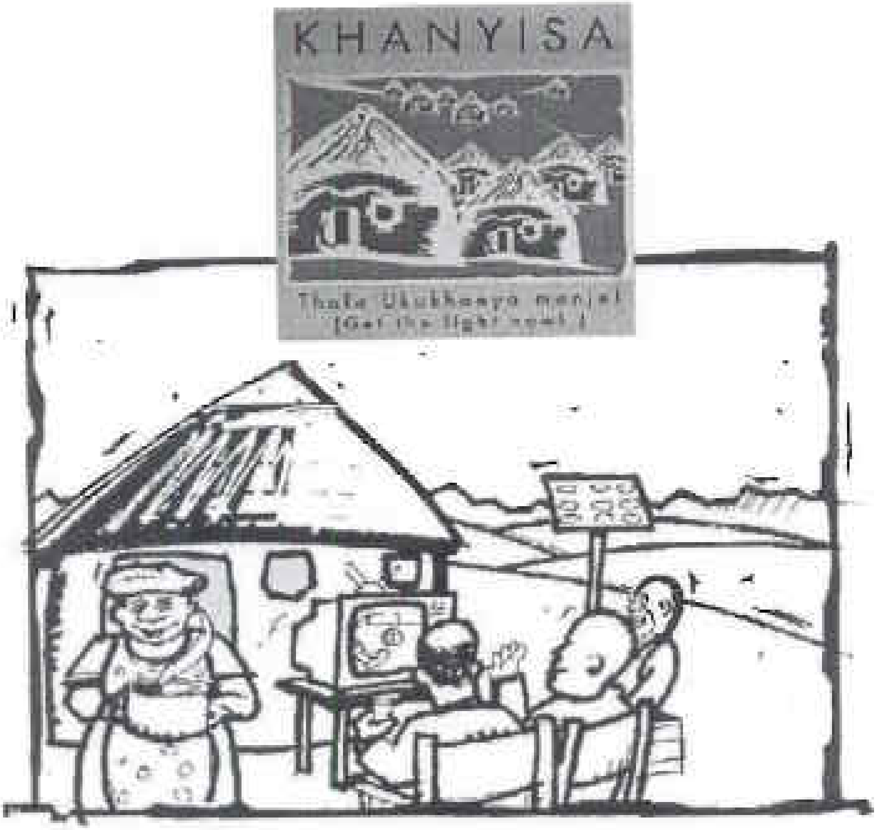
Report

Integrating Renewables into Energy Systems



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EXECUTIVE SUMMARY

i. The relationship between energy and development is essentially an empirical one: the greater the degree of development the higher the demand for energy. At the basic subsistence level, the need for energy can dominate people's existence as they struggle to provide energy for the home. Once this level has been passed, increased demand for energy is expressed in numerous ways, including through the desire to support access to: education; high quality lighting, radio/TV; the energy needed for pumping water and sewage processing; powering health clinics; as well as support increased enterprise via provision of shaft power; improved food processing and storage etc.

ii. Historically, this need for energy has been met by expanding national electricity utility monopolies. However, the recent trend towards the liberalisation of the electricity supply sector has tended to stimulate increased interest in smaller and more flexible generating plant that, in turn, means that decentralisation of generation and supply is increasingly attractive. Against this backdrop renewables hold out the prospect of providing a range of technologies that are capable of providing access to modern, more sustainable, energy service in a manner that also realises maximum alignment with the general OECD Development Assistance Committee (DAC) goals, and the Department for International Development (DFID) aim of 'the elimination of poverty in poorer countries', and the three underlying objectives of:

- Policies and actions which promote sustainable livelihoods
- Better education, health and opportunities for poor people
- Protection and better management of the natural and physical environment.

iii. It is increasingly argued that renewables represent a set of technology options that can deliver direct benefits against the above objectives in developing countries. In particular they have been shown to provide a wide range of benefits against the following agendas:

- The environment (at a local, regional and global scale);
- Sustainability, which is potentially high in terms of impact on depletable resources etc.;
- Growing energy needs (the provision of modular technologies capable of centralised or decentralised application means that rapid and appropriate energy development is possible);
- Employment (Particularly in terms of providing local employment opportunities);
- Education (schools can use renewables to meet their energy demands);
- Health (benefits include providing power to clinics, removal of smoke from cooking areas, powering water pumping/purification processes, etc.);
- Socio economic benefits (women are particularly empowered by access to modern energy services, for example in terms of reducing the time they spend collecting fuel/water);
- Building appropriate industrial and institutional infrastructure;
- Providing secure and diverse fuel supply options (and providing a degree of insulation from variations in world energy prices).

However, whilst the technologies may be argued to be appropriate they are often not the most economically attractive option. However, cost trends for renewables are downward, and as such it is projected that an increasing number of technologies will be able to directly compete with conventional alternatives in the medium term.

iv. The project recognised, from the outset, that the introduction of renewables into emerging markets is complicated by the fact that they are not yet in a position to compete entirely on their own merits. Thus there is usually a requirement for some form of incentive to be offered. However, by definition any such intervention will involve distortion of the markets and this is often not conducive to building independent and sustainable markets. This therefore places the requirements that any interventions in support of renewables needs to be for clearly understood reasons, with clearly understood goals, produce minimal unwanted market distortions, and be time limited.

v. Against this background it is hardly surprising to find that there is no single approach to incentivising the technologies, or markets, that has emerged as universally effective. This study has probed how the various interventions currently on offer are perceived by, and reacted to, by actors in a number of case studies. These were: solar hot water in China, India and Kenya; solar photovoltaics in India, Kenya, Indonesia and South Africa; biogas utilisation in China, India and Zimbabwe; wind power in China and India; energy recovery from biomass in India, Indonesia and Thailand; plus other renewables-based power schemes in India, Kenya and Thailand.

vi. Analysis of the data collected was then undertaken with the intention of providing insights into the principles of best practice as they can be applied to overcoming market, technical and financial barriers to the wider scale deployment of renewables (with minimum adverse impacts). In carrying out this analysis the approach adopted for each case study was based on the need for the following steps:

- identify the appropriate market structure, and identifying the range of actors within the markets
- establishing contact with a representative sample of appropriate actors
- seeking their views on how, and why, each group of actors react to the range of incentives on offer (and how they would like to see them being supplemented)
- analysing responses in order to establish common themes and draw out individual elements of best practice.

vii. Underlying this analysis was the supposition that it is possible to segment each market and then effectively target interventions on the appropriate (key) actors, with minimal distortion on the functioning of the wider market. Once all the case studies had been compiled the total body of knowledge was examined and lessons extracted against a number of themes, as well as against the various technologies analysed. Thus, simple guides to the principles of best practice were derived under the following headings:

- Experience of gaining access to (micro) finance
- The technical and non technical issues raised when small, typically independent, generators seek access to central electricity grid systems
- How to best undertake awareness raising and dissemination activities
- Promoting, building and operating biogas systems
- Promoting, building and operating solar (photovoltaic) home systems
- Promoting, building and operating grid connected wind power
- Promoting, building and operating solar hot water systems
- Promoting agricultural cogeneration using crop residues.

viii. The study has explored how various forms of market stimulation have been applied in a range of developing markets. In essence the study shows that there is no single approach to market stimulation that provides universal benefits. However, it does show that a combination of carefully thought through, and controlled, interventions can be used to give maximum market stimulation for minimum distortion, over a defined timeframe. In practice this implies the need to select and target interventions according to the exact context under investigation. Such interventions will typically fall under one or more of the following headings:

- Guaranteed purchase price, or price support in the form of output subsidies. There is a general trend emerging during the commercialisation phase for renewables in developed economies that there has been a marked reduction in the application of capital subsidies in favour of output (revenue) subsidies. The underlying rationale for this is the intention to enable entrepreneurial innovation and capture market efficiencies.
- Investment support. This tends to take the form of grants, capital subsidies, soft loans, and/or tax breaks, and these relatively crude interventions will continue to have a role to play. However, more indirect investment support is possible via enabling (or underwriting) access to specialist support. For example this could take the form of providing access to key technical and commercial skills via independent institutions (such as research providers) for organisation too small to support such in-house expertise.
- Promotional measures that are intended to build the "softer" side of the market by addressing deficiencies in market awareness etc. via information and education programmes. This is often associated with supporting access to specialist advice along with carefully targeted demonstration schemes. It also includes raising general awareness using carefully selected vehicles that ensure the target audience is able to make a more informed buying decision in the future.
- Large scale demonstration (i.e. direct market stimulation). This is all about government building first of a kind demonstration plants. In some circumstances this has been a successful policy, but all too often in practice the kind of protected environment associated with such schemes means that they are often not seen as building a true commercial track record. Additionally, if the demonstration scheme is too heavily loaded with early production costs, then you may be undermining the general case by making it appear excessively expensive.
- The setting of a target can in itself induce market development. However, targets cannot work on their own, they need to be supplemented by specific measures. In addition a target in itself may not be a good thing, as they tend to become an end in themselves (i.e. norm setting) rather than being used as a visible indicator of progress towards underlying goals.
- It is possible to address some existing market distortions by looking at the legislative and regulatory process. This can involve empowering third party power production (at levels ranging from multi megawatt independent power producers down to solar home systems installing a number of systems), power sales outside the national utility monopoly, tariff reform, etc. However, this route is notoriously difficult to target at anything other than broad, macro level market defects.
- Voluntary agreements are an interesting hybrid between targets and legislation in so far as they can be used as the basis of an understanding between the participants which can result in increased efficiency of technology transfer. However this is only really possible when all clearly understand (and value) the arising mutual advantages (i.e. it is based on a bilateral voluntary agreement).

ix. Thus, assuming that such mechanisms can be used as practical economic instruments then this work can be used to help ensure that investment in renewables can be accurately targeted, constrained (as far as possible) to impact on the minimum number of relevant actors, and has a built in exit strategy. In turn this is expected to lead to projects that have an increased probability of being successful and sustainable in the longer term.

CONTENTS

1 INTRODUCTION

1. This report contains the findings of the work undertaken by ETSU on the Department For International Development (DFID) funded Research Project R6485 "Integrating Renewables in Energy Systems". The work also draws upon complementary EC DGXVII Synergy Programme funded work undertaken in India. The Indian work was published as 'Commercial and Regulatory Frameworks for Integrating Renewables into Energy Systems'. Overall, the work set out to provide guidance aimed at renewable energy developers (including donors) and policy makers. These guides are, in turn, based on developing an improved understanding of the most cost-effective market mechanisms able to promote renewable energy in developing countries. This in turn provides insights into the principles of best practice as they can be applied to the identification of the means to overcome market, technical and financial barriers to the large-scale deployment of renewables.

2. The findings contained in this volume (Part I: Main Report) are based on the production and analysis of 18 case studies based on renewable energy related activities in China, East Africa, South Africa, Indonesia and Thailand. The case studies cover: solar hot water in China, India and Kenya; solar photovoltaics in India, Kenya, Indonesia, and South Africa; biogas in China, India and Zimbabwe, wind power in China and India; energy recover from biomass in India, Indonesia, and Thailand; and power schemes in India, Kenya and Thailand.

3. The preliminary findings of the work were aired at a series of participatory workshops held in India, Kenya, China and Zimbabwe. The case studies and summaries of the workshops are presented as a separate volume (Part II: Case studies and workshop proceedings). The whole study is essentially based on meetings with as many participants in the case study areas as it was possible to interview. In each case the intention was to record the views of a wide cross section across the range of interested, and involved, parties.

4. Section 2 of this portion of the report discusses the role of energy in the general development process. In particular it shows how the process of development tends to stimulate a demand for energy which is often (erroneously) simply expressed in terms of electricity demand. For example the derived energy demand is often embedded within wider goals such as provision of water and sanitation, education, healthcare, empowerment of women etc. Meeting the emerging energy demands of the development process can be met simply by providing access to bulk electricity from a national grid, but this may not be efficient, practical or economic. When grid extension is not an economic or practical proposition, then an analysis of the attributes of alternative energy sources can be instructive. Whilst such sources may not be as flexible as a grid connection they can bring additional benefits, some of which are closely aligned with the underlying development process. The range of technologies described as renewables fall into this category, and they are discussed in Section 3.

5. However, introducing new energy options to emerging markets is not simple, and will often require the application of incentives and subsidies to overcome existing market distortions or barriers. The attributes for such market interventions form the basis of this work, and are discussed in general terms in Section 4. Section 5 then sets out the way the macro environment impacts on the development of energy markets. The mechanism for taking the case study analysis down to the local level (the micro environment) is discussed in Section 6. Section 7 then sets out the findings of the case studies (taken as a body), whilst section 8 sets out a critical appraisal of the work and its findings. Finally Section 9 sets out areas where further work is required, and also how the findings can effectively be disseminated.

2 ENERGY AND DEVELOPMENT

6. "It is hard not to be daunted by the scale of the problem of providing modern energy services to the world's rural population. ... For though the problem is daunting, practical and affordable prescriptions are now available." This extract from the foreword to the World Bank brochure "Rural energy development for two billion people" is a statement of the agenda that the World Bank, and other agencies, are beginning to develop. In particular they are looking to:

- promote a wide variety of energy choices;
- reduce subsidies and distorting tariffs;
- lower the first cost of energy services;
- provide innovative credit and financing;
- encourage diversity of innovation and investment;
- emphasise local participation/ industrial development; and
- address market failures.

7. But why are agencies such as the World Bank and DFID interested in investing in energy? The reasons for this lie in the relationship between the general development process and energy use. In short the relationship is an empirical one such that the greater the degree of development the higher the demand for energy. This is seen at all levels. At the basic subsistence level the need for energy can dominate peoples existence as they struggle to provide energy for cooking, and the need for energy to transport water to the home. Once this level has been passed increased demand for energy is expressed in numerous ways, for example via the desire to access more modern energy services to support access to education via quality lighting and radio/TV; meeting the energy required to pump water and in sewage operations; support to health clinics; and in providing support to increased enterprise (e.g. via provision of shaft power, improved food processing and storage, etc.). Thus it can be argued that the relationship between energy and development is like that between a cart and a horse. The provision of horses will almost certainly stimulate a demand for carts, whereas provision of carts will probably not establish an instant demand for horses.

Solar Home System, KwaBaza, South Africa

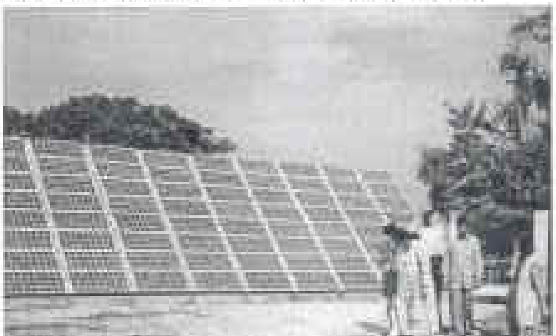
8. Traditionally access to increased energy services has taken the form of (national) aspirations to connect as high a proportion of the populace as possible to an integrated national electricity supply grid. Electricity fed into these grids being produced by central power stations sized to capture maximum economies of scale and minimise technology transfer problems. This process led to many developing country electricity utilities undertaking huge expansions of their centralised electricity supply infrastructures. However, the economic case for such expansions were often not made with the result that utility bankruptcy is only staved off by crippling intervention from the central exchequer.

