Report

ETSU Ref: 18401861/R1

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# Final Report to the Overseas Development Administration

## Critical Success Factors for Renewable Energy

June 1995

ETSU

ODA

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# Critical Success Factors for Renewable Energy

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# Executive Summary

This report contains the findings of the work undertaken by ETSU on the Overseas Development Administration (ODA) funded Research Project R6143 - Critical Success Factors for Renewable Energy. The report represents the views of ETSU. It does not necessarily represent Government or ODA policy.

Many renewable energy projects in developing countries have had great success in bringing affordable and environmentally acceptable energy to people, particularly in rural areas. There have however been other projects and programmes that have been less successful. This project set out to identify the key factors which need to be in place to maximise the probability that future renewable energy projects and programmes will succeed. In this context success is defined as sustained and replicated introduction into a suitable market place.

The key factors required have been called the Critical Success Factors (CSFs). CSFs have been identified by the analysis of successful projects, and discussion of current & planned projects, to ascertain what key factors are being incorporated into them. The analysis has been carried out by developing a wide ranging series of case studies. These case studies were selected to illustrate and analyse the diverse range of available technologies, markets, and institutions.

In using and applying the expression "Critical Success Factors" it is to be borne in mind that there are projects and programmes where some, but not all, of the CSFs are present and yet they succeed; there are some projects and programmes where some but not all CSFs are present and yet they fail. The chances of success are, however, enhanced when more of the CSFs are present. Conversely, the chances of success are reduced when fewer of the CSFs are present.

A characteristic of renewable energy technologies, clearly reflected in the case studies, is that they vary widely in scale, level of sophistication, and are highly location dependent. The case studies cover:

- a range of capacities from small (Watt) level (in solar photovoltaic lighting) to the large (MegaWatt) level (in small hydro and wind farm developments);
- potential markets ranging from provision of a minimal level of basic energy services, to full commercial integration in national power grids; and
- per capita incomes ranging from the UN absolute poverty level ($1 per day) to those of the level of the richest countries.

The case studies also span the range of available renewable energy technologies, and include :

- the use of turbines to tap the wind power resource. Such turbines can be used to generate electricity either for local use, or as part of larger developments (wind farms) to supply to an electricity grid.
- small scale hydro power development. In this context 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.

- solar photovoltaics. Photovoltaic technology directly converts light into electricity via the photo-electric effect. In theory photovoltaic power could be supplied to a grid, however, in practice at present application is limited to smaller decentralised applications (e.g. small scale lighting, powering pumps, etc.)
- solar thermal. Solar energy may also be captured as direct heat using solar thermal technology. 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 of low temperature process heat. In the UK the technology exists to raise steam with solar thermal collector technology; there was no evidence of this approach being used in any of the markets studied.
- biogas use. As biomass degrades it emits a mixture of gases including methane, which can be collected and combusted in much the same way as any fossil fuel based gas.
- biomass use via direct combustion. If the calorific value of biomass is sufficiently high, or decomposition slow, it is possible to directly combust biomass. This can be done in a variety of ways ranging from cookstoves, to multi MegaWatt boilers.
- cogeneration based on biomass. Biomass is also useful as a fuel in combined heat and power stations. In the case where the biomass (e.g. in the form of a process residue such as bagasse) is produced locally, it can form an attractive fuel source.

Taken together the results of the case studies contain an enormous amount of data on the multiplicity of CSFs that apply across the spectrum of accessible markets and technologies.

Throughout the study the fundamental goal has been to extract information on what ought to be present in order to make investment in renewable energy attractive. The result of this has been the derivation of a number of CSFs for each individual case study. The study then took these individual factors and developed an approach that categorised them by extracting common themes, lessons, and factors that apply at the institutional or technology level. Analysis of the case study CSFs has highlighted a total of 53 CSFs.

