balance between the risk of not achieving targets and the risk of very high prices for certificates. Hybrid mechanisms may be preferred when there is uncertainty about the cost and feasibility of achieving a target level. As discussed, this uncertainty is significant in the case of renewable heat, where there is little previous policy experience of policy intervention, estimates of technology and installation costs vary significantly, the nature and cost implications of barriers are uncertain, and achieving targets depends on the feasibility of the development of new and policy-dependent supply chains. In this situation, reliance on pure quantity instruments is likely to be risky, while a price instrument may forfeit much of the potential benefits of stability if repeated revisions to the price support are required to achieve the right target level.

In this section we consider the implications of applying a hybrid design to the heat sector, in lieu of the "pure" RHO and RHI options analysed in the foregoing sections. We also consider the implications of a link to the Renewables Obligation, which (as noted) has a buy-out mechanism that would make any RHO linked to it into a hybrid instrument.

9.1. Description and Design Options

9.1.1. Price ceilings

The most common hybrid feature is a ceiling on certificate prices. This could consist of a commitment by the scheme regulator to sell an unlimited quantity of allowances at a pre-specified price. Buyers in private market transactions would have no reason to pay prices above this level, creating an effective price ceiling.

Hybrid mechanisms can be designed with different emphasis on the quantity or price aspects of the regulation. A price ceiling set at a "high" level will serve chiefly as a "safety valve", used only at times of particular scarcity and price spikes. In this case, the regulation will chiefly resemble a quantity instrument, with more certainty about the quantity of certificates produced than about the price. (As noted in section 7.1.7, another approach to avoiding price spikes is to include intertemporal flexibility such as banking in the design of the certificate market.)

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[30] In the sense of Roberts and Spence (1976) and Weitzman (1978)

Alternatively, if the price ceiling is set at a "low" level it will constitute a "buy-out", expected to be used for a significant proportion of compliance. This resembles a fixed-price regulation with support at the level of the buy-out price. Prices of certificates will be capped for all periods when the buy-out price is binding, and thus relatively predictable. On the other hand, the amount of renewable heat produced would be uncertain. There also is a danger that extensive use of a buy-out without some mechanism for returning funds to the heat / fuel market would undermine scheme acceptability (it may be viewed as a tax).

The Renewables Obligation addresses some of these concerns by returning funds to holders of certificates created through actual generation of eligible electricity. This creates another influence on prices, because ROC prices depend on the amount of renewable generation that is achieved. A benefit of this system is that more funds become available for generation projects if fewer projects are delivered, and that costs can be bounded while still relating prices to scarcity and "distance to target". The potential drawback is that it re-injects price uncertainty into the market.

9.1.2. Price floors

Although it is less common, it also is possible to set a price floor on certificates. This would primarily serve to complement a cautious approach to target-setting in a quantity instrument. The simplest arrangement would be analogous to the above price ceiling mechanism, with the government promising to buy an unlimited quantity of certificates at a pre-specified price. The fiscal implications of such a commitment may make it less attractive, especially in a large programme where costs could be high.

9.1.3. Price regulation through quantity adjustments

Some emissions trading programmes and certificate schemes incorporate other types of mechanisms to adjust quantities and avoid price volatility. For example, the Regional Greenhouse Gas Initiative cap-and-trade programme (in the Northeastern United States) features "trigger" mechanisms to increase the effective supply of allowances in the event of high prices. In a certificate programme, the corresponding mechanism would be to reduce quota obligations if the certificate price reach a particular level. Alternatively, adjustment mechanisms can be designed to prevent price collapse, such as the "headroom" arrangement in the RO, which works by increasing the quota target if there is a risk of ROC oversupply. Such market regulation requires careful design to reduce the risk of market manipulation.

The concerns that lead to the introduction of the "headroom" provision may be less applicable in the case of renewable heat. Renewable heat technologies differ from renewable electricity technologies in that variable cost tend to be a greater component of long-term marginal cost for renewable heat. The risk of a price collapse of the type that has been discussed in the context of the RO therefore is smaller, as prices would not be expected to drop lower than the short-term marginal cost.

9.1.4. Link to the Renewables Obligation

9.1.4.1. Options for linking

A link to the RO could be arranged in several different ways. The most extensive form of linking would be to make RO certificates (ROCs) and RHO certificates (RHOCs) fully fungible, so that certificates generated from one type of renewable energy would qualify for the obligations in the other scheme. This would lead to a single price for certificates, and thus the same level of support per qualifying unit of energy output. In this scenario, there would likely be benefits to consolidating all support for renewable heat and electricity in a single system, including for the definition of obligations on energy suppliers, scheme administration, and compliance periods.

However, there are several reasons why a system providing the same payment per unit renewable electricity and renewable heat may not be desirable. As we discuss below, this could reflect different policy objectives or priorities for the electricity and heat sectors, or differences in pre-existing support that arise because of features of the pre-existing policy mix. An alternative approach would be to maintain the distinction between ROCs and RHOCs in one or more ways. For example, an "exchange rate" could be applied (so that one ROCs would be equivalent to either a greater or smaller number of RHOCs). Another option would be to limit the total amount of ROCs that could be use for compliance with obligations arising from heat use, and *vice versa*. Trade also could be made conditional on market conditions, e.g, by allowing trade only if prices rose above a threshold level.

9.1.4.2. Denomination of certificates

A complication in using the same mechanism to support both renewable heat and electricity is that the energy conversion efficiency differs drastically for the two types of energy. For this project, we have assumed that the ***output*** of renewable heat would be supported by policy. However, if the same certificate price applied per unit of electricity output and heat output, electricity generators using biomass would receive a payment per tonne of biomass ***input*** less than half as large as that received by heat producers using biomass.[31] Whether this structure of payments is desirable depends on policy objectives. One consideration is that the overall EU renewables target is denominated in terms of achieving a 20 percent share of renewable energy in total ***inputs*** by 2020.[32] This suggests that to achieve the European targets at the lowest cost, policies should be designed to equalise the support offered to all forms of renewable energy input.

Designing a joint RO / RHO policy that would do this could be complicated. For biomass the same input can be used for either heat or electricity and the distinction between inputs and outputs therefore is important. Designing the policy to meet EU targets at lowest cost would mean that each MWh of ***output*** from a biomass power station would receive two or more times the level of support that output from a biomass heat producer would receive (because the power station would use more biomass fuel to produce its output). But if the policies were designed this way, it could represent a departure from current treatment under the RO, which focuses on electricity output. This could have implications for other renewable technologies that are not be consistent with existing policy goals.

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31 This is because the conversion efficiency of biomass electricity generation is in the region of 30-40 percent, whereas biomass boilers are in excess of 80 percent efficient.

32 The EC Renewable Energy Road Map [COM(2006) 848 final] appears to refer to 20 percent of gross inland consumption. This measure of energy consumption corresponds to the sum of consumption, distribution losses, transformation losses and statistical differences.

For example, for wind power or solar heat the distinction between inputs and outputs is not particularly meaningful. This would mean that each MWh of electricity produced from wind would receive just one certificate—the same number that would be received by each MWh of biomass heat production, but just half of what might be awarded to each MWh of biomass *electricity* production. The treatment of heat pumps raises further questions, as the "efficiency" from inputs to useful heat is likely to be 300-400 percent. If energy from heat pumps running on renewable electricity were to be awarded RHOCs, care would need to be taken to ensure that the renewable electricity assumed to be powering the heat pumps was compensated appropriately in a way that avoided double counting – and both the electricity and the heat would need to be credited with certificates in a manner consistent with the system of national accounting used at the EU level assess whether renewables targets were met. Accounting for all of these issues would be complicated. The most straightforward solution could be to denominate certificates in terms of electricity or heat output, but to consider the use of an exchange rate between the two to approximate the relevant considerations. A disadvantage of such complexity is that it would increasingly involve the government or the scheme regulator in decisions that would shift the balance between technologies, reducing the extent to which investments were driven primarily by market forces.

9.1.4.3. Crediting arrangements

Another question is how to credit technologies that span both the heat and the electricity sectors. For example, the current proposed banding structure of the RO gives more support to biomass CHP than to sole electricity generation from biomass, presumably to reflect the additional benefits of the heat output. If an RHO were in place to support the heat output this additional support may not be warranted. Similarly, as noted above heat pumps present their own complications to any scheme, particularly one that attempts to link the heat and electricity markets.

Another consideration is that, as discussed above, an RHO could require up-front crediting to some technologies and / or segments of the heat market. If this were the case it would be necessary to consider whether there would be problems combining this with the crediting upon production in the RO, including whether this would lead to a bias towards one type of project over the other.