9. Thus the desire to copy the developed world's model of state owned monopolistic utilities that dominated until the 1980s has often proved problematic. Indeed it has also proved problematic in the developed world, with the result that many countries have felt it necessary to break up their monopoly utilities and replace national economies of scale with the increased efficiency of smaller, typically private sector, utilities. The benefits of this in terms of access to cheaper energy have been clearly demonstrated in counties such as the UK.

10. But how can these lessons be implemented in the developing word? The answer is not simple, and models for attempting this are still emerging. However, it does appear that in general the process is dependent upon the liberalisation of the generating sector (including giving greater access to the grid) and the development of smaller and more flexible generating plant. A natural corollary of this trend is that decentralisation of generation and supply is increasingly attractive, as is smaller plant size. Add to this the need to increase the sustainability of electricity production and general environmental protection trends and the reasons for the rise in interest in cleaner technologies, including renewables, over recent years become clearer.

11. Overall it is the combination of general economic goals with the inherent technical (and implied socio economic) attributes of renewable energy technologies that explains why these options are an increasingly desirable choice. Provided the background conditions are right, one of the most powerful ways to improve energy supplies is to ensure that the energy market is determined by consumers' choices. In particular this means that the price of energy should reflect its cost and that regulation of energy industries should encourage competition and choice. This will ensure that there is a level playing field for different investors in energy, whether they are public utilities, private firms or enterprises set up by the local community.

12. In summary current thinking is increasingly arguing that smaller, flexible generating plant including renewables represent a set of appropriate technologies for the developing world. This is based on their ability to deliver against a number of relevant agendas including; (local, regional and global) environment, sustainability, meeting growing energy need, employment opportunities, competitiveness, security and diversity of fuel supply etc. However, whilst the technologies may be appropriate they are currently often not seen to be the most economically attractive (least cost) option. Cost trends for renewables are downward, and it is projected that an increasing number of technologies will be able to directly compete with conventional alternatives in the medium term. However, in the short term this is not the case and hence in most cases renewables based schemes will normally only proceed if there is some form of external incentive on offer. Incentives may also be justified on the grounds of a need to address market failings and deficiencies. For example, it is often argued that a degree of interference is currently required in order to provide "a level playing field" for renewables by addressing the often pernicious and perverse support in place for entrenched conventional technologies. Thus, any "levelling of the playing field" would set out to eliminate existing tax, subsidy and import distortions that currently effectively discriminate against renewables in favour of fossil fuels. However, if not managed



PV Battery Charging Station, India

very carefully such reforms will simply result in the substitution of the "old" distortions with a new set without any real progress being made.

13. The desire to stimulate renewables markets, and the related need to incentivise their deployment creates a paradox. The paradox is based on the recognition that, in general, incentives and associated market distortions are seen as undesirable: but without them competitive, commercial, market frameworks for renewables (and other novel technical options) are unlikely to emerge. Thus, until renewables are capable of competing without incentives there is a real and practical challenge to implement approaches that minimise undesirable market distortions whilst effectively capturing the full range of benefits associated with access to such modern energy technologies whilst simultaneously overcoming current market inefficiencies and barriers.

3 RENEWABLE ENERGY TECHNOLOGIES

14. Considered as a group, renewable technologies have a number of important features that distinguish them from conventional energy technologies. Although each of these features does not necessarily apply to all renewable technologies, certain common characteristics are worth noting. These are:

- Some technologies such as wind, hydro and geothermal aquifers have been used for many centuries. However, in their modern guise most renewables are based on relatively new technology and hence have yet to be widely accepted as technically mature and commercially viable.
- Renewable energy technologies have relatively low environmental impacts. In their operation they produce little or no net emission of polluting gases, they tend not to deplete scarce resources, and they are relatively safe in operation.
- Many renewable energy technologies are available in a wide range of capacities. Wind turbines and hydro schemes are available from a few kilowatts up to multi-megawatt scale. Most other technologies can be considered modular in that they can be readily aggregated to make a larger system. This range in available capacities allows renewables to be tailored to meet the characteristics of particular resources and markets.
- The time taken to develop a renewable energy technology can be considerably shorter than to bring on stream (typically much larger) conventional power systems. This makes renewable technologies attractive in areas where there is a need for power with only limited existing infrastructure.

Wind Powered Water Pumping, Kenya

- Renewables tend to have a high initial investment cost (as measured in £/kW, but can be viewed as low in total £ invested terms) and low operating and maintenance costs. This is a natural consequence of technologies utilising free resources with a high conversion cost.
- Some of the renewables are only able to provide power intermittently. The output from sources such as wind, solar and wave is variable in both timing and power, as they are dependent upon the prevailing weather conditions and thus are unpredictable for more than a short time ahead, although in any given climate the resources tend to vary in characteristic ways. The biofuels are exceptions to this rule as they utilise an organic resource which can be stored, like a fossil fuel, for use when required. The variable and energy limited nature of renewables is sometimes cited as an impediment to their integration within a conventional supply system.

3.1 Biogas

15. Wet wastes such as 'green' agricultural crop wastes, farm slurry, night soil, and certain industrial effluent streams can be utilised - via anaerobic digestion - to produce a methane rich gas ("biogas") that can be collected and combusted in much the same way as any fossil fuel based gas. The impetus for biogas production may be environmental in nature (e.g. to protect

local drinking water sources, or to meet effluent discharge standards) or it may (more rarely) be based on energy provision.

3.2 Solar Photovoltaics

16. Photovoltaic (PV) materials generate direct current electrical power when exposed to light. Power generation systems using these materials have the advantage of no moving parts and can be formed from thin layers (1 to 250 microns) deposited on readily available substrates such as glass. To date, the photovoltaic effect has been widely exploited where the low power requirements, good solar resource and simplicity of operation outweigh the high cost of PV systems. Current applications include consumer goods, such as calculators and watches and, on a larger scale, power systems for lighting and water pumping in developing countries and in remote areas with no grid supply. Other potential applications include "professional" systems such as remote telecommunications facilities and cathodic protection of pipelines.

17. There is world-wide interest in developing PV systems for future power generation because of the huge potential renewable resource available and the environmental benefits offered by a technology which avoids the emissions and pollution associated with fossil-fuelled plant.

3.3 Wind Power

18. Wind power has been harnessed by Man for over 2,000 years and is currently viewed as having great potential for electricity generation. The existing technology offers a range of power ratings from a few kilowatts up to several megawatts. The technology is well established, with over 20,000 grid connected machines in operation world-wide. There are two basic design configurations - horizontal axis machines and vertical axis machines. Horizontal axis designs are at a more advanced stage of development and the evidence is increasing that they are also more cost-effective.

19. Wind power is an intermittent resource which is strongly influenced by geographical effects such as the local terrain. In addition there are limitations on the availability of land for wind turbine sites due both to physical constraints - such as the presence of towns, villages, lakes, rivers, woods, roads and railways - and institutional constraints such as the protection of land areas designated as being of national importance.

3.4 Solar Thermal

20. Solar thermal systems consist of solar collectors, which transform solar radiation into heat, connected to a heat distribution system. Hot water (typically in the range 60 to 80 °C) can be obtained using simple collector arrays. These can be the basis of domestic hot water supply (and can be designed to operate without the need for pumps), or as a source of low temperature process heat.

21. If the solar resource is plentiful then it is possible to use a variety of concentration techniques to transform the solar radiation into electricity. This is possible using a variety of approaches such as mirror arrays, trough collectors etc. The approach may, in principle be such that the sole energy input to the system is solar, but no commercial power station has yet been constructed on this basis. Current activity is focused on using concentrated solar radiation to pre heat boiler water in conventional power stations. This duel fuelling improves the overall economics of such plant, and also allows power generation to continue when there is no incoming solar radiation.

3.5 Direct Combustion of Biomass

22. Biomass available for direct combustion ranges from agricultural and forestry sources (either as industrial residue or via scavenging) to specialist energy crops grown specifically for energy purposes. Many methods for the conversion of biomass into energy services are available, reflecting the diversity of the final uses and the resource. At one end of the spectrum are simple combustion systems, whilst at the other end there are well-developed systems of varying scale available to provide direct industrial scale heat or electricity from biomass. In these applications electricity is usually produced by burning wood in a boiler to generate steam that is fed to a turbine. More advanced technologies involving gasification are being demonstrated in several parts of the world. These should allow electricity production at higher efficiency and lead to significant reductions in costs.

23. The use of biomass for energy production has one factor that inherently makes it potentially complex for larger scale deployment - the need to secure a fuel supply (often from a third party). This is a particular problem since biomass fuels are not internationally traded commodities but locally collected and shipped to the point of use, and hence security of fuel supply is often an issue. This distinction also means that the fuel cycle essentially becomes internalised within the technology, as opposed to say coal combustion where the problems of supply are usually considered separately.

24. A specific subset of biomass combustion is its use in cogeneration. Cogeneration is where both heat and power are produced at the same time ("combined heat and power"). In those cases where the biomass (e.g. in the form of a process residue such as the bagasse produced during sugar cane processing) is produced locally it can form an attractive fuel source. This is particularly the case where agricultural produce is centrally processed and a suitable fuel produced. In such circumstances combustion of the residue may make the plant self sufficient in energy terms or even allow export of heat and electricity (e.g. combustion of bagasse residue in sugar mills).

3.6 Small Scale Hydro Power

25. Hydro power comes from the energy available from water flowing in a river or in a pipe from a reservoir. Evidence of the use of hydro power as a source of energy has been found in primitive devices from the first century BC. During the Industrial Revolution, small-scale hydro power was commonly used to directly drive mills and various types of machinery; now hydro power is usually used to generate electricity.

26. Hydro power technology is in many respects the best known and most widely commercially deployed of the renewables. Turbine plant, engineering services and turnkey systems are sold by UK and overseas organisations. Numerous schemes have been built, ranging from installations ranging upwards from less than 1 kW to thousands of MW. In this study only small scale hydro power is considered. Such schemes are either based on run-of-river or small dam construction. The maximum scale of small scale hydro is not consistently defined, but tends to be in the region of 10 to 25 MW. Small scale hydro schemes avoid many of the environmental problems associated with large scale developments and the scale is better matched to local demand for power.

4 INCENTIVES AND SUBSIDIES

27. At their most basic level the role of all incentives is to distort the market in order to "steer" it towards what is perceived to be a desirable and sustainable solution. The most prevalent market distortion that exists is subsidy. Subsidies for electricity consumption are a particular problem, for example the World Bank reports that such subsidies are harmful in a host of ways, including:

- they constitute a huge and ongoing financial drain and may result in utilities becoming economically crippled (or the general tax burden will have to increase) ;
- subsidised supplies can undermine efforts of businesses to provide cheaper ways of generating electricity; and
- in general subsidies tend to benefit rich people more than poor.

This is not to say that subsidy *per se* is a bad thing - some subsidies may be justified: but only if they are limited to specific (and affordable) goals, and there is a prospect that the final position can be sustained without the need for further subsidy.

28. Thus, in saying that an increased penetration of renewable energy technologies is desirable (for a range of reasons), we must work within an apparent paradox. Incentives and associated distortions are often undesirable, but without them market penetration of new technical options is difficult. The difficulties inherent in entering any market can be compounded if existing incentives and distortions serve to increase the barriers to new entrants, rather than reduce them. It is the presence of often pernicious and perverse support measures for entrenched conventional technologies in the current energy markets that is the basis of the much argued case for renewables to attract positive interference so as to provide "a level playing field".

29. Incentives for renewables may also be justified on the grounds of a need to address market failings and deficiencies. These can include factors such as: the need to address excessive transaction costs; encouraging diversity of innovation and investment; emphasising local participation; need for local industrial development; etc.

Rural Electrification, India

30. Given this paradox the basic ground rules for supporting the move of renewable energy technologies into competitive energy markets begin to emerge. They acknowledge that in the short term at least some support is required, but that such support must be carefully targeted where actually needed, it should not be perverse in operation, and it should be capable of being withdrawn, at a later date, without damaging the emerging market.

31. Overall then it appears that the ultimate goal is to effectively influence liberal and competitive markets by use of controlled interventions and distortions. The objective being to "encourage" the market to move in a particular direction, and then when it arrives at the

desired end point to remove the distortion and then leave a 'perfect market' behind. This sort of utopian interference assumes that markets are capable of clearing at the desired equilibrium point. However, should the support be misapplied or withdrawn at the wrong time the result will probably cause immeasurable harm to most of the players. If the support mechanism is wrong the market will be distorted as to be incapable of moving towards the desired end point, or of returning to the previous status quo. Thus the process of "guiding" markets in the current increasingly liberalised context must be much more subtle (and short term) than has historically been the case.

32. So, is it possible to control, and by inference minimise, market distortions? The assumption that this is possible is the starting point for this project. The approach applied in this study is based on the application of a number of simple underlying principles derived from modern marketing practices. In essence these involve segmenting the intended markets by identifying groups with shared, relevant, attributes and then focusing interventions based on this market (actor) knowledge.

33. The first stage in undertaking such a segmentation exercise is an analysis of how interventions are viewed to act (or perceived to act) in various circumstances by the various parties within the market. That is to carry out an analysis that clearly indicates who is playing, why they are playing, and how they react to what is on offer (i.e. how the intended beneficiaries actually view what is, or could be, on offer). This segmentation exercise is described in more detail in Section 6.

34. Once equipped with a suitable market segmentation the project then moved on to probe what these groups need (and desire) from their involvement, then to take the short step to talk about how they (and only they) can be efficiently incentivised. It is this information that is the key to effectively targeting future interventions. Armed with such market knowledge it is argued that the impact of carefully targeted incentives will be that only minimal, focused and temporary market distortions will result, and that hence the probability of a dynamic and sustainable market emerging will be increased.

5 ANALYSIS OF THE MACRO-ENVIRONMENT

35. To integrate renewables in the most effective and successful way, the drivers for development need to be identified on a household scale, a community scale and a country wide scale. Actions intended to encourage uptake of renewable energy sources must take these drivers into consideration, particularly if technology deployment is to be in harmony with the needs of the people and to fit in with the wider agenda for development. To aid this analysis the study has analysed the country and regional impacts at a general level - the macro environment. The more local issues were then included in an analysis of the more detailed micro environment, and this was explored in detail in each of the case studies.

36. Against this background it must be borne in mind that one of the problems in carrying out a generic study of activities and actions in developing countries is the development of a methodology that is capable of reconciling the widely varying agendas of the range of stakeholders. This is compounded when the broad spectrum of socio-economic conditions existing amongst these countries is also taken into account, with the result that the degree of complexity increases considerably.