It is, however, recognised that the blanket application of this large number of diverse factors would be impracticable. Hence a series of pertinent, smaller, categories have been defined. These categories are:

- **Universal Critical Success Factors.** These represent the basic attributes and requirements that renewable energy projects and programmes should have.
- **Critical Success Factors for Funding Bodies (and their Agents).** The nature and functions of the funding bodies, and their agents, all play in part in contributing to the success of programmes. The funding body may be a bi or multilateral aid organisation, and their agents include development banks etc. The common theme for such organisations be they an arm of government, a non-governmental organisation, or a specialist agency is that they all operate at the policy level.
- **Critical Success Factors for Managing Agencies.** In many situations programmes are managed by a third party. This may be a specialist energy agency or it may be a reflection of how financial institutions manage their investments. Some bodies operate as both Funding bodies and Managing agencies. However, in this study a distinction is drawn in that managing agencies are assumed to essentially operate outside the policy making framework (i.e. they implement policy).
- **Critical Success Factors for Provision of Basic Energy Services.** The provision of basic energy services is treated as a distinct case, with its own underlying rules, and

hence a specific range of CSFs. This is because such programmes tend to have an emphasis on making energy services available to the poorest sections of society for the first time. Thus they can be equated to the very early stages of market establishment.

- **Critical Success Factors for Rural Electrification (based on renewables).** In contrast to the basic energy services based programmes, rural electrification programmes are viewed as having the underlying aim of developing newly established energy markets. In these cases the underlying aim can be viewed as market enablement, and this focus leads to the identification of a distinct set of CSFs.
- **Critical Success Factors for the Individual Renewable Technologies.** Each of the renewable energy technologies then has associated, specific, CSFs.

The CSFs that apply in these categories are summarised in the Table overleaf.

The universal CSFs are

- A medium term strategy ought to be in place
- The programme will use a proven or reliable design (or a proxy for this)
- The investment has acceptable economics
- That an appropriate finance package can be put together
- That there is provision for a market support structure (i.e. maintenance, spares, etc.)
- Establish that the target market actually exists
- Do not give free gifts
- Ensure that a chain exists (i.e. ensure that all the necessary actors from fuel suppliers to financial intermediaries to end users exist)
- Site specific factors have been considered
- That there is a favourable legislative/political/regulatory framework in place
- That there is an acceptable tariff structure (i.e. costs can be recovered)
- That there are mechanisms to disseminate/publicise the programme and its results
- A system of project review, including provision of feedback, and suitable record keeping has been established
- That the programme has built into it the ability to cater for future changes in demand (particularly growth).

The CSFs that apply in each of the identified categories are summarised in the Table overleaf.

Thus, the output from this study can viewed as a manageable, structured, list of relevant CSFs. This derived hierarchy, with its associated interactions between the various categories and factors, is such that it should be possible to select manageable and pertinent lists of factors for the majority of situations. Hence, this equates to a guidebook that highlights good practice in renewable energy developments. Such a handbook will be of value to those considering a renewable energy programme, and to those tasked with evaluating such proposals.