9.1.4.4. Renewables Obligation design

It also may be necessary to consider whether the design of RO would need to change for successful combination with an RHO. One issue is the buy-out price level, which has been set in consideration of the cost of reaching the renewable electricity targets of the RO. Another consideration is the banding structure, which may require modification or an equivalent structure in the heat sector to achieve the desired level of support to different electricity and heat technologies.

9.2. Evaluation

9.2.1. Feasibility

Linking the RO and a potential RHO would require attention to a number of design issues, as discussed above. Some of these issues are complicated and would require detailed quantitative analysis to assess properly. Linking also would have the potential to affect the existing renewable electricity support system in significant ways, which could make it more complicated to secure stakeholder support for the policy.

9.2.2. Effectiveness

A hybrid option would offer less control over the amount of renewable heat produced than would a pure quota-based RHO without a buy-out provision. Linking to the RO also would mean that there would be less control over heat delivery than with a policy under which there were no option of investing in renewable electricity rather than renewable heat. As discussed, however, a firm quota anyway may not be feasible in practice given the uncertainty of associated costs.

With full linking between renewable electricity and heat certificate markets it would not be certain what proportion of the combined targets would be met by electricity or heat technologies. The amount of renewable heat therefore would be uncertain. The introduction of such linking provision would be motivated by a judgment that the policy objectives underlying support for renewable heat could be reached equally through increases in renewable electricity supply.

9.2.3. Cost-effectiveness of heat measures undertaken

The rationale for a link between policies typically would be to increase cost effectiveness. In general, a single price for equivalent certificates would lead to greater economic efficiency, distributing the use of renewable energy to the sectors and uses where its use has least cost. This could help resolve the potential difficulty with apportioning the overall target for use of renewables across heat and electricity by relying on the joint certificate market to achieve the split in the way that is most cost-effective. This refers both to the relative cost of heat and electricity projects, and to the efficient use of inputs that are common to both types of generation (notably biomass).

The ability to achieve this has several limitations, however. Most fundamentally, the potential cost-effectiveness gains from linking presuppose that the same benefits attached to one unit of renewable heat also attach to one unit of renewable electricity. If this were not the case then a certificate scheme that effectively allowed for the exchange of one for the other may not be desirable. This ultimately depends on a judgment about the objectives reflected in the support of renewables.

An additional consideration is that the scope for achieving "equivalent" incentives is limited by the effects of pre-existing policies. Notably, the inclusion of electricity generation in the EU ETS means that the (short-term) CO_2 benefits of using renewable electricity are rewarded already (through higher electricity prices). By contrast, most heat use is not subject to similar incentives to switch to low-CO_2 energy sources (although some consumption is within the

EU ETS, and some subject to the CCL, as discussed). This means that, even if RO and RHO certificates had the same value per unit renewable energy, the resulting net incentives to direct renewable investments would not necessarily be identical.

9.2.4. Impact on CO_2 emissions

The displacement of one MWh of fossil fuel-fired generation typically leads to grater fuel savings than does the displacement of one MWh of fossil fuel-fired heat. The main reason for this is that the conversion efficiency to electricity is much lower than the efficiency for heat, as noted above. For illustration, Defra uses an emissions factor of 0.43 tCO_2 / MWh as the CO_2 intensity of long-term marginal electricity generation, whereas gas heating has emissions in the region of 0.25 tCO_2 / MWh and oil-fired heating in the region of 0.3 tCO_2 / MWh. The impact on CO_2 of linking an RHO and the RO therefore would depend on whether it resulted in a shift away / towards more heat, compared to two separate policies.

9.2.5. Distributional impact

A hybrid system could help avoid very high certificate prices, which also would be associated with very high costs and potentially rents to low-cost technologies.

Linking to the RO also would have some distributional impacts. To the extent overall cost-effectiveness were improved by linking an RHO to the RO the burden on consumers would be smaller. However, the price would likely rise in one of the schemes and fall in the other, leading to a different distribution of rents than in a single scheme.

9.2.6. Other policy objectives

As with a stand-alone RHO, we have identified no significant impacts of a hybrid RHO on other policy objectives such as security of supply, competitiveness, energy market competition, or local pollution, apart from the implications for the renewable electricity markets under a linked RO-RHO.

10. Summary Evaluation and Discussion for Selection of Instrument Short-List

10.1. Summary of Evaluations

A summary of the evaluations are presented in tabular format in Table 10.1 on the next page.

Table 10.1 Summary of Evaluations of Policy Long-List

Policy	Feasibility	Effectiveness	Cost-effectiveness	CO2	Distributional
Emissions trading and taxation					
Expansion of EU ETS -- upstream	OO	–	–	–	OO
Expansion of EU ETS -- downstream	O	OO	OO	OO	–
Direct price instruments	OO	P	P P	P	OO
Expansion of CRC	O	OO	O	OO	–
Modification of CRC recycling	–	O	O	O	–
Investment support: grants, loans, and other credits					
Large-scale programme	–	P	–	P	–
Targeted	P P	O	P	O	–
Renewable heat obligation — no up-front crediting, no differentiation of renewable heat support					
RHO with tradable certificates	OO	P	(P)	P	OO
RHI with fixed-price subsidy	O	O	–	O	O
"Hybrid" RHO with safety-valve	O	–	(P)	–	O
"Hybrid" RHO with RO link	O	–	(P)	–	O
Renewable heat obligation — up-front crediting, no differentiation of renewable heat support					
RHO with tradable certificates	OO	P	P	P	OO
RHI with fixed-price subsidy	O	(P)	P P	(P)	O
"Hybrid" RHO with safety-valve	O	–	P	–	O
"Hybrid" RHO with RO link	O	–	P P	–	O
Renewable heat obligation — up-front crediting, differentiation of renewable heat support					
RHO with tradable certificates	OO	P	(P)	P	O
RHI with fixed-price subsidy	O(O)	(P)	P	(P)	–
"Hybrid" RHO with safety-valve	O(O)	–	(P)	–	–
"Hybrid" RHO with RO link	O(O)	–	P	–	–

<u>Note</u>: As with any summary table, distilling the extended discussion within this report into illustrative rankings or scorings requires substantial simplification, and therefore the table should not be relied upon without reference to the more complete discussion in this report.

10.2. Conclusions about Policy Categories

The following are high level conclusions about the long-list of financial instruments to promote renewable heat.

10.2.1. Conclusions about policies that raise the cost of non-renewable energy

Raising the cost of non-renewable energy, through carbon pricing or otherwise, can be cost-effective and administratively light-touch, but concerns about distributional impacts and political and legal feasibility means that this approach to encouraging renewable heat is unlikely to be feasible.

§ Higher fossil fuel prices could be a cost-effective way to incentivise renewables. Their chief benefits are that they send consistent price signals and have low administrative cost.

§ Extending existing emissions trading programmes (the EU ETS and CRC) to cover additional emissions sources would have little aggregate effect on renewable heat, as the additional coverage and / or financial incentive provided would be limited to a small section of the commercial and industrial sectors, with no additional incentive in the household sector or for heat use already subject to one of these programmes.

§ Upstream coverage in the EU ETS could be more effective, depending on future allowance prices, but is unlikely to be legally feasible within the relevant time horizon. Coverage could be substantial, including all of the commercial and industrial sectors not currently in the EU ETS, as well as all of the household sector.

§ Very substantial increases in energy prices would likely be required to achieve significant deployment of renewable heat. This could have adverse distributional impacts and increase fuel poverty.

§ Overall, the low feasibility and limited impact without potentially adverse distributional effects render these policy options unattractive under the evaluation criteria for this study.

10.2.2. Conclusions about grants schemes

Grants have the advantage of overcoming up-front obstacles to the adoption of renewable heat technologies but maybe unsuited to some technologies and sectors. The difficulty of administering a large-scale programme to ensure cost-effectiveness, uptake, and low infra-marginal rents is the main obstacle to using a grants programme as the main policy to meet renewable heat targets.

§ Grants have several attractive features. In particular, up-front financing is suited to overcoming many of the demand-side barriers that may impede the uptake of renewable heat.

§ It may be difficult to achieve long-term commitment to the continuation of a grants programme. Using grants to underpin consistent *demand* therefore may not be an efficient way to encourage the long-term development of the renewable heat supply chain.

- Under a capacity-based grants scheme, investment support is decoupled from actual output, which may reduce cost-effectiveness. This may be mitigated through a "deeming" approach varying grants by the future expected heat output of projects. However, grants may be more problematic for technologies with large ongoing costs (notably, biomass): without ongoing monitoring there may be a risk of reversion to the use of fossil fuels.

- The administration of grants would likely need to vary significantly by sector, with light-touch and standardised procedures for small projects in the household and commercial sectors but more extensive appraisal of project viability and additionality for larger projects in industry and larger commercial / public organisations. It may be feasible to use tendering through auction to improve cost-effectiveness and reduce rents for large projects in the commercial and industrial sectors, though design of auction arrangements to ensure delivery of contracted capacity can be difficult.