37. For these reasons analysis of the data gathered during this project was carried out at the macro level in order to set out the context in which individual case studies must be set. A knowledge of the type of macro environment is necessary as it affects the way in which incentives operate. For example in the case of financial incentives private equity can be readily mobilised in *laissez faire* markets, but not so easily in command ones, where public equity will be much more prevalent. Other incentives that can also be affected by market type include:

- Regulation (e.g. planning, standards, certification)
- Information/education
- Research and Development (R&D)
- Voluntary agreements
- Market based instruments (e.g. tax, tradable permits).

38. Underlying this there are also variations in why countries want to introduce renewable energy technologies, and this needs to be understood. As previously asserted introducing renewables can bring a range of benefits. The factors that often underpin this desire are numerous, and vary in importance between countries. Table 1 sets out a crude (and essentially subjective) analysis of the broad factors that can underlie such programmes. The Table lists highlights a number of drivers and shows how they are seen to differ across the surveyed range of countries (with figures for the UK included to show a typical developed country agenda).

39. Similarly, the economic environment will vary from country to country. This is illustrated in Figure 1, which shows how selected countries can be argued to fit (at the current time) into the spectrum of market types that lies between pure *laissez faire* and rigid centrally planned command type economies.

Table 1: Underlying Drivers for the Introduction of Renewables

Factor	*Priority, on a scale of 1(low) to 5 (high)*				
	India	Zimbabwe	Kenya	China	UK
Sustainability	3	3	3	4	4
Energy Need (population growth)	5	4	5	3	2
Technology	4	4	2	5	4
Financing	3	2	4	4	5
Institutional deficiencies	4	5	4	5	2
Efficiency (energy intensity)	2	2	2	3	3
Environment					
Local	4	3	3	4	3
Regional	2	2	2	4	2
Global	3	2	2	4	5
Employment	4	3	3	5	3
Cohesion	1	3	1	3	2
Security & Diversity (import dependency)	2	3	4	2	2
Competitiveness	1	1	1	2	5
Integration	3	2	2	4	2
Decentralised supply	4	3	3	4	1
Nuclear alternative	2	1	1	1	3

Figure 1: Market Types

Laissez Faire	*Consensus*	*Command*
UK	India	Kenya
	Thailand	China
	Indonesia	
		Zimbabwe
	← MARKET LIBERALISATION ←	

40. Underpinning this approach is a simple factor analysis. This is where pertinent factors are grouped as relevant to the Sociological, Technical, Economic, Environmental, and Political (legal) agendas. How these can be structured to facilitate the analysis is shown in Table 2.

41. In order to capture the underlying general development gains from activities in the energy sector (see Section 2) it is very important to concentrate on the social and cultural impacts of energy systems in developing countries. In many cases these factors play a major role in determine the appropriateness and acceptability of energy technologies. In the context of this project, social and cultural issues were treated as underlying themes that spanned the development process and thus needed to be addressed at every point in the market matrix where a transition is taking place, or where a transition is desired.

Table 2: Standard factors for STEEP analysis

Sociological	Technical	Economic	Environmental	Political
There is adequate public awareness of the benefits to society	Proven robust technology	Adequate financial systems are in place	There is adequate public awareness of environmental issues	Legislation in place to minimise environmental pollution
The scheme meets the needs of the community directly	The technology is easy to operate and maintain	Supporting financial infrastructure exists	The scheme promotes reduction of environmental pollution	The scheme promotes indigenous production (e.g. growth in industry or agriculture)
The scheme improves amenities for local communities (e.g. power for hospitals & schools, street lighting)	Technology can be manufactured within the country of application	The return on investment is sufficient to attract support	The scheme includes sound disposal of environmentally hazardous waste (liquid, gaseous and solid)	Sale to third parties allowed
The scheme supports improvements in health/sanitation /quality of life?	Spare parts are easily available and of good quality	The scheme is financially sustainable	The scheme promotes sustainable use of natural resources	The scheme promotes or complements the national energy plan
The scheme helps to improve productivity at a household, community or industrial level	Appropriate training is given where local skills are lacking	The scheme is able to carry on after the initial period of support	The scheme promotes energy efficiency	Institutions are established in an optimal way to encourage and support the implementation of schemes
The scheme has a sense of "community ownership"	The scheme is suitable for isolated grid applications - rural development	The externalities of the scheme are taken into consideration (in economic terms)	The biodiversity of the region is protected, or enriched/regenerated	Fiscal policy complements the scheme
The scheme creates job for the local population	The scheme is suitable for large grid applications - urban development	The scheme includes subsidies or tax concessions	Natural habitats are protected or improved where environmental degradation has occurred	Regulations complement the scheme
The scheme creates increased wealth in the area other than from employment (e.g. tourism)	The scheme, is suitable for non-grid applications, e.g. industrial captive power generation	Wheeling and banking is allowed	The environmental externalities of schemes are compared on an even basis	A "must take" policy over a fixed period is included in the scheme
The scheme frees up time for women and children otherwise spent collecting firewood, or water	The scheme will encourage the most suitable energy mix to be adopted	Power is guaranteed a premium price		
The scheme addresses gender issues	The scheme is flexible enough to allow technological break through to be adopted easily			

42. Underpinning these macro level factors are a number of regional, or "meso" level, factors, particularly those where social and cultural issues impinge upon the uptake and integration of renewables. For example the scale and location of a project will influence who is most suitable to finance it, the institutional structure might create barriers to implementation and the environmental impact of schemes might conflict with social concerns. For the purposes of this study these issues have been grouped under four headings; scale/location, institutional social and cultural, and environmental. Table 3 gives examples of the issues addressed under these four headings.

Table 3: Social and Cultural Impacts

Scale and Location
- Size of project
- Size of investor: individuals, local communities or regional bodies
- Location of project: urban, peri-urban, rural
- Location of those who benefit from the project
- Location of those with disbenefit

Institutional
- barriers to implementation
- key players
- appropriate structural changes need
- responsibilities and roles
- availability of horizontal and vertical support

Social and Cultural
- how do people want to develop?
- drivers for development
- appropriate technology
- practical financial mechanisms
- training and support
- the role and influence of the people - what can they do?

Environmental
- renewable energy resource availability (including waste resources)
- sustainability
- environmental impact
- local verses global issues regarding pollution

44. Table 4 shows a selection of the actors that typically are involved in energy investment decisions, along with their roles and some indication of their "agendas".

45. For successful introduction and sustainable operation of any given project it is necessary to analyse the market structure (i.e. interdependent networks of the sort shown above). This then allows the analysis of the relationships between the actors. For the project to succeed it is then necessary to try to engineer the relationships so that the maximum number can be viewed as based on mutual benefit ("a win-win chain"). In the early days of market development it is probable that the relationships will have to be externally influenced so as to engineer the structure of the chain so that all the critical actors in it receive benefit from their involvement.

46. It is this type of analysis and the focusing of incentives on the weakest links in the chain that is felt to be the key to more efficient use of incentives when seeking to develop new market structures. However, if the market is to be sustainable in the longer term the imposed framework must be capable of being maintained (or evolving) without external inputs. This may involve awaiting changes in the market dynamics or simply helping establish some actors (or even waiting for some actors to be rationalised out of existence).

6.2 Case studies

47. The basic aim in constructing the case studies was to obtain some form of structured statements as to what represents 'Best Practice' in different circumstances, as viewed from the perspective of the (segmented) actors. The assumption is that once equipped with this knowledge then when analysis shows a market to be flawed because a role is vacant, or weak, then it should be possible to focus incentives in this area only (and hence minimise unwanted distortions). However, such flaws and gaps in the appropriate market structures are not easy to identify. In this project the approach adopted, for each of the 18 case studies, was to probe the interplay between the various actors and the incentives on offer, whilst taking account of external (macro) factors. Table 5 presents a list of the case studies. These case studies were constructed via a combination of fact finding country visits and the use of local partners.

Table 4: Actors and Roles in Renewable Energy Development

Actor	Characteristic Role	Comment
Central Government	Finances construction via national budget	Funding can overlook prevailing market conditions, political drivers can change & budgetary uncertainty
State/Provincial Government	Finances construction via delegation of national budget	Competition for funds from other priority areas, plus lack expertise in finance, management, etc.
Development Agencies	Finances construction via national budget (usually third party government)	Competition for funds from other priority areas
Local (Community) Government	Smallest formal structure concerned with infrastructure and development issues	Lack of relevant expertise in finance, construction, management, etc.
Villages	Non formal government structure	Not a formal legal entity. Limited skills, ability to plan and execute.
NGOs	Financed through third party contributions	Limited finance available
Private Companies	Investment in projects with adequate return on investment	Driven by market conditions and economics
Co-operatives	Grouping of producers/consumers with common goals	Lack of skill and expertise. Moving towards reliance on simple bottom line profit/loss or cost/benefit criteria
Families	Basic unit of society/production in agricultural societies	Low access to capital & skills. Social structures/ culture may be problem.
Lending institutions	Investment in projects with adequate return on investment	Usually need large projects and national government involvement
Education Institutions	Role can be said to be investment in manpower and human capital	These always exist at some level. Access can be restricted for women or minorities.
Utilities	Usually single purpose with a very focused mission statement	Single mission focus can cause "blinkered" view. May have vested interest e.g. in distribution system
Regional Businesses	Looking for sustainable levels of business with adequate added value	Need to reach critical mass to support activities such as custom design and installation
Local Business	Access to appropriate finance, technology, etc.	Needs institutional support plus technical backup (see also families)

Table 5: Case Studies

Country	Case Studies
China	Solar hot water, Wind power, Biogas
India	Biogas, Solar photovoltaics, Wind power, Bagasse cogeneration, Solar hot water, Solar thermal electricity
Indonesia	Solar photovoltaics, Cogeneration from agricultural residues
Kenya	Solar hot water, Solar photovoltaics, Agricultural cogeneration
South Africa	Solar photovoltaics
Thailand	Cogeneration from agricultural residues, Energy from landfill gas
Zimbabwe	Biogas

48. The standard approach to data collection, and presentation, allowed the construction of broadly intercomparable case studies. The basic case study template introduces, via a short discussion, what the case study is about and then goes on to explore how the incentives on offer operate in the given context. In deriving the case study format the underlying intention was to set out the project/programme environment; indicate what incentives are on offer (and who/how they are supposed to be attractive to); and perhaps most importantly what the work is supposed to be offering and to whom.

49. The next stage of the analysis involved discussing how each group of actors viewed their role(s) within the case study context. For each group of actors this involved setting out the nature of their involvement, along with a short discussion of the implication of their involvement. In carrying this out the following were explored, for each actor, as far as possible:

- Their perspective, i.e. stating who the actors are, and what their role is, within the case study (see next section). In each case actors were assigned to one of the categories set out in Table 4, and their comments interpreted accordingly.
- The bottom line attributes as seen from their standpoint, i.e. how each market segment (actors) feels about how the incentive framework affects them. In particular an emphasis was placed on finding out exactly what characteristics of the various types of incentive attract them, and why. Similarly if an actor indicates that they do not like an incentive this was explored to the same degree as a positive response.

50. Thus, in essence, the case studies can be argued to be based on a repeated asking of the question "What attracted you to this project/programme in the first place, and what would make it even more attractive?". In turn this reveals how the currently available incentives affect the actors at a very immediate and practical level.

51. Each case study concludes by setting out the lessons learnt, and in particular how the case study contributes to the overall project aim of identifying the building blocks of best practice. This in turn involves exploring what the various stakeholders wanted out of the work and if/why they expected to win. As part of this it was revealing to analyse how actors responded to a supplementary question of "If you could see the incentives on offer being changed what would you like to see happen?". The immediate answer was usually a request for a direct cash subsidy, but when pushed for alternatives interesting and revealing options and views were often aired. It was at this point that the importance of impact of indirect support such as via research institutions, the need for support networks, and the difference between addressing affordability rather than simply increasing access to credit tended to emerge. These themes are explored further in the next section.

7 THEMATIC FINDINGS

7.1 (Micro) Finance

52. One of the biggest problems facing renewable energy technologies is that they are difficult to finance (i.e. they are effectively expensive to purchase). This may be expressed in terms of the cost of energy supply, or more general problems arising from the unfamiliarity of many borrowers with formal credit transactions, problems in disbursing appropriate scale loans or in the relatively high degree of capital intensity of these technologies.

53. This section draws upon the experience of funding renewables investments as discussed in all the case studies. However, as the problems are most pronounced for the smaller, typically individual home, scale technologies of solar PV, solar hot water systems and biogas the experience drawn from these case studies tends to predominate.

7.1.1 Discussion

54. Despite their high initial costs in many contexts renewables are either the least cost option for providing modern energy service, or they have the potential to be least cost in the medium term. Thus, there is an underlying requirement for the development of appropriate financial instruments that can be used to support renewables, especially those that are deployed as individual units (e.g. solar home systems). The problems with providing suitable financial instruments and incentives (and building appropriate supporting institutions) runs as a common theme through all the case studies. Taken as a body the case studies show that considerable investment has been made by a wide range of bodies in developing and refining financial instruments and incentives.

55. However, no single approach can be confidently predicted to be universally successful, but all need to share the objectives of:

- making renewables affordable
- building a suitable infrastructure
- building financier confidence
- allocating (sharing) risks between the most suitable actors
- encouraging stakeholder development.

When analysing financial incentives that can be applied to renewable energy technologies it is convenient to broadly classify them as those which offer a capital subsidy (either direct or indirect) and/or those which provide a revenue (or production) subsidy. Selected characteristics of these two approaches are shown in Table 6.

56. Grants, soft loans (both direct) and tax concessions (indirect) are all generic forms of capital subsidy. Grants can be provided before, during or after the course of a project through national programmes but are progressively tied to meeting certain requirements or milestones of eligible projects. Soft loans, usually provided by funding agencies give a repayment holiday or provide subsidised interest rates. Tax concessions may be aimed either directly at the project (providing capital relief) or more recently at investors in the project (improving investment returns). Tax concessions aimed at the project capital may take the form of tax credits, preferential Value Added Tax treatment, depreciation allowances, interest deductions, R&D tax credits and capital gains tax deductions. Accelerated capital recovery is simply a policy on depreciation which allows for project capital equipment to be written-down (written-off) quickly thus reducing the tax payable in the early and more vulnerable years whilst increasing

cash flow. Such policies can also provide for a lower corporate tax rate on earnings which improves cash flow and increases the after tax returns to investors in the project.