## SUMMARY OF CRITICAL SUCCESS FACTORS

| Critical Success Factor | Agencies/Markets* | | | | Technologies** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | A | B | C | D | E | F | G |
| Autonomy from government | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | |
| Identify markets and benefits | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ | ✓ |
| Market pull | ✓ | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| All in market chain win | ✓ | | ✓ | | | ✓ | | | | ✓ | |
| Plan to remove any subsidies | ✓ | | | | | | | | | ✓ | ✓ |
| Credible project champion/entrepreneurial capacity | ✓ | | ✓ | ✓ | | | | | | | |
| Access to relevant experience | ✓ | | | | | ✓ | | | | | |
| First mover advantage | ✓ | | | | | | ✓ | | | | |
| Ability to pay and affordability | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | |
| Ability to monitor and respond | ✓ | ✓ | ✓ | | | | | | | ✓ | ✓ |
| Integration with wider development plans | ✓ | | ✓ | ✓ | ✓ | | | | | ✓ | |
| Clear Goals | ✓ | ✓ | ✓ | | | | | ✓ | | | |
| Develop the cheapest first | ✓ | | | ✓ | | ✓ | | | | | |
| Independent scrutiny | | ✓ | | | | | | | | | |
| Encourage competition | | ✓ | | ✓ | ✓ | | ✓ | | | | |
| Staff Commitment | | ✓ | | | | ✓ | | | ✓ | ✓ | |
| Appropriate diversification | | ✓ | | | | | | | | | ✓ |
| Identify and address choke points | | ✓ | | | | | | | | ✓ | |
| Output focus | | ✓ | | | | ✓ | | | | | |
| Competence of developers and managers | | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | |
| Accounting and arbitration procedures | | ✓ | | | | | | | | | |
| Resource/Fuel known to be available | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Consistent or predictable load | | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Full or part indigenous sourcing | | | ✓ | | ✓ | | | | | | |
| Access to a range of customers | | | ✓ | | | ✓ | | | | | |
| Right and targeted incentives | | | ✓ | | | ✓ | | | | ✓ | |
| Holistic view of benefits | | | ✓ | | | ✓ | | ✓ | | ✓ | |
| Cash Vs Development dilemma | | | ✓ | | | | | | | ✓ | |
| Bureaucratic streamlining | | | ✓ | | | ✓ | ✓ | | | ✓ | ✓ |
| Appropriate and flexible design | | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ |
| Informed and appropriate selection possible | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | |
| Competent contractors/suppliers | | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | |
| (Sustained) Job creation | | | | ✓ | | | ✓ | | | | |
| Environmentally acceptable | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Training | | | | | ✓ | | | | | | |
| Demand for, and arrangements to ship, power | | | | | ✓ | | | | | | ✓ |
| Suitable site with access | | | | | | ✓ | | | ✓ | | |
| Ease of operation | | | | | | ✓ | | | ✓ | | |
| Ensure appropriate standards | | | | | ✓ | | | | | ✓ | |

* i Funding Bodies and their Agents
ii Managing Agencies
iii Provision of Basic Energy Services
iv Rural Electrification

** A Wind Power
B Small Scale Hydro Developments
C Solar Photovoltaics
D Solar Thermal
E Biogas
F Direct Combustion of Biomass
G Cogeneration

# CRITICAL SUCCESS FACTORS FOR RENEWABLE ENERGY

## CONTENTS

# 1. INTRODUCTION

This report contains the findings of the work undertaken by ETSU on the Overseas Development Administration (ODA) funded Research Project R6143 - Critical Success Factors for Renewable Energy. The report represents the views of ETSU. It does not necessarily represent Government or ODA policy.

The project set out to identify the key factors that need to be in place to maximise the probability that future renewable energy projects and programmes will succeed. These are the Critical Success Factors (CSFs). In using and applying this expression it is to be borne in mind that there are projects and programmes where some, but not all, of the CSFs are present and yet they have succeeded; there are some projects and programmes where some but not all CSFs are present and yet they have failed. Overall, the chances of success are, however, enhanced when more of the CSFs are present. Conversely, the chances of success are reduced when fewer of the CSFs are present.

Section 2 of the report describes the overall objectives of the work, and Section 3 describes the methodological approach used and outlines the work programme. Section 4 describes how the identified CSFs have been processed into a more structured form. The structure is based on the identification of those CSFs that are generally applicable (the Universal criteria). Underneath these are criteria which relate to the types of agencies that are applicable in renewable energy development, selected specialist niche market areas, and the final tier of the hierarchy is based on CSFs that are technology specific. In this way a manageable number of relevant CSFs factors for each category of institution, programme and technology can be accessed.

The derivation of the CSFs was based on the production and analysis of 28 case studies. These case studies are contained in Annex A. The case studies were essentially based on meetings held with interested and informed parties. Visit notes for these meetings are presented in Annex B. The case studies and visit notes are based on confidential meetings, and hence they are not available for general use.

# 2. BACKGROUND AND OBJECTIVES

Many renewable energy projects in developing countries have had great success in bringing affordable and environmentally acceptable energy to people, particularly in rural areas. However, there have also been other projects and programmes which have been less successful. Many potential investors are not familiar with the technical and non-technical issues involved in introducing renewable energy to their markets. Hence uncertainties can inhibit future investment in appropriate systems.