- Grants can be a useful complement to other policy, particularly to the extent there are market failures preventing an efficient level of investment in innovation or in the renewable heat supply chain.

- Many of the attractive features of grants could be replicated in a certificate obligation using a "deeming" approach to metering and up-front crediting for lifetime output. This would result in a grants-like schemes administered by private sector parties.

10.2.3. Conclusions about Renewable Heat Obligation

An RHO has the theoretical advantages of cost-effectiveness and potential for long-term commitment through legislation. The main potential drawback of an RHO is that it would be an administratively complex policy with several challenges to implementation.

- A key attraction of the tradable certificates approach is the theoretical ability to bring about the most cost-effective renewable heat projects required to meet a target level of output.

- Administration of an RHO would likely be complex. The standard model of tradable certificates, with investment in anticipation of future certificate revenue, appears unlikely to appeal to many heat consumers (or supply chain participants) except in the case of very large consumers or projects. Administrative and institutional arrangements would likely need to vary by sector or heat market segment: small consumers would face essentially no administrative requirements, with others undertaking reporting for them, whereas larger commercial and industrial consumers could be asked to provide data and evidence on heat use.

  – Potential modifications to overcome this barrier may include up-front crediting for lifetime heat output, a "deeming approach" to heat monitoring to reduce equipment and administrative cost, and institutional and contractual arrangements that allowed large parties to take on much of certificate price risk as well as administration.

- Where deeming and up-front crediting were used, the RHO would resemble a grants scheme administered by private sector parties. It would have the potential advantage of longer-term commitment and clearer funding arrangements.

- A quota approach has a good fit with targets for renewable heat output. However, certainty of achieving the quota may be limited by several important factors.
  - It may be difficult for a government to make a credible commitment to future quota levels because information about the potential for and cost of a large-scale increase in renewable heat is very uncertain.
  - An RHO system would likely need a safety valve ("hybrid") arrangement to avoid a high cost of certificates.
- An RHO is likely to be more economically efficient than policies that do not provide the same support across technologies and sectors, or which are not linked to actual heat output. However, efficiency may be reduced by some features required to implement an RHO. Depending on scheme design, this may include the use of deeming (rewarding capacity instead of actual output), the differentiation of support, uncertainty about future certificate prices, and the absence of an active and efficient certificate market.
- An RHO would lead to higher bills for consumers of fossil fuels and electricity and the transfer under an RHO from energy consumers generally to consumers and/or suppliers of renewable heat could be significant if the cost of eligible heat projects varied significantly. Differentiation of support ("banding") could help limit infra-marginal rents, but may be difficult to design.
  - The policy allows only for providing different relative support to different technologies or other categories of heat projects (with absolute support depending on the certificate price).
  - The information on which to base banding is limited.
  - Cost-effectiveness would be reduced if differentiation diverged significantly from the actual cost of categories of projects.

10.2.4. Conclusions about Renewable Heat Incentive

Like an RHO, an RHI with fixed support for renewable heat would have the theoretical advantage of cost-effectiveness. However, there would be less certainty about the resulting level of heat output than under an RHI, and effectiveness would depend on the feasibility of channelling support to small end-users.

- Like an RHO, an RHI with fixed support would be a "market-based" mechanism with the theoretical ability to select the most cost-effective heat projects.
- An RHI would require many of the institutional arrangements required under an RHO, including heat monitoring and the production of records of heat output. Many of the same administrative complexities therefore would arise.
- An RHI would offer less certainty of reaching a given level of output than would an RHO. If payments were too low there would be a risk of missing targets. (However, as noted, the certainty achievable under an RHO also may be limited.)
  - Revision of payment levels over time could reduce the risk of missing target levels of output, but would risk deterring or delaying investment.

- Response to the subsidy and uptake under an RHI would depend on the feasibility of contractual arrangements to channel subsidies to small end-users.
  - The absence of active involvement by obligated parties may limit uptake, compared to the situation under an RHO. Deeming and up-front crediting therefore may be more important under an RHI.
  - On the other hand, certainty of support could enable the participation of additional parties in the renewable heat supply chain who would not be prepared to participate under the uncertain support of a RHO.
  - Without the direct involvement of the obligated parties it may be necessary to administer support through a centralised purchasing agency. This would make the RHI similar to a grants programme funded through a levy on the obligated parties. Difficulties of administrating a large-scale support programme may be greater with such centralisation.
- As with an RHO, the economic efficiency of projects selected is an attraction with an RHI. Like with an RHO, however, up-front crediting, differentiation of support, and other factors may reduce the cost-effectiveness advantage over a grants programme.
  - The greater certainty to project developers of levels of future support under the RHI system may lower the cost of finance compared to the cost under quota systems, although the magnitude of any such effect is uncertain. “Behavioural” barriers may reinforce the benefits of certainty about future support.
- Differentiation of support may be easier under an RHI than under an RHO, as the level of subsidy is under direct political control. However, the potential difficulties of limited information on which to base differentiation and the potential adverse impact on cost-effectiveness would be the same under an RHI as under an RHO.

10.2.5. Conclusions about a “Hybrid” Renewable Heat Obligation

A “hybrid” RHO with a buy-out provision would reduce concern about very high costs, at the expense of less certainty about reaching targets. A link to the Renewables Obligation for electricity generation has theoretical advantages but may be difficult to implement.

- Design of a hybrid RHO would face many of the challenges arising under an RHO discussed above, and additionally would need to consider linking arrangements and the design of price floors or ceiling and / or buy-out provisions.
- Hybrid arrangements reduce the certainty of achieving targets that otherwise is an advantage of an RHO.
- Despite the potential complexity and potential disadvantage, a “safety valve” arrangement nonetheless may be desirable to reduce the risks associated with introducing firm obligations in a situation of considerable uncertainty about heat potential and cost.

- A link to electricity markets could promote the efficient use of inputs and of contributions to the overall renewable energy target. However, there also would be several considerations that may make linking less desirable.
  - The amount of resulting renewable heat would be less certain, as the split between renewable electricity and heat would not be pre-determined. This could reduce the certainty to heat market participants, including in the renewable heat supply chain.
  - It would be important to consider how different technologies contribute to the overall UK renewable energy target. Complex design considerations arise for different energy sources (e.g., wind and biomass); the use of the same input in the electricity and heat sectors (notably, biomass); and for individual technologies related to both sectors (notably, heat pumps and CHP).
  - More generally, it is not clear that the benefits of renewable heat and renewable electricity are equivalent (and an "exchange rate" for certificates therefore may be required.)

10.3. Selection of Shortlist of Policies

In consultation with the Steering Group, the following policies have been taken forward for consideration in Phase II of this project (which involves modelling of costs and benefits), and for more detailed description in the next section of this report:

- Renewable Heat Obligation;
- Renewable Heat Incentive; and
- "Hybrid" Renewable Heat Obligation with link to the Renewables Obligation for electricity.

The headline advantages of these policies over other financial instruments considered in this report include:

- The ability of the mechanisms to achieve cost-effective uptake of renewable heat. The main advantages include:
  - linking support to output (albeit limited by the potential use of a "deeming" approach to heat monitoring and up-front crediting of lifetime deemed output); and
  - the ability to provide consistent financial incentives across diverse technologies, sectors, and other heat market segments (and, in the case of a "hybrid" RHO, across heat and electricity sectors).
- Broad coverage of heat users to aid in achieving the challenging increase in renewable heat output implied by overall renewable energy targets, and the accompanying cost-effectiveness of using the same support mechanism for different sectors and technologies of renewable heat (and, in the case of a "hybrid" RHO, across heat and electricity sectors).

- The possibility of long-term commitment to providing support through a mechanism based in legislation, and with a clearly identified source of funding.
  - This appears especially important given the need rapidly to develop new supply chain infrastructure across a range of technologies.
- The ability to draw on previous institutional and administrative experience with similar support mechanisms for renewable electricity, energy efficiency, and transport.

The key potential disadvantage attendant to both the RHO and RHI approaches is the complexity of designing a policy suitable for all technologies, sectors, and counterfactual fuels, and the possibility that complexity could create or reinforce barriers to uptake. The other main potential disadvantage is the risk of very high subsidy levels (especially for an RHO), or of not achieving targets (especially for an RHI).