Table 6: Selected Characteristics of Capital and Revenue Subsidies

Capital subsidies	Revenue subsidies
The level of expenditure is known to the funder from the outset	Promotes efficient, least cost, power production
The producer knows what he will receive (and when)	Easy to administer as outputs may be verifiable by third parties.
Overall capital intensity is effectively reduced	However can be difficult to apply at the individual system level
The approach cannot be refined easily	
Tends to reward construction rather than operation	Allows continuous refinement of incentive levels
Can promote a 'build and leave' mentality amongst developers	Can be difficult to prioritise selected systems or technologies
May not promote cost effectiveness and/or efficiency	Uncertain cash flow for producer if the project does not meet predicted performance levels
Tends to be relatively vulnerable to fraud	Cash flow from the funder is maximised only when production is maximised
Potentially high bureaucratic overheads	

57. In contrast, revenue subsidy is normally given as a premium on the price of energy under a direct sales contract or a preferential sales mechanism which is Government mandated. The key to a strong sales contract is to quantify the sales terms and conditions, i.e. unit price, volume and length of sales period. Over recent years revenue subsidy has begun to emerge as the preferred type of incentive for many bodies, as the underlying approach is fully compatible with the global move towards market liberalisation.

58. These types of approach can be applied at all levels, ranging from rewards to individuals through to multi-national corporations. The relative attractiveness of any given approach will vary with perspective and/or context, but it is this which allows financial incentives to be relatively accurately defined so as to appeal to (i.e. enable) a well defined target group. This is shown schematically in Figure 3. The diagram simplifies the issues considerably, as for example it does not show that there is an underlying pressure to move the underlying context from poverty elimination towards competition, via the process of 'development'. For example it can be argued that in the UK the primary linkage goes venture capital through guaranteed access/price into deregulated markets (i.e. the Non Fossil Fuel Obligation renewables support mechanism). The same can also be said of some of India's current renewables incentives. However in the poorest parts of some countries it is more likely to be aid organisation to capital subsidy (often approaching 100%) to basic energy services. Thus, there is a need, therefore, to look at how other elements within the grid can be used to enhance the development process.

59. During case study analysis, and again throughout the workshop phase of the study the potential offered by the concepts of micro credit and variations on the energy service company model were noted with interest. The reasons for this level of interest, along with the attributes of these approaches that make them potentially suitable finance vehicles for renewables, are explored in more detail below.

Figure 3: The Relationship Between Financial instruments and End User Context

Source of Finance		Application Mechanism		End user context
Individual Investor	→ ↘	Capital Subsidy	→ ↘	Basic Energy Services (Poverty Elimination)
Venture Investor	↗ → ↘	Accelerated Capital Recovery	↗ → ↘	Market Establishment (Productive capacity)
Development Bank	↗ → ↘	Guaranteed Market Access	↗ → ↘	Market Support (grid & rural electrification)
Aid Organisations	↗ →	Guaranteed Purchase Price	↗ →	Deregulated Markets (Competition)

Micro Credit.

60. Specialist providers of micro credit schemes are obvious candidates for inclusion in schemes aimed at introducing small, particularly stand alone, systems. This is because micro credits are highly flexible (being tailored to individual needs) and can assist in development, but they involve higher fixed cost of loans, can be bureaucratic and sometimes debt recovery has proved problematic. In addition such organisations tend to already work in the grey area between cash and barter economies, with the result that they are not as constrained by the need for rigid, cash based, repayment plans on an inflexible schedule.

61. However, many local credit unions, groups or banks face problems in extending their operations into the financing of small scale renewables investments as they typically do not understand the technology or context well enough to feel comfortable that they have covered their risk exposure sufficiently. Another problem that often faces specialist agricultural banks is that they may be barred, by charter, from lending outside the agricultural sector. In many cases this is taken to have a very literal meaning. Thus in some cases investment in PV systems for farm homesteads is viewed outside the strict agricultural remit.

62. In such circumstances it is necessary to analyse the charter of such organisations, and then come to a decision as to whether or not the rationale for excluding them from energy related investments is compatible with the underlying 'philosophy' of the credit body or not. However in all contexts there is a need to undertake training of local credit and finance groups on the technologies and the opportunities that exist. A critical factor that needs to be addressed is the fact that the potential users need to be educated in what finance providers require. This is not a simple process.

63. An interesting example of how deficiencies in the technical competence of the Co-operative Bank of Kenya are addressed is outlined in the Kenyan PV case study. This bank uses the combination of an existing co-operative society to onlend, and draws upon an independent

consultant to provide technical support and to ensure the appropriateness (and quality) of the installed systems. Overall security for the loans, and a grant element to cover technical support, were provided by the World Bank. The standards for the systems were drawn up by, and installation carried out under the supervision of the technical partner in conjunction with the World Bank.

64. The net result is that experience now clearly shows that dealing with co-operatives is easier and more effective than previous attempts to deal directly with individuals. This is due in part to the fact that the onlender and local co-operative normally have a history of collaboration (i.e. a credit rating), even if the individual members do not. Also the onlender may view the assets of the co-operative (e.g. tea options) as security for the loans.

65. How effective this model can prove in other contexts is very difficult to gauge. It requires both a forward thinking credit provider and a technical partner who is credible with all parties (i.e. users, local credit organisations, and the underwriting funders). Such combinations will not be easy to develop in the near term, implying that this model is not one that can be replicated easily or rapidly.

Energy Service Companies (ESCOs)

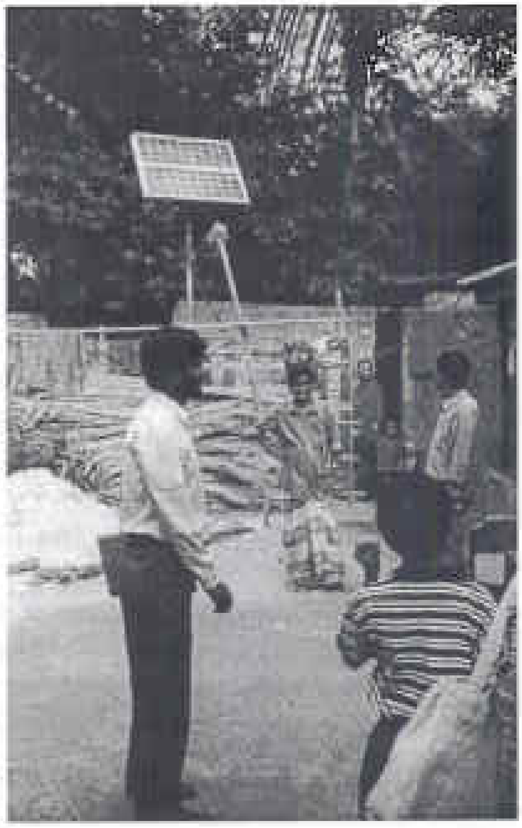
66. ESCOs function as specialist companies that are paid for providing energy service, and not for energy supplied. Thus consumers pay for energy service received (e.g. lighting) rather than having to directly invest themselves in energy equipment. Thus the hosts (and final beneficiaries) do not own the equipment but effectively 'hire' the equipment from the ESCO. On the other hand the ESCO is able, as a specialist company, to build its own credit rating and, by centralising purchasing power, to extract maximum purchasing power for items it wishes to install. The concept has seen some application in developed countries, particularly where utility bills can be paid via a third party.

67. ESCOs aimed at providing rural communities with basic energy services are not yet common, although a number of pilot studies have been launched (and one large scale venture - the "Powerhouse" initiative in South Africa). One of the main reasons for their low uptake is because the risk profile assumed by suppliers has tended to deter them from offering these kind of services. As experience in (successfully) operating this type of venture grows it is expected that the model will become more widely adopted. From the consumer standpoint it has the advantage that they keep their capital, but this is partially offset by the fact that they may never own the equipment. This lack of ownership also adds to the risk, as if somebody does not own the equipment, their incentive to manage it efficiently may be low. Thus, if some form of commitment is not established then mismanagement leading to physical damage of the installation may become rife. This in turn could undermine the viability of an entire scheme. However, if the agreement between the two parties is clearly understood, then a degree of commitment from the end user could develop since the user will see that if the agreed level of service is not delivered, then he will have some form of redress available to him.

68. The ESCO will also be looking to improve the installations, as it has a major incentive to drive down costs whilst maintaining standards and quality at high levels: simply because if the system does not function it does not get paid. However, the structure and operating remit of the ESCO will need careful planning, the ESCO must have the ability to impose sanctions, up to and including removal of equipment, from users who do not pay their bills or abuse the equipment.

69. Finally, given that successful ESCOs will be organisations with good cash flows (i.e. able to cover more than simply their day-today operating costs) they should be in a good position to build up capital reserves and hence meet growth in demand from their own resources. Indeed it is conceivable that an ESCO could make the transition from installer/ owner of individual household systems to owners and operators of micro and mini grid systems.

70. The benefits of introducing an ESCO include the ability to bring in specialist support, manage equipment standards, ensure maintenance, and help to build stakeholding across the board. In addition the idea of a single organisation installing a number of systems also means that there is the scope to plan the emergence of locally based maintenance and support providers on a sustainable basis. Such opportunities, based around ESCO operations, are more likely to succeed than expecting to see such functions to emerge on a piecemeal basis following sale of individual systems. This is because the ESCO can optimise the ratio of support staff to installations, and also as the owners of the equipment they have a vested interest in avoiding the problem of no, or poorly trained, support staff.



Village PV Scheme, India

71. There are a number of organisations who might be interested in operating as ESCOs, these include:

- Independent Power Producers (IPPs) who could make their margin by supplying an integrated approach to energy management (i.e. combined supply and demand side management)
- Equipment manufacturers/importers/dealers who could benefit by achieving greater economies of scale for equipment purchase, supply and their maintenance operations
- Large scale employers, who could use the basic approach to introduce improved energy service to their employees (e.g. tea estates providing lighting to workers houses, in exchange for higher rent).

72. Overall, whilst the concept has created a lot of interest, the small number of examples of successful operations means that without external support and pump priming the chances of getting schemes to work in the near future are remote. This could, however, be addressed by using a suitable third party (such as an NGO) and convincing them that this approach is a suitable vehicle for breaking down aid funding (see section 10).

73. A particular variant on the general ESCO concept is that of third party finance (TPF). In such cases development of a particular resource is passed on to a specialist organisation that then raises the finance and carries out the development. In exchange, typically, for access to the power output for a specified period the developer carries out the development. At no time does the original site owner give up his title to the site. This combination of external finance and gaining access to specialist expertise may have interest in certain specialist areas. In

particular it may be a suitable vehicle for developing hydro, commercial scale wind generation, or certain types of biomass fired cogeneration.

7.1.2 Check List

74. The overall position that emerges from the analysis of how different actors have approached finance related barriers is not simple. It is clear that the affordability of systems, particularly at the individual level, is a key barrier to increasing the market penetration of renewables and that this will remain even as the final cost of systems fall in the medium term. However, it is equally clear that whilst many novel approaches are emerging there is no single, simple, panacea that is guaranteed to address finance related barriers. Thus the formal extraction of the principles of best practice is not possible, and would probably be misleading if attempted.

75. However, what does emerge from the analysis of the case studies is that there are a number of largely untried concepts being trialled in various contexts, and that these need further support and refinement before they can be assessed as suitable for more widespread replication. The following attempts to summarises the emerging thinking and identify key points as they have arisen during this study. At this stage this list cannot be viewed as comprehensive. The check list has been constructed with the intention of each point stimulating a simple yes or no answer. In applying the check list to any specific example the greater the number of yes answers, the greater the probability that the project will succeed, although there is never any guarantee of success. When the answer to a question is no, it should not be taken as a guarantee of failure, instead it should be used as an opening to explore the extent to which the underlying issues have been addressed (and understood).

76. For ease of application in the following check list each of the questions been assigned as most relevant under the general heading of policy, legislation or implementation.

Policy	
• Is there an actionable policy that clearly states support for renewable energy technologies?	Y / N
• Is there dedicated funding to support renewables development?	Y / N
• Can the funding be channelled through an output/revenue subsidy approach, or using the underlying principles?	Y / N
• Is small scale generation possible outside the national utility monopoly?	Y / N
• Is the credit industry liberalised (i.e. credit is relatively easy to obtain)?	Y / N
Legislation	
• Is disbursement of relevant funds adequately controlled?	Y / N
• Is it possible to operate outside monopoly regulations?	Y / N
• Do banking charters etc. allow relevant activity and operations?	Y / N
• Is the tax system supportive of renewables?	Y / N
• Does the tax system support efficient operation (as opposed to simply construction)?	Y / N
• Is access to credit facilitated and encouraged?	Y / N
• Is credit available outside the formal banking sector?	Y / N
• Does a credit rating system exist?	Y / N
• Is it easy to establish a credit rating?	Y / N
• Can specialist companies be created (e.g. ESCOs)?	Y / N

Implementation

- Is there a simple, user friendly, loan disbursement system? Y / N
- Is it possible to (partially) customise the loan terms according to the context (i.e. varying according to both who the buyer is, plus what he wishes to purchase)? Y / N
- Is there a practical and efficient mechanisms for collecting payments? Y / N
- Is there any flexibility in the repayment schedule (e.g. is it possible to make payments around harvest times)? Y / N
- Have contingency plans been made for cases of loan default? Y / N
- What is acceptable as security for the loan (and is it valued by the borrower)? Y / N
- Can the collateral value of livestock be utilised? Y / N
- Can dedicated companies (e.g. ESCOs, credit unions, co-operative, etc.) be established on a legally recognised basis. Y / N

7.2 Connection to Central Electricity Grid Systems

7.2.1 Technical Issues

77. The development of national electricity networks in most countries has followed a similar pattern: local industry has a specific power requirement and meets it internally, power exports begin, initially to meet several local loads; adjacent generators or networks are then linked to improve security and quality of supply; followed by interconnection of these mini networks to produce a national network. As this process proceeds power levels increase leading to a requirement for higher voltage systems and ultimately the large centralised generation and transmission which now dominates the electricity industries in most countries. In almost all electricity systems around the world the technology and operational rules are based on Western European and US systems.

78. It is into this centralised electricity transmission and distribution context that many renewable energy schemes are being introduced. Problems arise within this because whilst in terms of renewables such schemes may be large (i.e. multi megawatt scale), in terms of national grids they are classed as small, embedded, generating sets. In addition to the demands that operating as a small power producer within a national grid system can make, problems can arise since such systems work best for constant and controllable capacity. Whilst many of the renewables discussed in this report are essentially constant and controllable some are not, and others are perceived as variable and uncontrollable generation.

79. This section discusses the lessons highlighted by the analysis of the technical aspects of the experience of connecting (or attempting to connect) a range of renewables, all with power export capacities in excess of 0.25 MWe, to national grid systems. In particular it draws upon the following case studies:

- wind power in China and India;
- energy recover from biomass in India (bagasse), Indonesia (palm oil), and Thailand (bagasse, palm oil and rice husks);
- a small hydro development in Kenya; and
- a landfill gas scheme in Thailand

This section presents a technically based analysis that is complementary to the discussion of the largely non technical and institutional issues surrounding gaining access to grids is discussed in Section 7.2.2.