This project aims to identify the key factors which need to be in place for renewable energy projects and programmes to succeed. It does this through analysis of completed projects, and discussion of current/planned projects, to ascertain what success factors have been incorporated into them (i.e. what lessons developers are building into their current projects). The analysis has been carried out by developing a wide ranging series of case studies that illustrate the way in which these factors can work together. In this context success is defined as the sustained and replicated introduction of renewable energy technologies into a suitable market place.

It is a characteristic of renewable energy technologies that they vary widely in scale, level of sophistication, and are highly location dependent. Hence, a large number of apparently disparate success factors can be identified. This reflects the range of factors that can influence issues, such as location, financing, training, maintenance, institutional structures, support, etc. In response to this an approach has been developed which categorises the identified success factors by extracting common themes and lessons, and then identifies more specific critical success factors that are applicable at an institutional or technology level.

It is hoped that the project will assist ODA, and other potential investors in renewable energy to improve their decision making processes. In addition project proposers and appraisers should be able to draw upon the findings and work together to ensure the incorporation of appropriate factors, implement "Best Practice", use practical guidelines, and address the pertinent range of relevant criteria. In this way future renewable energy technology investments should have an increased overall probability of success.

## 3. RENEWABLE ENERGY TECHNOLOGIES

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 form, most renewables are relatively new technologies for energy provision and 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.
- 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. 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 Wind Power

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.

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.

### 3.2 Small Scale Hydro Power

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.

Hydro power technology can be regarded as being fully commercialised. 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.

### 3.3 Solar Photovoltaics

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.

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.

### 3.4 Solar Thermal

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. In the UK the technology exists to raise steam with solar thermal collector technology, though there was no evidence of widescale use of this technology in any of the markets studied.

### 3.5 Biogas

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.

### 3.6 Direct Combustion of Biomass

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.

The use of biomass for energy production is inherently complex. This is because the biomass fuels are not internationally traded commodities but locally collected and shipped to the point of use. This distinction 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.

## 3.7 Cogeneration

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 bagasse) 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).

# 4. METHODOLOGY

To meet the objectives of the project, ETSU undertook to carry out fieldwork by analysing selected institutions, programmes and projects in Western Europe (drawn from the UK, Germany, Greece, and Spain) and in selected Developing Countries (Botswana, India, Thailand, and Zimbabwe). This section briefly describes how this data collection phase of the work and its associated fieldwork was undertaken.

## 4.1 Methodology for Visits

At the outset is was known that, in order to be comprehensive, the study would have to visit and interview a wide range of interested parties. This was necessary to cover the wide range of renewable energy technologies, analyse a suitable range of appropriate institutions, reflect the geographic spread of resources, as well as span the range of prevailing macro economic conditions.

The targets for visits were then broken down into two groups: Western European and Developing Countries. Visits within Europe concentrated on exploiting existing contacts that ETSU has with developers and institutions within the European Union. This network allowed a range of national energy related agencies (ETSU itself in the UK, GTZ in Germany, CRES in Greece, and IDAE in Spain) to be studied. These agencies in turn nominated suitable projects for analysis within their own spheres of operation. In addition the views of the World Bank, as a major player in the development of renewable energy in Developing Countries were sought. In the final selection of Developing Countries for analysis use was again made of existing links between ETSU and appropriate national bodies. The decision was then made to concentrate analysis, on three regions: India, Southern Africa, and the Far East. Between them these three regions span the spectrum of per capita GDP commonly found in the developing world, and all have significant renewable energy programmes in hand.

Once the destinations had been decided upon the next step was to use existing contacts to gain access to appropriate institutions and programmes. Once a suitable programme of visits had been drawn up missions were undertaken and appropriate meetings and site visits undertaken. As far as possible, prior to meetings all parties were briefed on the background to the project. Discussion was based on the following basic questions:

- what programmes have you had that have been a success, and how do you characterise and define success ?
- why do you think these succeeded ?

- what would you look for and/or do differently if you were starting out again today ?
- what do you look for when you decide to enter a market ?
- if you are working on programmes at present, what are you building into them to increase their probability of success ?