10.4. Sector-Specific Factors

Although the short-listed instruments can be grouped into two broad policy categories (tradable certificates in the RHO, or fixed support in the RHI), it is likely that the administrative provisions of either type of instrument would need to vary between different segments of the heat market. Key design considerations include:

- different protocols for monitoring, reporting, and verifying renewable heat output, including:
  - the use of deeming where ongoing monitoring would be too costly,
  - use of input-based monitoring where appropriate, and
  - the need for ongoing monitoring and/or reporting where there may be a risk of "gaming" or reversion to the use of non-renewable heating;
- different crediting arrangements for different heat market segments and / or technologies
  - up-front – and possibly lifetime – crediting where there would be significant barriers to the investment in renewable heat in the expectation of receiving future certificate revenue,
  - ongoing crediting for larger projects, or for technologies where a significant proportion of the lifetime cost is variable rather than fixed costs;
- different contractual and institutional arrangements for different parties of the supply chain, including
  - use of "managing agents" taking on administrative requirements for small consumers,
  - use of pre-contracting for suppliers or others unable to provide large lines of credit, and
  - much of certificate revenue risk taken on by large parties, notably energy suppliers; and
- possibly, different levels of support for different policies (to avoid the creation of infra-marginal rents).

In practice, these differences mean that the arrangements for support for different technologies and market segments could vary. However, this variation seems much more likely to be a feature across market segments and technologies than across the policies themselves. That is, the detailed implementation of the RHO or the RHI would be likely to involve very similar features, despite the high-level difference between quantity- and price-based instruments.

We discuss the details of how the policies may function in practice in the next section.

11. Detailed Description of Shortlist Policies

This section provides further details on the design of the short-listed policies and how they would be likely to work in practice. We discuss the assignment of targets; how measures are likely to be chosen; the contractual arrangements and relationships likely to develop between consumers, energy suppliers, and parties in the renewable heat supply chain; the timing of support; the method of determining the level of support; and monitoring, reporting, and verification considerations.

11.1. Policy 1: Renewable Heat Obligation

A Renewable Heat Obligation would have the following key features:

- The government would set an overall target for the production / use of renewable energy for heating.
- Responsibility for meeting this target would likely be given to suppliers of energy used for non-renewable heating (fuels as well as electricity), although in principle it would be possible to impose the obligation on distribution network operators. These suppliers would have an obligation to hand over to the government or regulator certificates equal to a proportion of their overall share of the heat energy supply market each year.
- All forms of renewable heat would be eligible to receive renewable heat certificates (RHCs), although the method by which technologies would be awarded certificates would vary depending on their characteristics.
- Rights to the certificates would by default rest with the final consumer of the renewable heat, but it is almost certain that most consumers would agree contractual arrangements whereby their rights to certificates would be assigned to other parties. These parties could include conventional energy suppliers, as well as equipment manufacturers, installers and renewable fuel suppliers.
- Obligated energy suppliers would be likely to develop contractual arrangements with other parties in the renewable energy supply chain.

11.1.1. Sources of demand for measures and assignment of obligations

The most feasible option for an RHO appears to be to impose an obligation to purchase certificates on suppliers of energy used for non-renewable heating (fuels as well as electricity). Under these arrangements, energy suppliers would need to acquire a target level of certificates, and therefore would have incentives to either initiate or collaborate in the development of renewable heat projects, or to purchase certificates from a potential secondary certificate market. (There is some question as to whether a liquid secondary market would materialise, as we discuss in section 11.1.4 below.)

There would be experience on which to draw in determining the targets for each supplier, as both the RO and CERT both impose similar obligations (in both these cases the policy is regulated by Ofgem). Nevertheless, the heat sector raises various additional challenges in determining the level of obligation for individual suppliers.

Challenge 1 – large number of small suppliers: The first is that the number of suppliers of energy for heating is orders of magnitude larger than the number of suppliers subject to the RO and the CERT. Coal and heating oil suppliers, which as noted above account for around 10 percent of heating energy, number in the hundreds or even thousands, many of them very small (AEA 2007). Suppliers below a certain threshold (in terms of MWh supplied or turnover) could be exempted from the requirements of the policy to reduce administrative burdens. (For example, the EEC previously limited obligations to companies with more than 15,000 customers, subsequently raised to the current level of 50,000 customers, or just 8 companies.) On the other hand, exemptions would themselves impose additional administrative burden. To determine obligations it would be necessary to collect information periodically (perhaps annually) on the amount of energy supplied for use in heating, which would form the basis for obligations during the next compliance period.

Challenge 2 – relationship between energy used for heating and obligations: This raises the second complication with assigning energy suppliers with individual targets for renewable heat: for any given supplier, only a proportion of its total energy supplied may actually be used for heating. In some cases (e.g. domestic gas) the proportion will be essentially 100 percent. In other cases the proportion will be significantly smaller (e.g. around 31 percent of commercial electricity use is for heating). In assigning renewable heat targets for different energy suppliers, it would be necessary to apply at least some differentiation by fuel to account for the proportion of energy devoted to heat production. It may also be desirable to differentiate by customer segment (in industry, for example, 44 percent of electricity use is for heat, much of it process heat). Within each fuel (and customer) category, it would be possible to assign a uniform target of renewable heat (in MWh) per MWh of total energy supplied for heat, or to differentiate further using additional information—such as whether or not the consumer was on the gas grid.[33]

Distributional implications: the share of the obligation imposed on each supplier would have distributional implications for the consumers on whom the cost would fall. Moreover, the detailed rules about how targets are assigned have the potential to affect how suppliers factor the costs of the policy into their pricing decisions (and more generally in how the costs are reflected in fuel and electricity prices).[34] The distributional implications of the options are difficult to assess without detailed data about the costs of renewable heat, the characteristics of individual suppliers, and the characteristics of consumer segments.

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[33] The "targets" for each sector would contribute to the overall obligation for each supplier – they would not need to be met individually in each customer segment or fuel category.

[34] As discussed below, we assume that suppliers pass through the average cost of the policy into energy prices; depending on supplier business models, policy design, and market structure, actual supplier pricing strategies could deviate from this assumption. See NERA 2007 for a discussion of retail energy price pass-through behaviour in the context of potential designs of the UK Supplier Obligation.

11.1.2. Renewable heat measures chosen and differentiation support

Eligibility of technologies and sectors: An RHO would be most cost-effective if extended to include all potential renewable heat technologies (biomass, biogas, heat pumps, and solar thermal) and all heat use across all sectors.

Impact of location of obligation: In an open certificate market the decision about where to place responsibility for fulfilling the obligation need have no direct impact on the uptake of renewable heat or on the choice of projects undertaken. Energy suppliers (and potential project developers and installers relying on certificate revenues) would have incentives to focus resources on the measures that produce the most certificates at the least cost. However, the uptake of measures could be complicated by suppliers' customer relationships. For measures undertaken among customers of the supplier, there is a cost not only of the price paid for the certificate, but also of any sales foregone by the switch to renewable heat by one of that supplier's customers. If this effect were significant, suppliers could prefer to support measures for customers not currently their own, or whom they did not expect to be able to supply themselves. It is unclear how important this effect would be in practice—the same issues apply under the CERT (and under its predecessor), but we are not aware of any evidence that this has made the achievement of EEC or CERT targets more difficult. It is possible that the effect could be more significant for some suppliers than others—for example, it may be relatively inexpensive to switch consumers of non-net-bound energy to renewable forms of heat, in which case suppliers of non-net-bound fuels could be disproportionately affected by a heat obligation—not because they would bear disproportionate costs, but because they would face disproportionate loss of sales.

Possible differentiation of support: An important design consideration would be whether to differentiate support by sector, technology, or other market segments. Preliminary analysis of costs suggests that there is substantial variation in the cost of renewable heat across technologies and customer segments. It also suggests that there is significant variation in net cost depending on the energy source that would otherwise be used to provide heating (the "counterfactual" fuel). Offering the same level of support across all renewable heat measures therefore could lead to significant "rents" being earned by low-cost measures. One way to reduce these rents would be to introduce "banding" of support, whereby different types of projects would receive different numbers of certificates. We have not analysed the potential implications of different definitions for "bands". This would be an important area for further research—in particular, to what extent banding in the case of renewable heat would be able to reduce rents, given the variation in costs across the multiple relevant parameters.

11.1.3. Heat monitoring

The monitoring of heat within an RHO would need to vary by the type of heat project, including the size and technology. We briefly discuss below the three main options for heat monitoring: direct heat metering, indirect metering of fuels, and "deeming" of heat use.

11.1.3.1. Direct heat metering

Heat metering poses difficulties that do not arise in the metering of fuels or electricity. The amount of heat delivered depends both on the flow rate and temperature of the medium used to deliver heat (e.g., steam, liquids, or air). Compared to fuel or electricity metering, heat metering also is relatively invasive, as meters need to be integrated into the pipes delivering the heat. Retrofitting heat meters therefore requires shut-down of the heating system. Additionally, there are some types of heating that are not delivered through piped systems, such as electric convection or storage heaters.

There is limited information relevant to the UK on the cost of heat metering. One source is a desk study by BRE (2007), which examined the costs and benefits of installing heat meters in existing community heating schemes in the UK. This relied on data from the Community Energy Programme launched in 2002 and on surveys of community heating scheme users and practitioners.