80. Factors that need to be considered when renewables are being integrated into existing grid systems include:

- **Power system protection** (safety) will demand the incorporation of at least one set of circuit breakers and associated relays. These must be sufficient to detect most abnormalities and the presence of potentially dangerous fault conditions. Such requirements may discriminate against small systems that cannot carry the cost of the full protection specified.
- **Power system stability** is generally split into transient stability and steady state stability. Transient stability is the ability of the generator to continue operating through system transients and should not be a problem with well designed schemes. Steady state stability is the ability of the system to operate normally in the desired modes without excessive interaction between system components. This problem is normally controlled by the network operator, but there could be potential problems if a number of embedded generators are connected electrically close to each other.

Tea Estate Hydro Installation, Near Kericho, Kenya

- Variation in **voltage range** (flicker) can result when embedded generators cause changes in absolute and transient voltage ranges. There are however, a number of technical solution which can be applied to control this problem.
- Generators incorporating power converters can generate substantial levels of **voltage and current harmonics** which can interfere with other components on the network, notably IT and communications equipment. Well designed filters can remove this problem.
- Embedded generation may reduce **system losses**, although whether the overall impact is beneficial or not depends on the size of the generation plant and the characteristics of the local network.
- **Fault level** is a measure of the severity of a potential fault at any point in the network. Connecting renewables plant to a system may increases its fault level and hence potentially push it beyond the capability of the installed circuit breakers.
- **Thermal capacity** is a measure of the level of power which can be pushed down a section of network. Again embedded generation can have a beneficial impact depending on the exact combination of capacity and network conditions under consideration.
- In applications where power cuts and 'brown outs' are common the addition of embedded generation may improve the **security of supply**.

Discussion

81. The implications of connecting renewables plant, as embedded generation, to an existing grid network is discussed below. In order to structure the discussion the various

renewable energy technology options have been placed into one of three categories, based on how predictable and/or intermittent their output is: large scale intermittent sources (e.g. wind farms), small scale, largely predictable intermittent sources (e.g. small scale hydro); and essentially fully predictable sources (e.g. landfill gas and biomass cogeneration schemes).

82. Wind energy can be captured by single turbines or by farms of turbines and as such can represent intermittent embedded generation. A wind turbine's output may, in a worst case, vary from nothing to rated capacity in a matter of minutes. Techniques are being developed to predict wind farm power outputs but these are only accurate for a short time periods and only predict average powers not instantaneous variations. Technical developments may overcome these problems, but in the meantime the impact of wind capacity on the local grid is as follows:

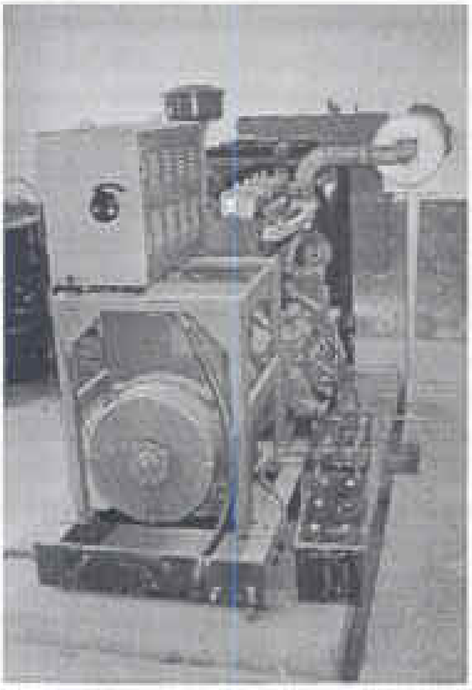
- Fault level. Wind turbines tend to be located in areas serviced by relatively weak parts of the grid, this coupled with the use of induction generators means that there are rarely problems with fault level.
- Thermal capacity. Wind farms tend to be connected to weak parts of the network which may have some spare capacity, but if capacity is restricted they may cause local problems.
- Voltage ranges. These are a major problem for wind farms because they can be connected at the end of long radial feeders. This is particularly true of lower 10 –20 kV lines with voltage boosting transformers, when the power flow is reversed in one of these lines there can be significant voltage rises.
- Losses. The impact of wind energy on network losses varies from site to site, and for any given site may be positive or negative.
- Security of supply. The variable nature of wind means that it cannot contribute significantly to security of supply.

83. In the case of small hydro plant the generation profiles are likely to follow the rates of water flow in the host river. Hence there may be significant variation in power output, but these variations should happen gradually over periods of several hours. Thus hydro plant can be viewed as small scale, but with a largely predictable degree of intermittency. The impact of this type of plant can have on the local grid is summarised below.

- Fault level. When used the fault level contribution from the induction generators is far less severe than from the equivalent synchronous generator, but may cause a problem for local switchgear etc.
- Thermal capacity. Some hydro schemes connect into the low voltage network and can cause local problems.
- Voltage ranges. Schemes connected to low voltage networks can cause local voltage problems.
- Losses. The level of impact will be very site specific and for any given site may be positive or negative.
- Security of supply. The impact of small hydro systems on security of supply will depend on the type of scheme and how it is operated. However, in general reliable and predictable embedded generation of this form should have a beneficial impact on security of supply.

84. Energy delivered from landfill gas and biomass fired cogeneration schemes is normally expected to run at full capacity 24 hours per day all year round (bar routine servicing downtime). Thus, apart from minor variations in generated power due to differences in calorific value and moisture content of the fuel stream output is fully predictable. The scale of

- Many developers, particularly overseas ones, are suspicious of the degree of commitment to market liberalisation by utilities (particularly where supply and distribution operations have not been split)
- Market liberalisation is in itself not a sufficient incentive to bring in new investment.
- Efficiency of energy production is key measurable, and not capacity installed.
- Ideally there needs to be good replication potential.
- Competition and the exploitation of market mechanisms almost invariably accelerate progress down learning curves and hence should wherever possible be allowed, and ideally encouraged.
- Quality is paramount. The ability to carry out performance certification type activities which allow benchmarking against similar installations is an essential part of risk management strategies for many actors.
- Deficiencies in awareness raising, training and education are common worries. These apply as much to the owners/users/ customers of the installation as to the technical support and maintenance staff.
- Appropriate standards that encourage deployment of efficient and durable systems seem to be essentially absent in all countries.



Spark Engine for Converting Biogas to Electricity

90. Analysis of how these barriers are, or could be, addressed is the basis of international best practice. In this case the elements of best practice that could find wide application in this thematic area include:

- It is recognised that in virtually all current circumstances some form of incentive is required to help renewables enter new markets. However, it is also recognised that a subsidy based sector is not tenable, and that any incentives used should try to incorporate the following principles:
    - There should be a clear plan to remove all market distortions (subsidies) to avoid nurturing subsidy cultures.
    - Where incentives are required they should, in general, try to adopt a production based approach as this tends to be more efficient than investment incentives (particularly for the more mature technologies).
    - The adoption of competitive mechanisms can be beneficial in helping to capture market efficiency gains. Indeed if well designed it is possible that the competition will eventually drive subsidies down to zero.
    - Plans setting out how withdrawal of the incentives will be managed (i.e. an 'exit strategy') need to be in place at the outset.
- The legal step of opening up systems to independent power producers is usually not sufficient, in itself, an incentive to encourage new entrants. Best practice involves the tailoring of a support package to local market conditions, but based on establishing the legal status of independent power producers (IPPs). The sort of supplementary incentives that have been found to attract differing actors in differing contexts include:

  * Must take contracts
  * Premium buy back rates
  * Model power purchase agreements
  * Power wheeling and banking
  * Third party sales
  * Tax breaks for private investment.
- Success usually requires that the stakeholders in a project value their stake in the longer term, ideally by making them monetarise a portion of the cash benefit (e.g. by using the subsidy to establish lease-purchase arrangements, or encouraging development on a third party basis).
- Indirect subsidy via technical backup can be very effective in addressing deficiencies in support infrastructures and institutions.
- Replication is based on copying successful designs, therefore systems must be seen to focus on real situations.
- Appropriate standards setting agencies need to be put in place. The function of these will (by inference from other sectors) need to be carefully controlled. Their function should be to ensure that any assets meeting the standard that are purchased will be acceptable to the funding body (i.e. reduce the risk premium that the lender demands) and not simply a burden that adds to the existing high market entry cost.
- There is often difficulty in initiating dialogue between small IPPs and the utility operating the grid, with the result that the modalities of selling power to the grid are not in place. Without this dialogue there is no opportunity for either side to demonstrate that a "win-win" relationship is possible. For example in many remote grid connected areas the weakness of the system means that disproportionate benefits can be gained by introducing relatively small, firm generating capacity to the system. However, it is usually virtually impossible for the small IPP to gain a premium price for his power in these circumstances. Approaches to addressing this problem are varied, but can include:
  * The building of partnerships between producers, power shipper, utility and government should be encouraged. For example small IPP development could be accelerated if some form of guiding document(s) can be developed, that would clearly spell out all the requirements regarding quality, capacity etc. Such documents could also form the basis of standard purchase arrangements/contracts.
  * the introduction of more transparent procedures such as power pooling, or published common carriage terms.
- The cost of negotiating grid access is often protracted and demands significant input from what may be a small, specialist management team. Thus the fixed costs of obtaining contracts may sometimes prove to be excessive unless it is possible to streamline the process of applying for consents. This can be, at least partially, offset by having framework agreements that can form the basis of negotiation, as opposed to starting with either an inflexible standard contract, or a blank sheet of paper.

7.2.3 Check List

91. The underlying principles of best practice that arise from analysis of the case studies are summarised below in the form of a check list. The check list has been constructed with the intention of each point stimulating a simple yes or no answer. In working through the list for any specific example it is to be borne in mind that the greater the number of yes answers, the greater the probability of success (although there is never any guarantee of success). When the answer is no, it should not be taken as a guarantee of failure, instead it should be used as an opening to explore the extent to which the underlying issues have been addressed, and by inference understood. For ease of application in the following check list each of the questions

has been assigned as most relevant under the general heading of policy, legislation or implementation:

Policy	
• Is there clear government support for small generators to access the grid?	Y / N
• Is there a market for independently generated electricity?	Y / N
• Is there an empowered regulatory body with a renewables remit?	Y / N
• Is there a clearly understood and published market price?	Y / N
• Are there recognised mechanisms for valuing electricity generated in specific locations?	Y / N
• Is there currently, or is a transition underway to, a liberalised electricity market?	Y / N
• Do policies allow fair competition in the electricity sector?	Y / N
• Is it policy to remove power sector distortions?	Y / N
• Is there co-ordination across Government Departments to facilitate developments?	Y / N
• Is there a single national body that 'champions' renewable sources of energy?	Y / N
• Are the policy makers and implementers accountable for their targets?	Y / N
• Is there a positive rural electrification policy?	Y / N
Legislation	
• Is there a clear statutory based and economically attractive support mechanism?	Y / N
• Is private power production allowed?	Y / N
• Is grid access guaranteed?	Y / N
• Is the support mechanism responsive to market forces?	Y / N
• Is the support mechanism production related?	Y / N
• Is there an exit strategy in place for the incentives on offer?	Y / N
• Are there clear, and appropriate, standards in place?	Y / N
Implementation	
• Are sales of electricity to third parties allowed?	Y / N
• Is the delivering institution clearly identified (and favourably disposed)?	Y / N
• Is the supply and maintenance chain fully identified and enabled?	Y / N
• Are legally sound, relevant and widely recognised model power purchase agreements available?	Y / N
• Are international joint ventures encouraged?	Y / N
• Is there a clear monitoring and feedback pathway for information and experience gained during implementation?	Y / N
• Are the project risks well understood (and stated)?	Y / N
• Do these risks rest where they can be best managed?	Y / N
• Is there a clear replication potential and pathway?	Y / N
• Does reliable and accurate resource information exist?	Y / N
• Do the demonstration schemes have good prospects for replication?	Y / N

7.3 Awareness Raising and Dissemination

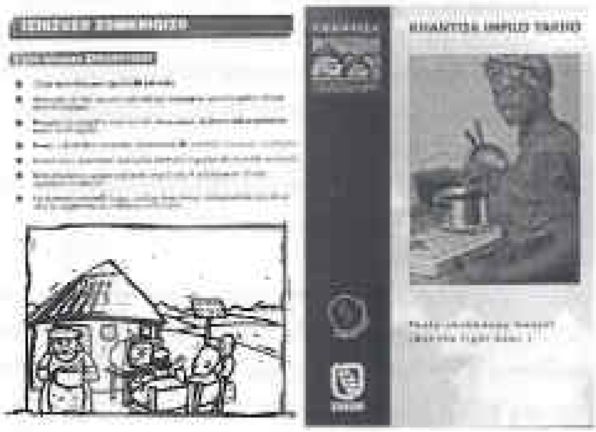
92. The processes that between them constitute awareness raising and dissemination (and the terms are used interchangeably here) should not be misconstrued as a simple process whereby data is placed in the public domain and thence is taken up by the relevant parties and applied. The net result of this sort of broad, unfocussed, activity is that the message becomes scattered and fragmented, with the information (message), spread so widely that all the necessary

and relevant stakeholders are highly unlikely to receive (or often even understand) the message, let alone act on it.

93. This section draws upon the findings and discussion contained in all 18 case studies.

7.3.1 Discussion

94. Given the above it is important not to waste effort by scattering information to all and sundry, but rather specific actors or 'segments' should be identified or 'targeted' and then specifically addressed, both in terms of the message given and the vehicle used to deliver it. The key to this communication process is based on the need to initiate a transition from unawareness to a state of awareness. This means that the recipients comprehend the issues, and in this particular context follow this up with an appropriate commitment to participate in the process of introducing renewables into their markets. The process of arriving at a relevant set of segments is based on the assumption that it is possible to identify groups of actors with shared attributes and responses, which can have a psycographic, demographic or geographic basis. Once identified the common characteristics of the segment should be capable of explaining (and predicting) responses within the grouping.



Local Dialect Promotional Literature, South Africa

95. Once suitable segments have been identified it is necessary to look at how a real or perceived lack of knowledge can be addressed. There is no short, or simple solution, but the overall process requires concerted, ongoing actions to be initiated. However, sometimes these processes are met by combinations of inertia, apathy, lack of understanding, and competition. These problems can be addressed by adopting some of the basic principles of commercial marketing, i.e.

- establish that the segmented groups will able to see what is on offer
- establish how much it will cost
- position the reputation or image (whilst clearly demonstrating the benefits), and
- raise awareness of the products.

96. These principles need to be applied as an integral part of any project or programme, it is not enough to simply carry out the work and then begin to question how the findings can be broadcast to "the right people". In much the same way as engineering retrofits are neither as cost effective or as efficient as good up front design, so dissemination (communication) activities are best designed into work at the outset and not bolted on as an afterthought.