The answers to these questions were sought, and categorised, using SITE factors (Social/ Political, Institutional, Technical, and Economic). Then on completion of each meeting a visit note was produced so as to record both what was said and the judgements of ETSU staff present. These visit notes were then used, along with professional judgement, to construct the case studies.

## 4.2 Case Study Format

The target for case studies was a short formally structured discussion of the institution/ project/programme that was being analysed. The specification that all the case studies were prepared to is outlined below.

- **Description.** A short overview of the institution/project/programme. This includes selected technical detail, plus an indication of the economic and other benefits expected or achieved.
- **The macro environment.** This section describes the wider operating environment of the institution/project/programme. It is not specifically focused on CSFs, but is intended to put the institution/project/programme into the widest possible context. Factors discussed under this heading include; national economic climate, sector climate, technology availability, appropriate government policies, energy supply and prices, etc.
- **The micro environment.** This section describes the environment at the individual firm level. Again it is not specifically focused on CSFs. Factors for discussion under this heading include; management, level of available expertise, operating experience, etc.
- **Critical Success Factors.** This section pulls out the CSFs, along with a short discussion of them. The CSFs emerge from data made available during the interviews, but also draws upon the professional judgement of the interviewers.
- **Relevant Visit Notes.** The final section of each case study lists all the visit notes that have been used in its derivation. The visit notes are presented as Annex B to this report.

## 4.3 Case Studies Undertaken

Table 1 lists the case studies produced during the course of this study; the full studies are presented in Annex A.

## 4.4 Analysis of Results

The completed case studies were analysed and CSFs identified and extracted from them. The incidence of CSFs as a function of case study is illustrated in Table 2. The shorthand descriptions of the factors contained in the Table are expanded upon in Section 5.

In total 53 separate CSFs were identified from the 28 case studies. The blanket application of this large number of diverse factors would be impractical. Hence a series of pertinent, smaller, groups have been defined. These groups have been selected so as to enable the highlighting of a tractable number of CSFs that are appropriate to relevant circumstances.

### Table 1: Case Studies Undertaken

| Number | Title | Country |
|---|---|---|
| 01 | ETSU | UK |
| 02 | Forestry Residue Fired Heating Scheme | UK |
| 03 | The Glenridding Small Hydro Project | UK |
| 04 | Faccombe Estates Wind Turbine | UK |
| 05 | The World Bank & Related Organisations | USA/India |
| 06 | The Centre for Renewable Energy Sources (CRES) | Greece |
| 07 | Greenhouse Heating Using Biomass Feedstocks | Greece |
| 08 | Instituto para la Diversification y Ahorro de la Energia (IDAE) | Spain |
| 09 | Wind Power in Spain | Spain |
| 10 | Small Scale Hydro Power in Spain | Spain |
| 11 | Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) | Germany/India |
| 12 | Thai - German Biogas Programme | Thailand |
| 13 | Thai Small Hydropower Schemes | Thailand |
| 14 | South East Asia COGEN Programme | Thailand |
| 15 | Ministry of Non-conventional Energy Sources / IREDA | India |
| 16 | Indian Financial Institutions | India |
| 17 | Photovoltaics in India | India |
| 18 | Active Solar Heating in India | India |
| 19 | Wind in India | India |
| 20 | Industrial Biogas in India | India |
| 21 | Small Scale Hydro Power in India | India |
| 22 | Cogeneration Using Bagasse in India | India |
| 23 | Miscellaneous Indian Bodies | India |
| 24 | Zimbabwe Photovoltaics GEF Project | Zimbabwe |
| 25 | Solar Powered Telecommunications in Botswana | Botswana |
| 26 | The Photovoltaic Sector in Kenya | Kenya |
| 27 | The ODA Kong Dong Island Wind Diesel project | China |
| 28 | Improved Biomass Cookstoves | Various |

These groups are described below.