The numbers used in the analysis suggest that the cost of heat metering in the domestic sector would be very large. The equipment cost for a heat meter would be in the region of £135, while additional up-front cost such as installation, automatic reading equipment, etc. would amount to another £200 per meter. There also would be large ongoing costs associated with billing and administration, amounting to around £55 per year, while maintenance and replacement costs add another £20 per meter. Based on these and other assumptions, the study estimates that installing heat metering in existing community heating schemes in the UK that are not currently metered would cost over £1bn between 2008 and 2020. It is unclear how applicable these numbers would be to heat metering in contexts other than district heating, e.g., for the metering of output from individual biomass boilers, ground-source heat pumps, or solar thermal installations. Nonetheless, they can be taken as an indication that metering costs are high even in relatively standardised heat delivery systems.

By contrast, the study finds that costs in non-domestic systems are significantly lower relative to the overall cost of the energy consumed. The estimate in the study is that a non-domestic meter would cost around £1,800 for equipment and installation. Again, it is not clear whether this number would be applicable to situations other than district heating, such as biomass boilers. However, information from Enviros Consulting (which is undertaking a parallel study on barriers to renewable heat) suggests that direct metering already is standard practice for many large heat loads.

11.1.3.2. Input (fuel) metering

Given the high costs of directly metering heat, an alternative approach would be to meter inputs (e.g., fuel) and apply standardised conversion efficiency factors to estimate actual heat output. The feasibility of this method differs across technologies and heat markets. Heat pumps use electricity which is already metered and input into biomass heating also could be measured. By contrast, solar heating input could not be easily measured.

The accuracy of input metering depends on two main factors. First, the energy content of fuels may vary, particularly in the case of biomass. However, this may not be a significant cause for concern where fuels are produced to standardised specifications. Second, the conversion efficiency may vary from its actual value, either because equipment categories are broad and incorporate a range of values, or because it varies with the specifics of how equipment is installed and used. In most cases, this may be a relatively small source of uncertainty, not least because heat users already have incentives not to waste fuels.

11.1.3.3. “Deeming” heat output

The third main approach is to measure neither inputs nor output, but to estimate heat production from heating system characteristics that are easily observed. For example, heat production from biomass may be estimated based on the rated output of the boiler, a standardised conversion efficiency, and a standardised load factor. Compared to input metering, the main uncertainty is the degree of utilisation (both in terms of peak capacity and in terms of the number of hours of operation).

In theory, deeming could incorporate additional factors to improve accuracy. For example, estimates could be adjusted *ex ante* for factors such as geographic variation in heat requirements or solar intensity, or the size or energy efficiency rating of the building. It also could be adjusted *ex post* for factors such as weather. A further issue includes whether changes over time (e.g., to occupancy patterns) should be incorporated into the estimate. The approach to deeming also may vary with the size of the project, using more complex methodologies where the amount of heat generated is larger.

The incorporation of additional factors rapidly leads to a trade-off between accuracy and administrative complexity. The most directly relevant UK experience of deeming is the calculation underlying savings attributable to projects in the Energy Efficiency Commitment / Carbon Emissions Reduction Target. The approach taken is highly standardised, as required for the processing of millions of individual measures and projects. Deeming also has been used in the context of renewable heat and electricity production. As noted, the Australian MRET policy, uses deeming for small projects that use wind, solar or hydro energy.

A major potential problem with deeming is that there would be no ongoing monitoring of the use of renewable heat equipment. This is particularly relevant where ongoing costs could be significant, and where there therefore may be an incentive to revert to the use of non-renewable technologies. This may be the case for biomass, and possibly for heat pumps. Without assurances that renewable heat measures remained in-use, deeming would risk providing certificates for heat projects that did not in fact produce renewable heat output.[35]

11.1.3.4. Implications for implementation of an RHO

It has not been possible to assess the feasibility of heat monitoring as required for an RHO in any depth for this report. Prior to implementing an RHO it would be important to establish the costs as well as likely accuracy of different approaches. It also would be necessary to analyse where there may be risk of reversion to non-renewable heat technologies.

Our preliminary assessment is that an RHO likely would have to rely on a combination of different monitoring methods, varying by technology, size of heat load, and market segment. While data are very limited, it appears that direct heat metering may be most feasible for large projects, and especially where heat is already metered. Further work would be

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[35] It is worth noting that for at least some technologies, under-utilisation of measures would not necessarily pose a threat to the UK’s ability to attain its official renewable targets, because the measurement against the target would *itself* almost certainly be based on a form of estimation or deeming. For example, if output from heat pumps were not measured directly, the only way to calculate the total national heat supplied by heat pumps would be to estimate their output based on assumptions about their use, and the aggregate of these estimates is what would contribute to the national energy statistics used to judge whether the UK had achieved its targets.

necessary to establish what proportion of facilities or heat use would be amenable to this approach, but it is likely that direct metering would be overly costly for several heat market segments.

Input metering seems feasible for a large share of heat projects where equipment costs of direct metering would be too large. However, it is not clear whether the savings would be sufficient to make the option viable for small heat projects. For the smallest installations an ongoing requirement to provide input or other proxy data could involve administrative requirements that would be significant in relation to the potential value of certificates generated. One potential way to alleviate this would be to require suppliers of inputs to renewable heat (notably, biomass fuel) to report the amount supplied to particular customers with registered renewable heat projects receiving certificates. However, the feasibility of such arrangements would need to be investigated further.

Deeming is likely to be a suitable option where output or input metering would lead to disproportionate equipment costs or administrative requirements. As we discuss below, deeming would also make possible the award of certificates in advance of heat actually being delivered. Up-front crediting of renewable heat projects may be important for a large share of such projects, and deeming therefore may be an essential feature of an RHO.

11.1.4. Administrative and contracting arrangements

A key challenge for an RHO scheme is to achieve arrangements that allow heat consumers to access the subsidies made available without incurring either high administrative cost, high risk, or a requirement to evaluate or understand complex policy arrangements that would not normally arise in the context of everyday decisions about heating a home, business, or industrial process. The feasibility of finding administrative, contracting, and other institutional arrangements to overcome this challenge is one of the key challenges of an RHO policy, and one that would require consultation with stakeholders and additional analysis to resolve.

11.1.4.1. Administrative arrangements

Administrative requirements such as registration of projects, reporting of heat output data, or verification of heat use would need to be designed to impose a proportionate cost, relative to the heat delivered by the measure being considered.

Experience with energy efficiency policy suggests that “barriers” – whether administrative or other “hidden and missing” costs – can be a significant deterrent to the uptake of energy measures that otherwise appear cost-effective.[36] For most households as well as businesses, heat use is not a major expenditure or a business priority, and even very high subsidies for renewable heat to make them cost-competitive with conventional alternatives would be unlikely to encourage consumers to undertake unfamiliar administrative activities associated

[36] For example, the latest CERT “illustrative mix” suggest that households are willing to pay around £200 for installation of insulation with a value in excess of £600. This is despite the fact that households need to undertake practically no administrative activity under the CERT.

with the creation of certificates under an RHO. Meanwhile, the time cost of administrative activity could easily outweigh the value of certificates.[37]

To alleviate these problems, policy would need to shift administrative burden onto parties better able to engage in the administrative activities required under the programme. These parties would include the equipment installer (or other "managing agent" similar to the agents used in the Australian MRET programme) and/or renewable fuel suppliers, who typically would be granted the right to certificates by consumers and would be required to complete standardised forms and submit them to energy suppliers as part of the reporting and verification process. Suppliers (or in some cases equipment manufacturers or others in the supply chain) would use these forms as part of the evidence packs submitted to the regulator to receive certificates and then demonstrate compliance. The process of verification could involve the inspection of evidence packs and random or risk-based detailed audits.

It also would be possible that much of the administration could be undertaken by energy suppliers on whom the obligation is imposed. This is the model used in the CERT, and may be the most viable arrangement for projects among small consumers, in particular. We discuss the associated contractual arrangements in more detail below.

11.1.4.2. Contracting arrangements

Perhaps the most significant difficulty with using the tradable certificate approach in the heat sector is that contractual terms that substantially alter prevailing relationships between consumers, equipment suppliers, and fuel suppliers are likely to face significantly higher barriers than terms that allow existing relationships to remain largely unchanged. We believe that most consumers would be unwilling to adopt renewable heat technologies that cost substantially more than conventional heating technologies on the basis of a potential future value of renewable heat certificates they will receive. The vast majority of consumers—both domestic customers and business customers—would be unwilling either to take on the risk or to devote time to evaluating potential future certificate revenue streams.[38] They also may not have access to credit that would enable them to purchase capital-intensive equipment (particularly if it has uncertain resale value). Consumers therefore will need to be offered up-front incentives to install capital-intensive equipment, and ongoing fuel discounts to use more expensive biomass fuels.[39] (In addition, for some technologies, there may be "demand-side barriers" that prevent the adoption of renewable heat, such as disruption, lack of information, or risk aversion. Consumers also may need to be compensated to overcome these barriers.)