97. This is based on the underlying assumption that communication is all about identifying the audience and then ensuring that the message is efficiently delivered in an appropriate way. Within this context suitable vehicles include, newsletters (including those in local dialect or based on cartoon characters where the audience is illiterate), education and training (including schools), media, advertising as well as exhibitions and demonstrations. Vehicles for effective communication include carrying out market surveys, targeting information, goods and services, managing end-user expectations, and accessing relevant information.

98. Overall, the basic best practice principle that emerges from the analysis of the case studies is that the process of dissemination should be clearly rooted in the simple model of:

- Identify the beneficiaries i.e. establish by market survey: who wants to buy, what they want to buy, why they want it, and how much they are willing to pay for it.
- Group them into appropriate segments (groups of actors). For example do men and women have different needs from the technology, should different vehicles be used to access them?
- Understand the attributes and objectives of these groups. This will also involve realistically looking at whether or not the technology on offer is capable of meeting the expectations.
- Carry out the work against these clearly defined and understood objectives, if mutual "win-win" relationships cannot be engineered, the probability of long term success is very low.
- Disseminate the results to the beneficiaries using appropriate vehicles in a controlled and targeted manner.
- Check to make sure that the message has been received and understood.

7.4.2 Check List

99. The underlying principles of best practice in awareness raising and dissemination that arise from analysis of the case study body are summarised in the form of a simple check list below. This has been constructed with the intention of each point stimulating a simple yes or no answer. In any specific case the greater the number of yes answers, the greater the probability that the project will succeed - although there is never any guarantee of success. When the answer to a question is no, it should not be taken as a guarantee of failure, instead it should be used as an opening to explore the extent to which the underlying issues have been addressed, and by inference understood. Each of the key points has been assigned as most relevant to the general area of policy, legislation or implementation.

Policy	
• Is there clear policy support for renewable energy technologies?	Y / N
• Have the intended beneficiaries been clearly identified?	Y / N
• Have they been characterised (segmented) in a logical manner?	Y / N
Legislation	
• Are choices restricted by the legal system? (e.g. are individual home systems covered by the same legislation as homes connected to the national grid).	Y / N
Implementation	
• Has the role of the target beneficiaries been defined?	Y / N
• Has a market survey been carried out?	Y / N
• Do the segment characteristics allow the various groups to be differentiated?	Y / N
• Are there any key groups of 'influencers' (e.g. teachers, village elders, etc.) who need to be specifically addressed?	Y / N
• Are there systems to collect and process feedback?	Y / N
• Have the desires of the users been shown to be practical (given the technology characteristics)?	Y / N
• Has a communication plan been drawn up?	Y / N
• Are there suitable communication vehicles (medium, language, etc.) in place?.	Y / N
• Have visible local benefits been identified?	Y / N
• Can these local benefits be advertised/disseminated?	Y / N

8 TECHNOLOGY SPECIFIC FINDINGS

8.1 Biogas

100. Biogas utilisation was studied via case studies in Zimbabwe, China and India. In general these case studies analysed smaller scale biogas systems that are applied in remote locations to produce gas which can be used for electricity generation, heating (including cooking) or even for direct provision of lighting via mantles. However, it is recognised that the technology also has industrial scale application where in addition to direct heat and power production the biogas can be used to displace fossil fuels in power plants. Also in these industrial settings the energy benefits from biogas production may be secondary to reductions in biological and chemical oxygen demand (BOD/COD) from liquid effluent streams.

8.1.1 Discussion

101. Taken as a group case studies show that:

- Contacting local businesses has proved almost uniformly problematic during this study, this is probably a reflection of the fact that suitable businesses often simply do not exist yet. This difficulty in locating the businesses cover all aspects of local operations including installation, technical support, and ongoing maintenance capabilities. This lack of local actors has often been associated with the fact that it at this level that biogas programmes tend to break down. The reasons for this breakdown seem to be associated with low level or intermittent orders and/or poor technical backup.
- Payment of simple capital subsidy is a major problem. Whilst system installers are very happy to take such cash payments, for most other actors the real impact is simply to reduce their level of involvement in, or commitment to, the project.
- Related to the capital subsidy problem is one of committing actors at the end user level to the long term success of the project. This is reflected by the way that many of these actors have a cash outgoing that is essentially replaced by the biogas installation. Instead of "demanding" that some of this cash stream be used in support of the installation (and hence giving a stake in it) final users (i.e. typically the system owner) tend to take the biogas as a "free good" and hence not end up in a position to maintain or renew parts of the system.
- The role of system specifier/designer often emerges as being a key one. In order to optimise the operation of biogas installations it is necessary to undertake a degree of customisation. However, the more diverse the designs, the more difficult it is to build a sustainable base for installation and maintenance. For instance in Zimbabwe it is reported that there are probably only five or six people in the whole country who can design biogas systems. This has led to the emergence of a single design which is installed regardless of resource or demand. This poor fit between supply and demand has led to system failures. On the other hand in China this role has been filled by centrally funded research institutes (i.e. via an indirect subsidy). This has led to good tailoring of systems to needs, but there are emerging worries regarding the potential conflicts of interest between research institutes and industry (as often the same staff fill roles in both). India tends more towards the Chinese approach, but without the same level of overlap between private and public sector roles. The net result is that in India installations are made from a restricted menu of designs, which allows adequate training and local support to be provided without overly restricting the final uses that the system can be put to.
- Training and education are common worries. Again Zimbabwe shows problems in that the degree of training given to users is low. This lack of training does not necessarily show in poor long term performance of the digester, but can be seen via factors such as ignorance of potential use. For example in one case a system owner did not value the light provided via

mantles, and hence let his system lapse. However, he did have a demand for refrigeration which he met via a kerosene refrigerator. He was totally unaware of the possibility of replacing the kerosene by biogas. Again China and India show much better signs of education and training both in operation and potential use systems.

- Standards for systems seem to be essentially absent in all countries. They exist by default in Zimbabwe and India since the designs are very standard. In China they are basically set by the supporting research institutes. However, they are not formalised in any country.
- Cultural factors are very important. The ultimate potential for exploitation of biogas in Zimbabwe is limited by taboos placed on certain waste, India has well documented (sociological) problems with communal units (e.g. reinforcement of the caste system, and/or problems with absentee land owners) whilst China with its long history of co-operative and communal activities has a much higher success rate for larger schemes.

102. Elements of best practice for biogas schemes include:

- Ensure that all the stakeholders in a project value their stake in the longer term, ideally by making them monetarise a portion of the cash benefit (e.g. by using the subsidy to establish lease-purchase arrangements, or encouraging development on a service company basis). This leads on to the recognition that taking a tangible stake in the investment can be recognised by lending institutions. As well as giving credibility to their involvement, actors will find that they will often increase future access to capital via the acquisition of a credit rating recognised by commercial institutions.

School Biogas Installation, Zimbabwe

- Indirect subsidy via technical backup can be very effective. Replication is based on copying successful designs, therefore systems must be seen to focus on real situations and practical locations.
- Educating people as to the range of potential end uses is nearly as important in training in system operation.
- Appropriate standards setting agencies need to be in place. The function of these will (by inference from other sectors) need to be carefully controlled. Ideally their function should simply be to ensure that equipment meets an agreed standard. This standard needs to be acceptable to the funding body (i.e. reduce the risk premium that the lender demands) and not set so high that it prices eminently practical devices out of the market.

8.1.2 Check List

103. Overall the main issues arising from these case studies revolve around questions regarding: who pays the initial cost; who is responsible for training; and who is capable of undertaking maintenance. Underlying these is the issue of the availability and application of (appropriate) standards.

104. The following list summarises the key points from the case studies, each of these has been assigned as most relevant to the general area of policy, legislation or implementation. The list has been constructed with the intention of each point stimulating a simple yes or no answer.

In any specific case the greater the number of yes answers, the greater the probability that the project will succeed - although there is never any guarantee of success. When the answer to a question is no, it should not be taken as a guarantee of failure, instead it should be used as an opening to explore the extent to which the underlying issues have been addressed, and by inference understood.

Policy	
• Is there an (actionable) policy that supports biogas exploitation?	Y / N
• Can biogas be shown to be economic against other fuels (e.g. via removal of subsidies on liquefied petroleum gas or kerosene)?	Y / N
• Have domestic and industrial options been considered separately?	Y / N
• Are there any biogas deployment or production targets?	Y / N
• Do targets clearly define realistic standards that can be adhered to in practice?	Y / N
• Is there a mechanism for enforcing the standards?	Y / N
• Is there a single (governmental) agency responsible for implementation and/or co-ordination?	Y / N
• Is the technology seen as desirable in a country where drought is common?	Y / N
• Is there a system whereby people can be trained in installation and maintenance?	Y / N
• Does the support framework allow/encourage entrepreneurs? (i.e. allows them to make a profit, encourages end users to purchase from income, rewards post installation support, etc.)	Y / N
Legislation	
• Are there legal instruments in place to cover production and sale of biogas ?	Y / N
• If relevant, are there legal instruments for power purchase/grid connection ?	Y / N
• Are there any incentives schemes for specific actors (e.g. farm diversification funds)?	Y / N
• Is environmental legislation in place to penalise polluters? (particularly those where biomethanation is an effluent treatment option)	Y / N
• Is imported biogas equipment exempt from import tax?	Y / N
Implementation	
• Are there project finance and/or credit schemes accessible to potential end users?	Y / N
• Do the intended recipients have access to credit (or indeed a credit rating)?	Y / N
• If the project is to produce biogas for local use, is there an identified use for it?	Y / N
• If the biogas is it to be converted into electricity is there a market for it?	Y / N
• Can project feasibility (in the form of an economic case) be demonstrated?	Y / N
• Can the specified design produce the amount of gas required by the user?	Y / N
• Does the user have access to sufficient feedstock to match the capacity of the digester ?	Y / N
• Is collection of the feedstock logistically practicable ?	Y / N
• Will trained or certified builders undertake the construction ?	Y / N
• Will the construction be monitored/ certified by an independent organisation ?	Y / N
• Will the construction be covered by a guarantee ?	Y / N
• Will the biogas user receive adequate training in the operation and maintenance of the digester?	Y / N
• Is some form of building maintenance and back-up service available?	Y / N
• Is post installation (independent) monitoring, with provision for feedback, provided for?	Y / N

8.2 Solar (PV) Home Systems

105. The use of solar photovoltaic systems to provide basic energy services (lighting, radio, television) is probably the best known application of renewable energy technologies in the developing world. In this work case studied have been constructed detailing the status of such systems, and the related markets, in Kenya, India, Indonesia and South Africa.

106. The solar PV market is a dynamic one, as is shown by the fact that since data collection for this work was carried out the position within South Africa has changed with the formation of a joint venture between ESKOM and Shell International Renewables. This joint venture is reported to be positioning itself to become a large scale provider of PV solar home system installations using an energy service company approach (ESCO).

8.2.1 Discussion

107. In all of the countries studied the PV market is essentially based on private sector companies selling equipment to government (or quasi government) organisations. There are also usually rather small scale commercial markets selling directly to industry and/or individuals. In all cases those involved tend to target niche markets where PV is the least cost option for electricity supply. In practice this tends to mean market segments such as; meeting NGO requirements (particularly for healthcare and education), the provision of power for telecommunications, remote signalling, etc. tend to be the most attractive.

108. Whilst the markets studied vary considerably they are all similar in so far as an underlying desire in each case appears to be to position the country to obtain maximum benefits from solar PV once the unit cost has reached its predicted future (low) level. This is often reflected in a national desire to establish indigenous solar cell manufacturing facilities. However, not all countries can successfully do this as the required economies of scale in the production process require access to regional markets (at least in the short to medium term).

109. Attainment of these low levels of cost depends upon "buying down" PV costs as a function of cumulative global production. This means that the majority of current national programmes are heavily reliant upon intervention in the form of subsidies. The exception to this is Kenya where the PV market is an essentially commercial one with low (but growing) external intervention. In practice this means that in Kenya the PV industry is currently targeting the rural populace who have access to capital, but no access to grid electricity (i.e. the rural rich). Elsewhere the emphasis is on providing PV to those without grid access, but without discriminating according to ability to pay.

110. This means that often current markets are based on payment of subsidy that is intended to 'prop up' a technology which is not ready for the rural market at which government programme are usually aimed. This in turn leads to the emergence of companies which are only looking to exploit available subsidies. The concern is that when these 'soft' government schemes end these companies will exit the market leaving it with an unsustainable industrial, support and entrepreneur base. The net effect of this could be collapse of the market just at the time when PV could be becoming commercial without government support.

111. Thus, there is a particular need to look at the current position and extract principles of best practice, such that more sustainable national markets become established in the future. Such lessons include:

- There is a need for strong leadership from government. However government should not dominate the market, its role should be to facilitate and encourage.
- Good co-ordination between the public sector actors is required if uptake of PV in rural areas is to be successful. This also implies that PV should be targeted on areas where it is possible to make a clear economic and practical case for deployment.
- PV products need to be clearly demonstrated to be practical and robust. In particular they should be demonstrated to deliver the same level of service as other, competing, technologies so that they are not perceived as second best. PV products that are more robust and lower cost need to be developed for the rural electrification market. In the end replication of successful demonstrations is much simpler than having to overcome scepticism caused by previous failures.

Domestic PV Installation, Near Malindi, Kenya

- This in turn implies the need for targeted promotion/awareness campaigns (see also Section 7.3). These should be based on publicising successful case studies wherever possible. The target audience needs to be carefully defined and appropriate messages put across by use of suitable media (e.g. pictograms/strip cartoons, with titling in the local dialect).
- Training is needed in management of dissemination programmes, financing, servicing and maintaining PV products.
- An effective service and maintenance network must be put in place to support rural PV systems, and the end-users must be shown the benefits of paying for maintenance. These networks need to reach a critical mass before they can be self sustaining. This can be achieved by approaches such as ESCOs, franchise arrangements, or by targeting business expansion support on companies with suitable technical and commercial potential.
- End-users need to be encouraged to value their stakeholding, and hence take some responsibility for ensuring the success of the installation. The best way to do this is to get them to have a financial or other stake in the continued operation of the system. If people have to pay for something, and/or it allows them to better their standard of living, they will tend to look after it.
- It is possible to overstate the benefits PV based systems can bring, in the longer term if success stories are to be generated it is necessary that potential users be made aware of the limitations of PV installations, as well as the benefits they can bring.
- Longer term market development strategies need to be drawn up. This means that private sector involvement has to be encouraged, and that market niches outside government subsidy activities need to be exploited. Support for this type of activity can be via more indirect interventions such as tax breaks to support business expansion via re-investment. This type approach also has the benefit of preparing companies for operations outside a subsidy regime, which will mean that the longer term business sustainability is enhanced (e.g. by improved credit rating).
- Market development for PV systems and support operations can be undermined if local utilities do not adhere to published grid extension plans. Until PV is more established and

the benefits widely accepted then the current preference for grid access as the preferred source of energy service will continue to seriously undermine public and business confidence in the sector, and hence limit market penetration.