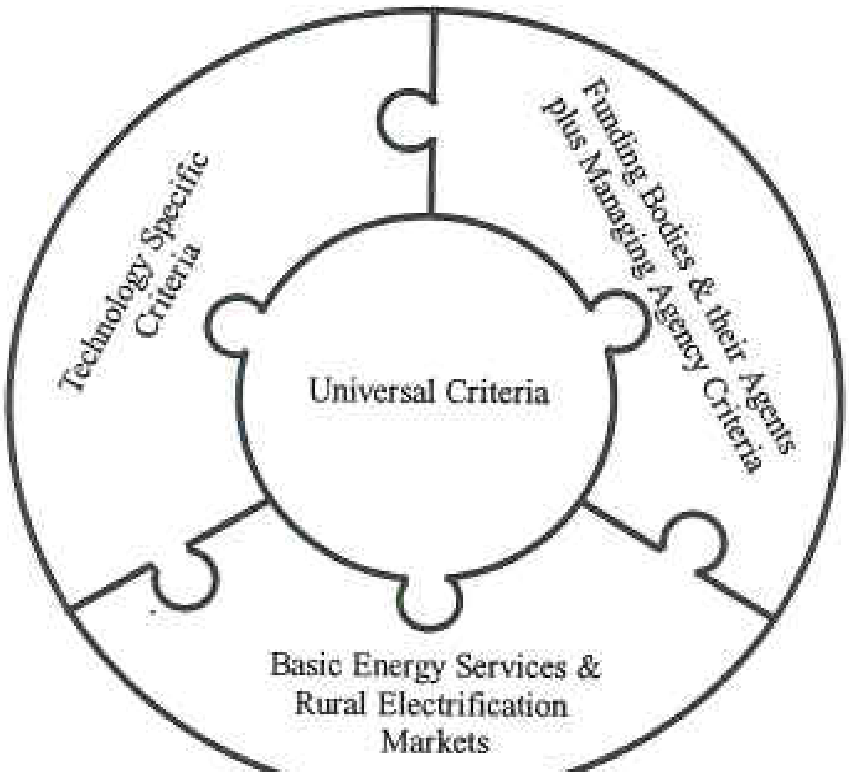
- **Universal Critical Success Factors.** These represent the basic attributes and requirements that renewable projects and programmes should have. They are called universal criteria because they are felt to be sufficiently fundamental that their absence is indicative of only a small probability of overall success.
- **Critical Success Factors for Funding Bodies (and their Agents).** The nature and functions of the funding bodies, and their agents, all play in part in contributing to the success of programmes. The funding body may be a bi- or multilateral aid organisation, and their agents include development banks etc. The common theme for such organisations, be they an arm of government, a non-governmental organisation, or a specialist agency, is that they all operate at the policy level.
- **Critical Success Factors for Managing Agencies.** In many situations programmes are managed by a third party. This may be a specialist energy agency or it may be a reflection of how financial institutions manage their investments. Some bodies operate as both Funding bodies and Managing agencies. However, in this study the distinction drawn is that Managing Agencies are assumed to essentially operate outside the policy making framework (i.e. they implement policy).
- **Critical Success Factors for Provision of Basic Energy Services.** The provision of basic energy services is treated as a distinct case, with its own underlying rules, and

hence a specific range of CSFs. This is because such programmes tend to have an emphasis on making energy services available to the poorest sections of society for the first time. Thus they can be equated to the very early stages of market establishment.

- **Critical Success Factors for Rural Electrification (based on renewables).** In contrast rural electrification programmes are viewed as having the underlying aim of developing newly established energy markets. In these cases the underlying aim can be viewed as market enablement, and this focus leads to the identification of a distinct set of CSFs.
- **Critical Success Factors for the individual Renewable Technologies.** Each of the renewable technologies considered in this study has specific factors which relate to its deployment in energy markets. For example energy derived from biomass has to take into account the potentially complex problems associated with the fuel supply chain; whilst the question of fuel availability for solar technologies is considerably simpler.

How the above CSF categories interact with each other is shown schematically in Figure 1. The diagram shows the central role of the universal CSFs, and the fact that all categories interact strongly.