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[37] For comparison, the cost-benefit analysis of the CRC was carried out on the basis of a time cost of 14 days for the smallest organisations, with administrative costs valued at £7,000 (NERA and Enviros, 2006a). Participation in the RHO is likely to require less administrative time input, but these numbers nonetheless underscore that administrative costs of scheme participation quickly could grow larger than the certificate value of even relatively sizeable heat loads covered by an RHO.

[38] This is likely to be true even if a "deemed energy" approach were used to calculate a lifetime certificate award up-front.

[39] As we discuss below, this is likely to have implications for the way that the policy would need to provide support for measures that involve a significant capital outlay.

The situation may differ between sectors and sizes of heat projects. The very largest heat projects, such as large-scale CHP or boiler plant, may be more similar to investment in electricity generation, with an expectation of large up-front costs, long payback periods, and well-established procedures for investment appraisal and financing. These projects therefore may be amenable to the inclusion of ongoing and uncertain certificate revenue—although not without accounting for the costs associated with such uncertainty. In any case, such projects are likely to constitute a minority of renewable heat projects and consumption. It seems likely that in the majority of cases—even for larger energy consumers with dedicated energy managers accustomed to negotiating energy supply contracts—consumers will be reluctant to take on the risk that future certificate prices will fall below expected levels. It therefore seems likely that these consumers will wish to cede to other parties the responsibility for managing certificate trading and price risk.

For similar reasons, we believe it is unlikely that equipment installers will wish to carry the capital charges associated with installing measures up-front and then waiting for certificate revenue to arrive. The risk associated with installing equipment in the hope of recovering this cost via a secondary certificate market is likely to deter most installers from undertaking measures unless they have guarantees that they will be able to recoup their costs. (In the next sub-section we discuss how deeming of heat output could be combined with up-front certificate awards as one way to alleviate these risks.) Also, up-front subsidies may need to be large, making it difficult for all but very large equipment installers to access the financing required for such arrangements. Under the EEC and subsequently the CERT, similar circumstances have resulted in an environment with no secondary "certificate" market. Instead, energy suppliers agree contracts with installers and other agents and pay them a prearranged amount for each installation. These terms essentially mean that energy suppliers take on the "certificate value risk" themselves, and manage this risk by actively managing their compliance portfolios to ensure they are neither too "short" nor "long" in their development of projects and measures, relative to their obligation.[40]

On this analysis, the secondary market in certificates would be limited.[41] The most likely contractual model may be for larger energy suppliers to develop relationships with representatives at different levels of the renewable heat supply chain—from managing agents who would identify target customers, to equipment manufacturers and installers, to fuel suppliers—and enter into agreements with them to secure certificates, probably on fixed terms to protect the supply chain partners from certificate price risk.

For smaller energy suppliers, the administrative requirements of forming such relationships would be more difficult, and it would be preferable to them to be able to rely on a liquid certificate market, if one existed. One way they could comply would be to purchase surplus certificates from larger energy suppliers with a better capacity to manage the process of generating certificates. Experience with the EEC/CERT and other economic instruments suggests that competitors may be unlikely to trade with each other, and also that energy suppliers may prefer to retain their surplus credits as insurance against future requirements.

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[40] Another important reason for the central role of suppliers is that the rules governing the CERT require that they be involved in delivering measures, essentially as a way of reducing the risk of double-crediting of measures.

[41] The secondary market for ROCs is also relatively limited. In this case, energy suppliers – here integrated electricity generators / suppliers – play a central role in managing projects.

An important question, therefore, is how smaller energy suppliers would achieve compliance with the obligation, if they were included. One possibility is that they could enter agreements with relatively large equipment manufacturers, who might be better able to assume the associated risks. However, unlike energy suppliers, equipment manufacturers would face no obligation, and therefore their willingness to assume substantial risk under the policy could be very limited. Thus the position of small energy suppliers under the RHO remains an area of uncertainty.

It also remains an open question to what extent consumers would be willing to accept cost structures differing from those of the relevant conventional heating technologies. Contractual terms with customers are likely to vary between technology as well as sector or size. For biomass, for example, it is likely that contracts would be offered to consumers that would result in up-front costs similar to the up-front costs of the counterfactual conventional heating technology. The remaining additional up-front cost would be covered by the obligated energy supplier (or possibly by equipment suppliers in the expectation of recovering this cost through the sale of certificates to energy suppliers). Similarly, variable (i.e., fuel) costs to consumers would also be subsidised by suppliers to be competitive with the alternative conventional fuel. (Contracts might explicitly link variable charges to the price of the conventional fuel, for example.) For solar heat and heat pumps, on the other hand, consumers may be willing to accept some additional up-front cost (compared to the conventional alternative) in expectation of lower future operating costs. The extent of "barriers" to accepting such technologies and cost structures, and the cost of overcoming them, is an important question for further research.

11.1.5. Crediting periods and timing of support

The above reasoning implicitly assumes that energy suppliers would need to extend up-front subsidies to renewable heat consumers in expectation both of passing the associated costs on into product prices, and of receiving future RHO certificates necessary to comply with their obligations. This presupposes that suppliers are able to extend the subsidy—this may not be true for smaller suppliers, as discussed above. In addition, is assumes that suppliers would be able to rely on the subsequent award of certificates, but this may pose some difficulty.

In some cases, if certificates are to be provided on an ongoing basis as heat is generated, suppliers could be at risk of not receiving future certificates. For one, ongoing crediting and monitoring is likely to require some involvement of the consumer (e.g., to take meter readings, or to access the premises to verify the continued use of equipment). As noted above, arrangements that impose administrative requirements or ongoing involvement by consumers are likely to face higher demand-side barriers, although these may not be prohibitive. A second problem with ongoing monitoring and crediting could arise if the premises were sold, as it may not be feasible for the energy suppliers to enforce any agreements entered into with the previous owner (houses are sold on average every 7 years, which is shorter than the lifetime of several renewable heat measures).

These problems may be alleviated by awarding certificates up-front rather than on an ongoing basis. This would reduce the risks inherent in a certificate scheme—which include the risk of certificate delivery and the price risk of certificates—by awarding certificates *in advance* of the production of renewable heat. The up-front award of certificates would eliminate the first risk (of certificate delivery).[42] This would remove the risk to energy suppliers risk of not accessing future certificates. It also would make it more likely that equipment manufacturers and installers could participate in the market independently of large energy suppliers, although the likely degree of participation is very uncertain. If other parties in the supply chain did participate in the certificate market it would improve market liquidity, to the benefit of smaller energy suppliers. However, it would also increase the complexity of the policy.

In practice, a deeming approach to heat monitoring would have to be used to enable up-front crediting. As discussed above, this has disadvantages, including reduced measurement accuracy and potential gaming of scheme rules. For particularly large projects, it might be considered appropriate to meter the actual heat output and to award certificates for the variable heat output in a way that would “true-up” any difference between the deemed output and actual output. Even for measures where only deeming was used, it also may be preferable to award certificates for a few years at a time, with continued support contingent on verification that the equipment is still installed and used. At least for large projects, such verification may be necessary to avoid resale of equipment or other “gaming” of scheme rules. A particularly important consideration is to what extent biomass could fit into this type of system. As noted, it is likely that some ongoing monitoring of biomass use would be necessary to avoid reversion to non-renewable technologies, or gaming to access up-front subsidies for equipment that could be used to burn fossil fuels. This presupposes that ongoing monitoring can be achieved, and the corresponding certificates accessed by suppliers (for example, by biomass suppliers providing records of the amounts supplied to particular customers). These complexities would require further analysis prior to the introduction of an RHO policy.

11.1.6. Overall feasibility

The above discussion points to the fact that an RHO would require complex arrangements (both private and public) for the crediting, administration, and enforcement of provisions. These arrangements probably would need to differ by technology and market segment. The question therefore arises whether the associated complexity would render the policy infeasible overall.

Previous assessments about a tradable certificate scheme for the heat sector have come to divergent conclusions on this issue. For example, ILEX (2003) concluded that “there is no practical reason why an obligation mechanism with tradable certificates could not be used to support bioheat”. By contrast, the Biomass Task Force (Defra 2005) drew the diametrically opposed conclusion that this approach would be “unworkable”.

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[42] It could also reduce the second risk, by shortening the period over which price risks were relevant—thus an equipment installation or maintenance company relying on certificate revenues would no longer need to consider the possibility that the price of certificates in could fall dramatically when deciding whether or not to accept an installation contract. However, for longer-term business decisions, such as investing in production capacity or training of a workforce, certificate price volatility would remain a risk.