- When feasible, local manufacture of balance of system components should be encouraged in order to bring total (installed) system prices down.
- Small systems and system components can fulfil a function, and hence should not be excluded from support activities, breaking the system down into affordable units can help the market grow.
- The desire for access to television and radio is high, and should not be automatically overlooked in favour of lighting only applications.
- System design should always take into account the price-performance trade off. The performance required by the user is the key attribute, not the performance required by the financier. This should also be recognised via the application of appropriate standards, i.e. they should guarantee performance against a norm, rather than to price systems out of potential applications. For example a standard for a 12 Wp panel directly connected to a battery is as valid as one for a 0.5 kWp school power system, and hence should not have to conform to the same standards. However, gaining acceptance amongst potential funders for "lower" standards will cause initial problems.
- Defining, and then capturing, the replication potential is a problem, and can limit applications. Anything other than the most basic home systems requires professional design input, this tends to tie up scarce technical expertise, considerably increases costs, and/or results in inappropriate systems being installed.
- Affordability of installation is one of the key barriers to higher PV penetration. This is often seen in the observation that the lack of consumer credit arrangements for individual end-user is a major barrier to sales of PV installations. The situation is then compounded by the fact that the majority of current credit schemes have short repayment periods forcing monthly repayments that are hardly affordable for many households. Thus there is a need to look at other forms of payment, including replacing direct purchase of equipment with leasing, or movement into some form of fee for service type of operation (e.g. ESCOs).

8.2.2 Check List

112. The following list summarises the key points that have been extracted from the case studies, each of these has been assigned as most relevant to the general area of policy, legislation or implementation. The list is designed so that each point stimulates a simple yes or no answer. In any specific case the greater the number of yes answers, the greater the probability that the project will succeed - although there is never any guarantee of success. When the answer to a question is no, it should not be taken as a guarantee of failure, instead it should be used as an opening to explore the extent to which the underlying issues have been addressed, and by inference understood.

Policy	
• Is there an (actionable) policy that supports solar PV policy development?	Y / N
• Are the goals of this programme clearly stated?	Y / N
• Are individual home system, rooftop installations and grid connected options considered separately?	Y / N
• Have targets been set?	Y / N
• Do the targets require quality standards / best practice to be adhered to?	Y / N
• Is there a single (governmental) implementation / co-ordination agency?	Y / N

Legislation	
• Are providers of solar home systems not classified as Independent Generators?	Y / N
• If so can they gain appropriate legal status?	Y / N
• Are suitable legal instruments in place to cover power sales etc.?	Y / N
• Are there any incentives schemes for specific actors (e.g. system installers)?	Y / N
• Is imported PV equipment import tax exempt?	Y / N
• Are there any specific tax exemption options available?	Y / N
Implementation	
• Do the available project finance and/or credit schemes address affordability issues in a practical way?	Y / N
• Does the user have an adequate credit rating?	Y / N
• If not, is anything being done to open up access to credit?	Y / N
• Is there and established (and credible) approach to assessing project feasibility?	Y / N
• Have the requirements of the users been established?	Y / N
• Does the capacity of the system match the requirements of the user?	Y / N
• Has the system been design against the requirements?	Y / N
• Has a competent systems installer been identified?	Y / N
• Will the installation be covered by a guarantee?	Y / N
• Will the user receive adequate training in system operation?	Y / N
• Is some form of maintenance and back-up service available?	Y / N
• Can the system be expanded as demand expands or changes?	Y / N

8.3 Wind Power

113. Large scale exploitation of wind power was studied in China and India. In both of these countries, there are established frameworks intended to encourage expansion in the wind sector. The overall the position is that in India and China wind energy has proven that it can coexist with conventional energy sources.

8.3.1 Discussion

114. In India the main characteristics of the sector are:

- The general on-off policy with regards to inward investment and the status of joint venture companies in the large scale power sector has given the country a bad reputation.
- The incentives have been very generous for construction of wind farms, this has lead to significant development. However while there have been incentives for power production as well, these have not always been necessary for a beneficial investment by the company. Hence in some cases the incentive to continue operating has not been enough and farms have ceased to operate.
- Countries, such as India, with a power deficit the facility to ensure supply through power wheeling and banking is a significant incentive for larger users to get involved.
- The poor financial state of the supply and distribution companies and widespread and perverse energy subsidies complicate the market.
- Market reforms are urgently required but these alone will not facilitate renewables expansion.

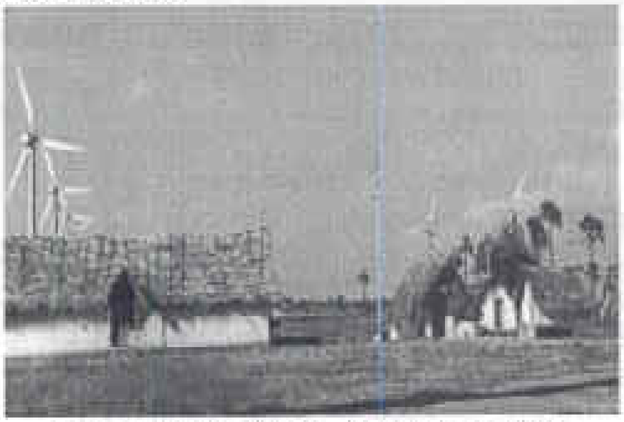
115. In China the main sector characteristics are:

- The country has ambitious targets relating to the development of the national wind resource. The probability of attaining significant levels of commercial development is difficult to assess.

- Support from provincial governments and related utilities exists in many areas.
- Finance is available from the Bank of China, and they are now familiar with making loans for wind developments.
- There is a good wind resource.

116. Indicators towards best practice that can be extracted from these case studies includes:

- Favourable government policies can be implemented in a way which involves the private sector. However, these need to be carefully thought through in order to ensure private sector commitment is for the longer term, and not simply to exploit short term opportunities. These policies need to be consistent into the foreseeable future.
- National goals should be rational, realistic and regularly reviewed and updated.
- Regional and local government (including associated utilities) are key players in the wind sector.
- Utility support is essential. Where the utility recognises, and accepts wind energy as a valuable contributor to electricity generation in the State they tend to provide support and practical help, which helps to signal a widespread commitment to successful development.
- Underlying, support from government, utility, etc. is the need to ensure that some form of accountability is evident. Outside observers (particularly in the private sector) want to see positive displays of commitment to positive outcomes.
- National wind mapping should be undertaken in order to facilitate developments, however, such mapping should be well founded and targeted at wind development (i.e. it should not simply be extension of basic meteorological data).
- Successful demonstration schemes help to build confidence in new technologies.
- Poor targeting of funds can give short term returns, but may be detrimental to the prospects for wind energy in the



Muppandal Wind Farm, Tamil Nadu, India

- Indigenisation of full manufacturing capabilities will not take place without some form of guarantee regarding the protection of intellectual property rights for key components.
- Quality of components, and a general lack of awareness of quality standards, can hinder foreign investment and/or undermine the credibility of the technology in the field.
- Shipping of power from remote, windy, sites to (urban) demand areas is often problematic.
- Provision of technical backup and maintenance regimes can undermine medium to long term performance prospects.
- Testing, certification and standardisation are all desirable, but if an inappropriate approach to introducing these is used then the results can be counter-productive.
- There is a need to reduce investment-based incentives and replace these with production-based incentives, so that investors are motivated to keep windfarms well-maintained and efficient in operation.
- Awareness of the technology, and its (successful) track record needs to be raised in order to help to maintain/boost investor confidence.
- Wind energy is now beginning to be seen as increasingly competitive and hence it is prudent to put in place plans indicating how current incentives can be phased out without damaging the proto commercial market (i.e. without destroying the emerging industry)

8.3.2 Check List

117. In summary the following summarises the key points from the case studies, each of these has been assigned as most relevant to the general area of policy, legislation or implementation. The is that each point in the list should generate a simple yes or no answer. In any specific case the greater the number of yes answers, the greater the probability that the project will succeed - although there is never any guarantee of success. When the answer to a question is no, the intention is that it should provide an opening to explore the extent to which the underlying issues have been addressed, and by inference understood.

Policy	
• Does wind energy contribute to national needs?	Y / N
• Is there a national policy supporting wind development?	Y / N
• Are there published national targets for wind energy?	Y / N
Legislation	
• Is the legal status of independent power producers recognised?	Y / N
• Are the terms and conditions associated with grid access equitable (when compared to competing electricity sources)?	Y / N
• Is some form of 'must take' power purchase contract available?	Y / N
• Are connection fees reasonable?	Y / N
• Is the period of regulated (guaranteed) purchase price long enough to ensure project viability?	Y / N
• Is there an understanding of what the position of the project will be after contract expiry?	Y / N
• Has a sound economic and financial case been made?	Y / N
• Are there guarantees regarding price stability over the payback period?	Y / N
• Have the utilities an stake in successfully implementing schemes?	Y / N
• Will the utilities accept independent generators?	Y / N
• Is there a provision to sell power to third parties (i.e. not just to the utility)?	Y / N
• Has the need to import components been accounted for ?	Y / N
• Are import provisions for components different to those for full machines?	Y / N
• Is there a requirement for certification from a national (or international) body?	Y / N
• Is there a need to purchase from an approved list of suppliers?	Y / N
Implementation	
• Are there currency import/export restrictions?	Y / N
• Is currency stability accounted for in the agreements (including inflation)?	Y / N
• Does the country have a suitable credit arrangement in place with an (international) finance organisation?	Y / N
• Is the country working towards implementing market based reforms?	Y / N
• Is the road infrastructure adequate for plant installation and maintenance?	Y / N
• Is there a local (or even national) capability to perform required maintenance activities?	Y / N
• Does the scheme satisfy any stated need for indigenous manufacture of all/part of the installation?	Y / N
• Are the intellectual property rights of the importer protected?	Y / N
• Can indigenous manufacturers meet the required quality standards?	Y / N
• Is it practical (or desirable) to set up joint venture companies?	Y / N

8.4 Solar Hot Water Systems

118. Solar hot water (SHW) systems are, in general, the least supported (incentivised) renewable energy technology. This is probably due to the fact that the energy service they provide is the fairly low grade one of medium temperature hot water. However, in all the case studies covered here water was often electrically heated, thus whilst SHW is a low grade energy source its application displaces a high grade one, electricity. The underlying technology for SHW systems may be viewed as 'appropriate' in so far as it ranges from simple box type construction through to high technology evacuated tube systems that require sophisticated materials and manufacturing techniques.

119. This section draws on the case studies describing the experience of deploying SHW systems in China, India and Kenya.

8.4.1 Discussion

120. The differing degrees of development of the SHW markets in China, India and Kenya is interesting in so far as they seem to bear very little relationship to the degree of government intervention. Kenya seems to have the most commercial market, and operates completely without subsidy, whilst India has very heavy subsidies and a poorly developed market. China falls between these two, with a developing market with only fairly general support focused on it, although as with other sectors within the Chinese energy sector it is difficult to discount the impact of positive messages from Central Government.

121. Indicators towards best practice that can be extracted from these case studies includes:

- The support available for establishing indigenous supply should be focused on output (i.e. effectively electricity consumption displaced) and not number of installations. Experience indicates that capital subsidies are not a prerequisite for significant market growth. The combination of receptive economic climate and careful targeting of products according to clear market sector requirements are sometimes sufficient in themselves to stimulate market growth.
- Bringing technologies such as SHW into building regulations may be a two edged sword. If the regulations are well drafted then the encouragement provided may stimulate wider deployment in the short term, but if poorly drafted or implemented they could result in inappropriate installations. In turn this would probably bring the technology (and possibly the whole industrial sector) into disrepute.

Solar Hot Water Installation, Near Hangzhou, China

- Specialist companies could take over energy management tasks, for example Energy Service Companies (ESCOs) may be a suitable vehicle for SHW to be introduced to selected industrial and commercial consumers (e.g. hotels, textile operations, dairies). The ESCO would provide the investment capital, install and maintain the equipment, in return for a guaranteed income stream from the consumer. This removes the investment risk from the consumer, and the sales risk from the ESCO.
- When opening up markets it is not necessary to aim initially at the mass market, early exploitation of niche markets can be a very good way of accessing critical 'influencers' who can lay the foundations for wider replication. Once identified it is the high profile influencers who tend to be copied.

- There needs to be a good match between the product and (surveyed) market needs. Such surveys allow matching of equipment to market, ensuring that what is eventually provided is capable of meeting requirements, and that the target market can afford it (and ideally show a better return than on alternative investments).
- There needs to be some form of formal survey of the willingness (ability) to pay, for each market segment, to reassure commercial actors that they can recover their investments.
- The lack of information on the benefits SHW can bring to the industrial sector appears to be one of the main reasons that this sector is so small. If the longer term benefits from SHW systems in terms of reduced longer term running costs are not well understood and accepted then the high initial capital outlay will always tend to make SHW installations seem unattractive to many corporate investors.

8.4.2 Check List

122. The lessons for best practice for solar hot water systems that can be drawn from this case study assigned to general areas of policy, legislation or implementation are shown below.

Policy	
• Is the potential contribution of SHW to national energy need recognised?	Y / N
• Is there a national policy on SHW promotion?	Y / N
• Is support available for establishing indigenous equipment manufacture?	
• Is there technology transfer, production and operational support available (e.g. through independent research institutes)?	Y / N
• Do import or export restrictions apply, and do they differ between components and finished goods?	Y / N
• Is there a free choice for final users when it comes to choosing between available technology options?	Y / N
Legislation	
• Is use of SHW systems supported via building regulations?	Y / N
• Are these regulations enabling or restrictive in nature?	Y / N
• Is it possible for specialist companies to take over energy management tasks?	Y / N
Implementation	
• Has the market been surveyed (especially important if the market is a new one)	Y / N
• Is there a good match between the products on offer and the market needs?	Y / N
• Do the companies in the sector have business plans?	Y / N
• Have critical 'influencers' (i.e. people who tend to be copied) been identified, and a strategy to access them planned?	Y / N
• Has an assessment of the willingness (ability) to pay for each market segment been carried out?	Y / N
• Is there a mechanism to allow the benefits SHW can bring to the industrial sector to be demonstrated and disseminated?	Y / N
• Are supporting design and installation services accessible?	Y / N
• Does the product specification inform/enable technology choice?	Y / N
• Is there any form of independent specialist technical support?	Y / N
• Are there existing indigenous manufacturers capable of providing basic manufacturing, design, installation and support service?	Y / N
• Can local production match import quality (as opposed to simply turning out low cost and low quality goods)?	Y / N
• Are there clearly stated reasons for pursuing any given technology (e.g. evacuated tube systems as opposed to flat plate collectors)?	Y / N

8.5 Agricultural Cogeneration

123. This section explores the data presented in the relevant case studies for India, Indonesia, and Thailand. Additionally the particular problems and options associated with exporting power produced in such contexts is discussed in more detail in Sections 7.2 and 7.3.