**Figure 1: Critical Success Factors**



## Table 2: Critical Success Factors as a Function of Case Study

| | Critical Success Factor | Case Study Number | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 1 | Fits the medium term strategy | X | | | | X | X | | X | | X | X | X | | | X | X | | | | | X | | X | | | | | X |
| 2 | Use of Proven/Reliable design or proxy | | X | X | X | X | X | X | | X | | | X | X | X | | X | X | | | X | X | X | | | X | | | X |
| 3 | Acceptable economics (least cost in market) | | X | X | X | X | X | | | | X | | | | | | X | X | | | X | | | X | | X | | | |
| 4 | Appropriate finance package(s) | | X | X | | X | | X | X | X | X | X | X | | | X | | X | X | | | | | X | X | X | | X | |
| 5 | Adequate market support | | | | X | | | | | | | X | X | X | | | X | X | X | | X | X | X | X | X | | X | X | |
| 6 | Establish that a market exists | | | | | X | | X | X | | X | X | X | X | X | | X | | | | | | | X | X | | | | X |
| 7 | Do not give free gifts | | | | | X | | | | | | | | | | | | | | | | X | | X | | | | | |
| 8 | Ensure that a market chain exists | | | | | X | | | X | X | | X | | | X | | X | | | | | X | X | X | X | X | | X | X |
| 9 | Consider site specific factors | | | | | X | | | | | | | | X | | | | | | | | | | X | | | | | X |
| 10 | Favourable legislative/political/regulatory framework | | | | | | | | X | X | X | X | | | X | X | | | | X | X | X | | | X | X | X | | |
| 11 | Acceptable tariff structure | | | | | X | | | X | | X | | | | | | | | | | | | | X | | | | | |
| 12 | Publicity/dissemination of programme and results | | | | | X | X | | X | | | X | X | X | X | | | | | | | | | X | X | | X | | X |
| 13 | Adequate project review, feedback, and records | X | | | | | X | X | | | | X | | | | | | X | | X | | | | | X | X | | X | |
| 14 | Cater for changes (particularly growth) in demand | | | | | X | | | | | | | | | | | | | | | | X | | X | | | | X | |
| 15 | Autonomy from government | X | | | | X | X | | | | | X | | | X | X | | | | | | | | | | | | | X |
| 16 | Identify markets and benefits | | | | | X | | | | | | | | | X | | X | X | | | | | | | | | X | | X |
| 17 | Market pull | | | | | X | | | | | | X | X | | X | | | | | | | | | X | | | | | X |
| 18 | All in market chain win | | | | | X | | | | X | | | | X | X | | X | | | | | X | | X | | X | | | X |
| 19 | Plan to remove subsidies | | | | | X | | | | | | | | | X | | | | | | | | | | | | | | X |
| 20 | Credible project champion or entrepreneurial capacity | | | | | X | | | | | | X | | | | | X | | | | | X | | | | | | | |
| 21 | Access to relevant experience | | | | | | | | | | | X | | X | | | | | | | | | | | | | | | |
| 22 | First mover advantage | | | | | | | | | | | | | | | | X | | | | | | | | | | X | | |
| 23 | Ability to pay and affordability | | | | | X | | | | | | | | | | | X | | | | | X | | X | X | | | | X |
| 24 | Ability to monitor and respond | | | | | | | | | | | X | | | X | | X | | | | | | | | | | | | X |
| 25 | Integration with wider development plans | | | | | | | | X | | | X | | | | | | | | X | | | X | | | | | | |
| 26 | Clear Goals | | | | | X | X | | | | | | | | | X | | | | | | | | X | | | | | |
| 27 | Develop the cheapest first | | | | | X | | | | | | | | | | | | | | | | X | | | | | | | |
| 28 | Independent scrutiny | X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29 | Encourage competition | X | | | | | | | | | | | | | | | | | | | | | | X | X | | X | X | |
| 30 | Staff Commitment | | X | X | | | X | X | | | | | | X | | | | | | | | | | | | | | | |
| 31 | Appropriate diversification | | | | | | | | | | | | | | | | X | | | | | | X | | | | | | |
| 32 | Identify and address choke points | | | | | | | | | | | | | | X | | X | | | | | | | | | | | | |
| 33 | Output focus | X | | X | | | | | | | | | | | | X | X | | | | | | | | | | | | |
| 34 | Competence of developers and managers | | | X | | | | X | | | | | | | | | | | | | | | | | X | | | X | |
| 35 | Accounting and arbitration procedures | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 36 | Resource/Fuel known to be available | | X | | X | | X | X | | | | | | X | | | | | X | X | | X | | X | | | X | | |
| 37 | Consistent or predictable load | | X | | | | | X | | X | | | | | | | X | | | | | X | X | | | | X | | |
| 38 | Full or part indigenous sourcing | | | | | | | | | X | | | | | | | | | | X | | | | | | | | | X |
| 39 | Access to a range of customers | | | | | | | | | | | | | | | | | | | | | X | | | | | | | |
| 40 | Right and targeted incentives | | | | | | | | | | | | | | | | | | | | | X | | | | | | | X |
| 41 | Holistic view of benefits | | | | | | | | | | | | | | | | | | | | | X | | X | | | | | X |
| 42 | Potential cash vs. development dilemma | | | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| 43 | Bureaucratic streamlining | | | | | | | | | | | | | | | | | | | | | X | | | X | | | | X |
| 44 | Appropriate and flexible design | | | | | | | | | | | | | | | | | | | | | | | | | X | | | X |
| 45 | Informed appropriate selection possible | | X | X | | | | | | | | | X | X | X | | | | X | | | | | X | X | | | | |
| 46 | Competent contractors/suppliers | | X | | X | | | | | X | | | | X | X | | | X | | X | | | | | | | | | |
| 47 | (Sustained) Job creation | | | | | | X | | | | | | | | | | | | | | | | | | X | | | | |
| 48 | Environmentally acceptable | | X | | X | | X | | | | | | | X | | | | | | | X | | X | | | | | | |
| 49 | Training | | | | X | | | | | | | | | | | | | | | | X | | | | | X | | | |
| 50 | Demand for, and arrangements to ship, power | | | | | | | | | | | | | | | | | | | X | | X | X | | | | | | |
| 51 | Suitable site with access | | | | X | | | | | | | | X | | | | | | | | | X | | | | | | | |
| 52 | Ease of operation | | | | | | | | X | | X | | X | | | | | | | | | | | | | | | | |
| 53 | Ensure appropriate standards | | | | | | | | | | | | | | | | | | | | | | | X | X | | | | X |