The main reason for the Taskforce's conclusion was that: "[i]n contrast to the electricity obligation, the [heat] obligation would rest with a supplier who had no control over the many, varied and often small users and producers of heat" (Defra 2005, p. 22). It is not entirely clear from this whether the chief objection is the heterogeneity and small size of heat market producers and consumers, or the lack of a relationship between suppliers and either users or producers. In principle, the lack of a relationship (or "control") would not appear to be a major obstacle. The essence of the tradable certificate approach is to create two separate commodities: first, use of renewable heat is compensated in standard energy markets through the demand for the physical output; second, a separate source of compensation is created through the "green" certificate, which is traded separately from the heat output. The two markets are not overlapping, and in principle the supply of renewable heat can be separated from the demand for certificates.[43]

As discussed above, it may well be the case that a more active involvement of suppliers will be necessary in the heat market than has been observed in tradable certificate schemes for renewable electricity. Even so, it is not clear that the lack of a relationship between energy suppliers and heat consumers would be a problem. In practice, energy suppliers would not identify potential measures or carry them out themselves, but would contract with other parties (similar to the arrangements in the EEC). Nonetheless, the feasibility of the policy would depend on finding administrative procedures that allowed suppliers or other parties to take on much of the administrative burden. As discussed, it also would depend on contractual arrangements that shielded consumers from much of the complexity of the policy as well as the revenue risk associated with certificates. Finally, it would require arrangements for the award of certificates that ensured the effective participation of small and large suppliers as well as manufacturers and installers.

We agree with the Taskforce's conclusion that "the complex details of such a scheme would inevitably take a considerable time to draw up and implement". We do not believe that this complexity would be significantly greater for an RHO than for other instruments. This becomes clearer if we consider some of the detailed implementation issues that would arise under an RHI, which we turn to next.

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[43] In the UK electricity market vertical integration of generation and supply means that there is a coincidence of organisations generating renewable electricity and incurring obligations under the Renewables Obligation. However, this is not a necessary feature of a TGC schemes, and other electricity markets with less vertical integration have similar certificate schemes for renewable electricity. In any case, for the vast majority of renewable electricity produced in the UK, energy suppliers' relationship with the final consumer is largely irrelevant—investment under the RO does not occur because suppliers have a relationship with consumers, but because they have an obligation to procure renewable electricity. The existence of the transmission and distribution system means that renewable electricity can be supplied and consumed without having to rely on any customer relationship. A customer relationship therefore is not a pre-requisite for a functioning certificate scheme. It is true that the market for heat differs from the market for electricity in that the majority of heat is produced at the point of use by those who will use it—but in this sense the "market" for heat is similar to the "market" for other energy services or for energy efficiency. Thus the EEC / CERT provides a useful model for an RHO. Under the EEC and its successor, energy suppliers have found it necessary to rely on third parties to reach households where measures can be delivered—their existing "relationships" have not sufficed, and therefore (again) may not be necessary for a functioning scheme.

11.2. Policy 2: Renewable Heat Incentive (Fixed Payment per MWh)

Many of the design parameters of a Renewable Heat Incentive could be the same as those under the Renewable Heat Obligation described above. The primary difference would be that whereas the RHO would fix the quantity of renewable heat to be delivered, the RHI would set the level of financial support to be offered per MWh. Although in principle this would make the policy similar to feed-in tariff approaches to support renewable electricity supply, the structure of the heat sector means that the implementing such a policy for heat would differ in important ways, as outlined in previous chapters in this report. We discuss below the relevant features, in particular where the policy would differ from an RHO.

11.2.1. Sources of demand for measures and assignment of obligations

Under the RHI option, energy suppliers would not be under any obligation to seek out renewable heat projects. Instead, they would be obliged to pay a fixed level of support per MWh for any renewable heat produced. Demand would therefore come directly from consumers, who would need to be offered attractive subsidies and prices to consider renewable heat alternatives.

Assigning obligations under an RHI would raise some considerations that do not arise under an RHO. It would be necessary to identify which party had the obligation to accept certificates from a particular renewable heat project. In electricity feed-in tariffs, the obligation typically is based on geography, so that the owner or operator of an electricity network has the obligation to pay the premium tariff at the point at which the renewable electricity is fed into the grid. This model would not be applicable if the RHI obligation were on energy suppliers, as suppliers in the UK do not serve a specific geography but instead aim to be national in their scope. As a consequence, there is no obvious default supplier that should be obliged to provide the payment to renewable heat production. In this sense, an obligation on DNOs would be more straightforward, as there only is one gas and one electricity DNO active in a particular area, and obligations to make payments under an RHI could be defined accordingly.

If the obligation were on suppliers other arrangements would be necessary. One option would be to oblige the previous supplier of the consumer receiving the renewable heat to make the payment. This could lead to disproportionate impacts on certain suppliers, however – for example, if renewable heat were more attractive off the gas grid, leading to disproportionate burdens on suppliers of oil, coal, and other non net-bound fuels. “Previous supplier” arrangements also would result in a “double-hit” for suppliers, who would potentially both lose a customer and be forced to pay extra for this loss. Such arrangements would give suppliers a strong incentive to discourage the adoption of renewable heat among their own customers, which could create a barrier to the uptake of renewable heat. Also, some consumers may rely on more than one energy supplier, which would complicate the assignment of their incentive payment. Finally, there would also be difficulty determining which supplier should be responsible for new construction.

The distributional issues arising from different types of obligation could be handled in several different ways. If the obligation were on suppliers, one option would be to use an essentially random assignment of areas to particular obligated suppliers. Another would be to use transfers between obligated parties to ensure that the final burden were shared equally. Such provisions have been included used in electricity feed-in tariff programmes, including a system splitting the overall burden *ex post* so that parties in areas with high renewable resource (and therefore their consumers) do not pay more than others. In the case of heat, such arrangements may be desirable both in the case of obligations on suppliers and on DNOs, and the split could be defined according to the principles discussed in section 7.1.1 (e.g. based on number of customers, or amount of energy input or heat output supplied / distributed), aiming to ensure that all electricity and fuel consumers paid the same amount towards the subsidy of renewable heat. One potential difficulty is to ensure that small companies did not face cash-flow risk from any *ex post* adjustment of payments. (Also, combining a "previous supplier" arrangement with an ex-post system of balancing payments seems likely to be complicated.)

As noted, one way to handle many of these potential problems would be to empower a central purchasing authority to fund all qualifying renewable heat, and then to charge each energy supplier, DNO, or other obligated party a pro-rata fee each quarter or year to cover the costs of support. Such an agency could be very similar to the type of central authority required to run a grants system, except that funding would be explicitly linked to parties in the energy supply chain.

11.2.2. Renewable heat measures chosen

The measures chosen under the RHI would be expected to be those that could profitably generate renewable heat at a cost less than the per-MWh subsidy offered (plus any contribution from heat consumers). Because the obligated parties would not choose specific projects to fund (but would be required to accept and pay for any certified records of renewable heat presented to them) it is possible that there would be less risk of a potential "bias" that may arise under an RHO against measures that would reduce sales by their own customers. As noted above, however, it is not clear how significant a problem this would be under an RHO.[44] Conversely, under an RHI the obligated party would have very little incentive, if any, to encourage the adoption of renewable heat measures at all, unless they believed it would be profitable for them to do so.

11.2.3. Heat monitoring

The monitoring requirements under an RHI would be similar to those of an RHO—it would be necessary to keep a certified record of the production of renewable heat (or some proxy for it, such as the supply of biomass fuel) in order to make a claim for the incentive payment. One difference may be that there would be a greater need for up-front crediting – and thus deeming – under an RHI than under an RHI, as discussed below.

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[44] "Own customer bias" would remain if individual suppliers were required to pay for measures undertaken by their own customers (even if they could expect to be reimbursed later), so this is another possible reason to prefer an approach that relied on a central authority for collecting and distributing the RHI.

11.2.4. Administrative and contracting arrangements

11.2.4.1. Administrative arrangements

The administrative requirements of an RHI—including the reporting and verification requirements—would be similar to those of an RHO. As we discuss below, it may be necessary to centralise the purchase of certificates in a single agency. This agency would then take on many administrative responsibilities, including ensuring that measures receiving support actually delivered renewable heat. This would need to be done through the maintenance of a "paper trail" similar to the one required under the RHO option for tracking certificates. Similar monitoring requirements could be established for each technology and consumer type. One difference from the RHO would be simplified procedures for trading of certificates, which would be bought at a fixed, pre-determined price.