124. Globally the agricultural sector is being encouraged to exploit its potential to produce energy to meet its own process requirements for heat and power (i.e. cogeneration plant), with the prospect of then exporting any excess electricity production to the local utility. Underlying this is the desire to capture the potential energy, industrial and agricultural benefits. The potential for cogeneration varies according to location and crop. The crop types that are most used in such plants are described below.

- Sugar production from sugar cane produces a mixture of waste streams. The most plentiful of these is bagasse, the remains of the cellulosic structure once the sugar has been extracted. This material, once dried is combustible and has been used as the basis of captive power production in many sugar mills (but without power export). It is also possible to supplement bagasse as a fuel by burning the cane trash. However, globally this is not yet a widely accepted practice although many countries are looking at cane trash combustion to improve the economic case for power export from bagasse power plants.
- Palm oil production produces residues in the form of fibre, shells and empty fruit bunches at the rate of some 400kg of residue per fresh fruit bunch of harvested oil palm.
- Rice husks (a by product of the milling process) are another agricultural waste stream which can be used as fuel in cogeneration plants. A typically current power plant would require 2kg of husk to produce 1 kWh, but this ratio is improving as the technology develops. There is a minimum size requirement before cogeneration becomes possible of 5 tonnes of husk per hour.
- Finally, wood residues produced from rubber and other forestry based operations could also potentially support cogeneration, with electricity export.

Biomass (wood) boilers, Tea Estate, Kericho, Kenya

8.5.1 Discussion

125. In the case studies the schemes were all based on energy production sufficient to meet process plant requirements, and all were looking at the prospects for exporting surplus electricity production to the local utility. However, in each case it was also recognised that additional benefits from using crop residues are possible, including environmental gains from reduced waste streams, displaced use of conventional fuels and a general strengthening of the agricultural sector.

126. Barriers to the wider uptake of this large potential resource also exist. These include the following:

- There is a widespread ignorance of the technical and economic case in support of cogeneration.
- A lack of successful, commercially based, experience. As a result the plants are often viewed as complicated to run. More advance conversion technology is beginning to enter the market place, but currently remains essentially unproved. Thus there is a need for improved technology, but developers and financiers are wary of regarding the out-dated technology currently in use, and the unproven (new) technology that is currently on offer.
- Fuel supply can be difficult to secure and fuel quality can be variable. Fuel supply related problems are classically displayed in the mismatch between the typically volatile and short term crop production cycle and the longer term and relatively fixed nature electricity supply contracts. Thus crop processors may be unwilling to be bound to long term supply contracts, and conversely the utility may not see the electricity supply contracts as enforceable (as typically processors are relatively small companies without a strong enough balance sheet to guarantee compensation).
- Energy is very often not viewed as the core business of potential plant operators.
- The full range of required supporting institutions do not exist yet (e.g. relevant specialist and technical advice).
- The impacts of mill size, fuel transportation and seasonality of fuel supply/electricity demand are difficult to quantify.
- Financial barriers, particularly in respect to imposition of high risk premia due to ignorance on the part of the financial community, who often do not understand the technology or sector.
- The work incurred in strengthening the distribution system, administration, and operation and maintenance, may be disproportional to the amount of power which is gained through such schemes. Conversely on weak grids small, firm, power sources can bring grid stability benefits which may not be monetarised by the utility.
- The terms of the power purchase arrangement are critical (see Section 7.2). In particular the ability to make third party sales could transform the economic case for many installations. With third party sales, pricing of power produced can reflect the value to the end user (i.e. a market based premium price), and not the system marginal cost for the utility.

8.5.2 Check List

127. The following list summarises the key points that arise from consideration of the case studies. Each item within the list should be answerable on a simple yes/no basis. Then, for any specific case the greater the number of yes answers, the greater the probability that the project will succeed - although there is never any guarantee of success. No answers should not be taken as a guarantee of failure, instead they should be used as an opening to explore the extent to which the underlying issues have been addressed, and by inference understood. For ease of application each of the questions been assigned as most relevant under the general heading of policy, legislation or implementation.

Policy	
• Is there an (actionable) policy that supports biomass cogeneration?	Y / N
• Do policies exist for rural electrification, and do they specifically include the use of surplus power from agro-industrial sources?	Y / N
• Is it clear how all actors can win via their involvement in the scheme?	Y / N
• Is detailed information on quantities and availability of agro-industrial residues?	Y / N
• Do alternative markets exist for the potential fuel (e.g. bagasse for paper pulp)?	Y / N

Legislation	
• Are independent power producers recognised, and if so are they encouraged?	Y / N
• Does legislation allow power evacuation (shipping)?	Y / N
• Does legislation allow third party sales?	Y / N
• Is environmental legislation affecting the disposal and use of residues in place and enforced?	Y / N
Implementation	
• Is the location desirable for embedded generation from the utilities perspective?	Y / N
• Is the utility positive about contracting for the power produced?	Y / N
• Is there a well understood (and equitable) power purchase agreement available?	Y / N
• Has the agricultural undertaking contacted independent power specialists?	Y / N
• Was their assessment positive?	Y / N
• Has the chosen technology been successfully demonstrated in a similar context?	Y / N
• Can the agricultural undertaking raise its share of the finance package?	Y / N
• Is there funding available for pre-feasibility and feasibility studies; loans or grants for capital investment?	Y / N
• Is there sufficient cheap biomass fuel available (and can supply be guaranteed)?	Y / N
• Do plant owners have a means of recourse if fuel supply contracts are broken?	Y / N

9 SUMMARY

128. It is apparent that the status of renewable energy technologies are changing at the moment. In particular there are a number of technologies that are at, or visibly approaching, commercial viability. This means that as a group renewables are moving out of the research and development stage, where the technology requires a high degree of technical development (technology push) into a more commercially driven environment. Such environments demand the integration of these technologies into mainstream commercial activities. The desired outcome from such commercialisation activities should, therefore, be the development of market pull (i.e. stimulating demand and not supply). Underpinning this transition is the need to empower a wider range of actors, particularly those outside the public sector. To this end this study has been driven by the basic premise that effective incentivisation of renewables is best addressed via the basic principle that potential markets can be segmented, analysed and the key deficiencies identified. Following this carefully targeted incentives can be introduced in such a way as to minimise the short to medium term "interference" in the market whilst maximising the long term development and commercial benefits.

129. It is in analysing this transition, and the demands it places on third party supporting bodies such as DFID, that this study has concentrated. In particular the study has started with the premise that the participants (actors) in any given context will all react differently to the incentives that are on offer. This can cause problems when trying to establish a full set of 'win-win' relationships. To further complicate the picture it is also recognised that the underlying technology-market transition will bring with it a need to change the mix of actors who need to be involved (and potentially their roles). Finally, this new commercial market is not yet sufficiently mature for renewables to operate without some form of support. This all leads to a complex scenario where the possibility of ineffective or perverse interventions is relatively high. This study has developed an approach that allows a structured, rational, approach to the analysis of any given context. This analysis can then be used to target interventions with the aim of maximising the desirable impact, whilst minimising unwanted market distortions. In this context a targeted subsidy is defined as one which is minimal, closely focused on clear objectives and time bound (i.e. will bring with it the essence of an exit strategy, so that incentive dependency does not result).

130. Renewables hold out the prospect of providing a range of technologies that are capable of providing access to modern energy service in a manner that also realises maximum alignment with the general OECD DAC goals, and the specific DFID aim of 'the elimination of poverty in poorer countries', and the three underlying objectives of:

- Policies and actions which promote sustainable livelihoods
- Better education, health and opportunities for poor people
- Protection and better management of the natural and physical environment

However, this does not mean that they are in a position to do this entirely on their own merits yet. First the fact that the need for the provision of sustainable energy sources tends to be internalised within the above objectives needs to be recognised. Then, the relative immaturity of the technologies means that the need remains for external intervention to support the emerging markets.

131. However, by definition any such intervention will involve distortion of the markets and this is often not conducive to building independent and sustainable markets. This therefore places the requirements that any intervention needs to be for clearly understood reasons, and

with clearly understood goals. However, at the same time it is necessary to remain aware that in order to leave a viable position in place when the intervention is complete we need unwanted distortions in the emerging (renewables) markets to be minimal. It is proposed that this be approach by carefully analysing the existing market structure (segmenting it) and then analysing its deficiencies. Intervention should then involve looking at the attributes of these segments and targeting interventions only in those segments that actually need support (and that the reasons for providing this support are compatible with the DFID agenda). The net result is that the probability of encouraging the right people to become involved (and for the right reasons) is increased. This in turn should maximise the chances of the market surviving the loss of the incentive. In addition targeting should reduce the chances of the incentive working in a perverse manner.

132. In terms of the tools that can be used to incentivise actors and markets the range available has grown over recent years. In general these tools fall under the headings of; removal of competing subsidies, the internalisation of external costs, and market stimulation. Of these market stimulation is the most discussed (and used) but the potential contributions from the others should not be dismissed without further consideration.

133. Many countries have a long (and often unhappy) history of subsidised energy prices. The reasons for this practice varies from country to country, but is usually rooted in objectives ranging from social pricing policies through support for nationalised industries, and on to attempts to minimise macro economic impacts of global oil prices fluctuations.

134. In most cases the introduction of energy subsidies has proved considerably easier than their removal; additionally all too often the subsidy will act in a perverse manner and hence undermine the original aims of the intervention. For example social pricing of electricity in urban markets tends not to markedly increase access to modern energy services for the poorest portions of the community: instead the rich can simply afford to consume more. Hence an early stage in any national strategy intending to streamline its subsidy regime is the careful analysis of where incentives currently exist and how they operate in practice. Equipped with this the next stage is to plan how to phase out unwanted elements of these - but it must be done in such a way that economic and social hardship is minimised.

135. It is often argued that new subsidies, based on the internalisation of external costs, should be introduced to benefit "cleaner technologies" such as renewables. In practice a full internalisation of external costs is generally held to be infeasible at present, due to uncertainties in assigning monetary values to many of the social and environmental impacts. However, it is theoretically possible to use these figures as the basis of an uplift, or adder, for electricity generated by technologies with relatively low environmental burdens, such as renewables. Indeed proxies for such uplifts form the basis of many output subsidies (such as some payments under the Global Environment Facility (GEF), or the premium payments under the UK NFFO scheme) which have tended to prove more successful than capital subsidies in developing commercial markets. However, whilst the payments in these cases may be indirectly related back to externalities this process is never made explicit when deriving the monetary uplift that is to be applied.

136. Thus, what is in principle a simple concept is fraught with difficulty in practice. After the problem of calculating what level payments should be at, the next question with internalisation is one of how do you actually process the money. If it is collected as a tax, then

in order to be acceptable at a macro economic level (and revenue neutral) it needs to be hypothecated, but in general governments do not like hypothecated taxes (they tend to prefer tax income flow through the general exchequer). Thus, the imposition of environmental taxes is fraught with problems, not least of which is that they will almost certainly result in a raft of new market distortions, at least some of which will probably be perverse in their operation.

137. However, the above tends to look at national economies as a closed book, which is not actually the case. Environmental adders may be introduced to developing economies via international "green investment" (e.g. Clean Development Mechanisms in whatever form they finally emerge from the Kyoto process). This is an interesting prospect as such mechanisms could turn out to operate as hypothecated taxes which are outside individual government control. This would open up many opportunities regarding how developed country money could be fed into developing economies, with one particularly interesting aspect being the prospect that private sector Northern investors will demand, as a condition of their funding, increased liberalisation and maximum involvement of the private sector. There is also a paradox emerging with regard to such potential North-South environmental payments: the Northern partner will seek reductions in greenhouse gas emissions, whilst the Southern one will be more interested in the wider general developmental gains. Renewables can potentially deliver against both agendas, but credible tools that clearly show this have not yet emerged.

138. The counterpoint to external factors being used to stimulate markets, is the need for measures to stimulate an initial market, or encourage the development of existing markets (typically small or new ones). These types of measures work best when the technology being promoted is either close to, or perceived as possibly approaching, some sort of cost effective level (i.e. people would consider buying it as the result of a rational economic buying decision). Taken as a group the aim of such measures is to encourage investment, allow economies of scale to be realised, and build evidence of successful operation (a 'track record') in a commercial, or near commercial, environment.

139. It is in analysing how these forms of market stimulation can be applied in developing markets that this study has concentrated. In essence the study shows that there is no single approach to market stimulation that provides universal benefits. However, we feel that the work does show how a combination of carefully thought through, and controlled, measures can be used to give maximum market stimulation for minimum distortion, over the shortest possible timescale.

140. In practice this implies the need to select interventions according to the exact context under investigation. These interventions, though will typically fall under one or more of the following headings:

- Guaranteed purchase price, or price support in the form of output subsidies. There is a general trend emerging during the commercialisation phase for renewables in developed economies that there has been a marked reduction in the application of capital subsidies in favour of output (revenue) subsidies. The underlying rationale for this is the intention to enable entrepreneurial innovation and capture market efficiencies. The success of schemes such as the UK NFFO show how effective this can be in reducing prices.
- Investment support. This tends to take the form of grants, capital subsidies, soft loans, and/or tax breaks, and these relatively crude interventions will continue to have a role to play. However, more indirect investment support is possible via enabling (or underwriting) access to specialist support. For example this could take the form of providing access to key

technical and commercial skills via independent institutions (such as research providers) for organisation too small to support such in-house expertise.

- Promotional measures that are intended to build the "softer" side of the market by addressing deficiencies in market awareness etc. via information and education programmes. This is often associated with supporting access to specialist advice along with carefully targeted demonstration schemes. It also includes raising general awareness using carefully selected vehicles that ensure the target audience is able to make a more informed buying decision in the future.
- Large scale demonstration (i.e. direct market stimulation). This is all about government building first of a kind demonstration plants. If the scheme works well then all is well, but all too often in practice the kind of protected environment associated with such schemes means that they are often not seen as really building a true commercial track record. Additionally, if you load the demonstration scheme too heavily with early production costs, then you may undermine the general case by making it appear excessively expensive.
- The setting of a target can in itself stimulate market development. However, targets cannot work on their own, they need to be supplemented by more specific measures. In addition a target in itself may not be a good thing, as they can become an end in themselves (i.e. setting the norm) rather than being used as simply a visible indicator of progress towards underlying goals.
- It is possible to address some existing market distortions by looking at the legislative and regulatory process. This can involve empowering third party power production (at levels ranging from multi megawatt independent power producers down to solar home systems installing a number of systems), power sales outside the national utility monopoly, tariff reform, etc. However, this route is notoriously difficult to target at anything other than broad, macro level, market defects.
- Voluntary agreements are an interesting hybrid between targets and legislation in so far as they can be used as the basis of an understanding between the two sides which can result in increased efficiency of technology transfer. However this is only really possible when both sides clearly understand (and value) the arising mutual advantages.