11.2.4.2. Contracting arrangements

Renewable heat equipment installers, manufacturers, and fuel suppliers would have certainty about the support provided per MWh under the RHI option (subject to adjustments to the level of support). Thus the risks associated with a volatile certificate price would not be an issue under the RHI. In addition, in contrast to the situation under an RHO, parties with an obligation under the policy would have much less reason to make efforts to initiating renewable heat projects by employ managing agents or to partner with installers or equipment or fuel suppliers. Instead, parties at each level of the supply chain would need to form their own partnerships, to offset the up-front costs of many of the technologies considered, as discussed for the RHO. For example, renewable fuel suppliers might agree to share with equipment manufacturers a portion of the per MWh support they expected to receive, in exchange for the opportunity to supply customers.

As with the RHO, however, such arrangements would expose the manufacturer, installer or fuel supplier to risks, depending on the contractual arrangements. For example, if manufacturers or installers were promised a share of actual per MWh revenues from a particular biomass fuel supplier, lower-than expected utilisation rates would leave them out of pocket, whereas the fuel supplier would have its (variable) costs covered. And even if utilisation were as expected, manufacturers or installers could be left exposed if customers were able to find alternative fuel suppliers who were "unburdened" by agreements with equipment suppliers. To be indemnified against such risks, equipment suppliers would need to receive up-front payments from fuel suppliers to cover equipment and installation costs. As noted above, it is not clear that biomass fuel suppliers would be able to cover these up-front costs and take the associated risks upon themselves. Similar risks would attach to the supply of renewable heat technologies whose costs were primarily the up-front equipment and installation costs.

For these reasons, similar to the situation under the RHO, there would likely be a need to award payments up-front to equipment installers, in addition to any support to defray variable costs. Such up-front support from the policy is likely to be even more important under an RHI than it would be under an RHO. As noted, under an RHO, energy suppliers would find it necessary to seek out projects to meet their quota targets, and thus to offer such up-front inducement to secure equipment and installation. This would be true ***regardless*** of whether or not the policy itself were designed to provide for the ***ex-ante*** award of certificates.[45] Under the RHI, if there were no such ***ex-ante*** award, equipment suppliers and installers would have a diminished incentive to offer their services.

These considerations again point to the potential need for a central authority that would be able to divide payments between equipment suppliers requiring up-front, one-off subsidies and other parties in the supply chain who would require an ongoing subsidy. Equipment suppliers and fuel suppliers would apply to this authority for payment, and would receive funding accordingly. Under such a policy, up-front funding would be very similar to a centralised grant scheme. As discussed above, there is some question about the feasibility of administering such a scheme on the necessary scale.

Although the arrangements under the RHO option (by which certificates are awarded in advance) would be similar to the up-front payment described here, the operation could differ in important ways that could help to ensure more cost-effective delivery of the policy. For example, more flexible contracting between energy suppliers and equipment suppliers / installers under an RHO could result in cost discrimination that would reduce costs to consumers[46]—whereas under the fixed support offered by the RHI, equipment manufacturers or installers could receive significant inframarginal rents.

11.2.5. Crediting periods and timing of support

For the above reasons, up-front crediting is likely to be even more important under an RHI than under an RHO. Whereas energy suppliers may out of necessity be compelled to offer up-front subsidies to meet their obligations, under an RHI there would be no such obligation

11.3. Policy 3: Hybrid Option

The third policy option considered above would be based on the RHO, but with additional mechanisms to restrict the volatility of the price, either to control costs or provide greater certainty about the level of support for the renewable heat supply chain – or both. Because the renewable energy targets set by the EU and adopted by the UK apply to total energy use, one important policy design option to consider is a policy that would ensure the most cost-effective use of renewables to generate both heat and electricity. This could be done by explicitly linking the RHO to the RO. The buy-out provision of the RO provides an effective cap on the overall cost of the policy. In addition, the RO has developed so that the buy-out price is now expected to serve as a price floor on the level of support offered.

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45 Although, as noted, some degree of up-front crediting may be necessary to ensure the effective participation of small suppliers, and to make it possible for suppliers to access the full lifetime revenue of certificates from a project.

46 Some participants in the EEC supply chain have observed that an element of price discrimination appears to exist in the markets for energy efficiency measures under the EEC.

11.3.1. Sources of demand for measures and assignment of targets

The demand for measures and associated certificates would still come from obligated energy suppliers. Targets would be more straightforward to assign, because there would no longer be a distinction between the supply of heat or electricity. Nevertheless there would still be a need to consider the conversion between the two forms of energy. Delivered electricity typically requires more primary energy input than delivered heat, so a judgment would need to be made about whether targets would need to be based on primary energy consumed or energy delivered—or whether some other "exchange rate" or mechanism for "banding" should apply.

11.3.2. Renewable heat measures chosen

The choice of measures could potentially differ dramatically under this option, because of the possibility of substituting renewable electricity measures for renewable heat (and vice versa). As for the assignment of targets, a key policy design parameter would be the conversion between heat MWh and electricity MWh. This would have a bearing on the number of certificates awarded to biomass used for heat and/or electricity, and to heat pumps, which use (renewable) electricity to generate heat. An important challenge for this policy option would be to try to ensure consistent incentives that would reward the most cost-effective use of renewable resources. Note that ensuring (short-term) cost-effective delivery is complicated substantially by the existence of banding within the RO.

11.3.3. Heat monitoring

Heat would be monitored under arrangements similar to the RHO.

11.3.4. Administrative and contracting arrangements

The administrative arrangements for reporting, verification, crediting, enforcement, and trading, would be similar under a hybrid option to those under an RHO.

Linking an RHO to the RO would be expected to reduce the volatility of the RHC price, but by how much would depend on Government policy to maintain "guaranteed headroom" under the RO. It also could result in substantially lower levels of support for renewable heat than would be provided by an RHO alone. It therefore could reduce the risks facing the renewable heat supply chain, but also reduce the expected attractiveness of renewable heat investments.

Contractual arrangements seem unlikely to differ substantially from what would be observed under the RHO, except to the extent different measures were chosen.

11.3.5. Crediting periods and timing of support

Linking the two policies could make it less desirable to allow up-front awards of certificates, since these are not provided under the RO. However, the different approaches may not be incompatible, particularly if up-front awards are only provided for smaller measures, or are subject to subsequent annual "truing up". As noted, the Australian MRET policy includes ongoing crediting alongside deemed monitoring and up-front crediting for smaller projects.

12. Summary and Areas for Future Research

This study has identified a Renewable Heat Obligation with tradable certificates and a Renewable Heat Incentive with fixed payments per unit renewable heat produced as the main realistic contenders for financial instruments to support renewable heat. The advantages of these policies include the possibility of long-term commitment to support and the ability to choose the most cost-effective measures across sectors and technologies. Nonetheless, the design of either an RHO or an RHI would face significant challenges, and more research and consultation with stakeholders would be required to consider options for the implementation of these policies.

A key uncertainty is the feasibility of achieving contractual arrangements that would enable heat end users to benefit from support for renewable heat without requiring significant administrative effort or exposure to risk by small end-users of heat. There is a risk that highly complex arrangements would be required, undermining the effectiveness of the policy. Under an RHO it may be feasible to encourage uptake through the active involvement and contracting by energy suppliers, similar to arrangements under EEC/CERT. Under an RHI, by contrast, other arrangements would be necessary, with contracts between other parties in the renewable heat supply chain. In both cases, it is likely to be necessary to make use of simplified monitoring and other administrative arrangements. In the RHI, and possibly under the RHO, may be necessary or desirable to credit measures with certificates or incentives *ex ante*. Even so, a risk with either policy is that the need for different arrangements for different technologies, size of project, or other heat market segments could make it complex.

A difficulty for either policy is that there currently is only limited information about the cost and potential for renewable heat. Although more research and consultation with stakeholders can address this to some extent, much of the uncertainty may be resolved only once a policy is implemented—and, possibly, fails to deliver. It therefore would be important to consider arrangements that were robust to subsequent revisions once the actual effectiveness of the policy could be gauged.

Related to this, it will be important to form a good understanding of the barriers to a large-scale expansion in renewable heat. This includes the need to develop the supply chain of key technologies and fuels as well as demand-side barriers, including unfamiliarity with the relevant technologies and the relatively low priority awarded to energy projects by many end-users in the commercial and household sectors. The extent of barriers will significantly influence what level of subsidy would be required to persuade the uptake of renewable heat (under an RHO), or alternatively to what extent measures would be taken up for a given subsidy (under an RHI). Also, the most appropriate arrangements under either an RHO or RHI would depend on which end-use sectors, renewable heat technologies, and fuel counterfactuals would be the most important for the achievement of a large-scale increase in renewable heat.

Finally, it also would be important to consider the market impacts of the policies. Both would lead to increased energy prices, and there is a risk that there would be large "overpayment" for some technologies or market segments. This could be mitigated through differentiation of support, but it would be important to consider how such arrangements would affect the cost-effectiveness of the policy. Another area for investigation is whether an RHO or RHI would have adverse impacts on non-renewable fuel markets, and especially on small suppliers.

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