# 5. CRITICAL SUCCESS FACTORS

## 5.1 Introduction

The critical success factors extracted from analysis of all the case studies are contained in Table 2. Within the Table the factors have been given "shorthand" descriptors. These descriptors are amplified in the sections below. It is to be noted that within the hierarchy of CSFs the Universal CSFs apply within all the different groupings. In addition it is to be noted that the chances of overall success are enhanced when more of the CSFs are present, and reduced when fewer of the CSFs are present. However, the Universal CSFs normally cover pivotal factors and hence failure to address these may remove the need to analyse further proposed programmes. For the other groupings of factors, the CSFs can, and do, apply in several different groupings, and that whilst the general definition holds there will be variation in emphasis between sectors and technologies.

In each of the following sections the CSFs for each category are expanded upon. Under each heading the shorthand definition of the applicable CSF is given, followed by the number (in square brackets) of the factor as shown in Table 2.

In expanding upon the CSFs it becomes clear that there are not always clear boundaries between individual CSFs. As an example, the distinction between training and market support (i.e. ensuring that staff, maintenance, spares, etc. are available) is not a clear one. However, a fine distinction has been drawn because in some cases the need to educate users, maintainers, suppliers etc. has specifically been mentioned, as opposed to the simple training of support staff. Hence, when examining potential projects or programmes there will always be some element of judgement of how the boundaries between the definitions have been interpreted.

## 5.2 Universal Critical Success Factors

The fourteen universal CSFs are described below. It is to be noted that the order in which they appear is not significant.

**Fits the medium term strategy [1].** It is axiomatic that all projects in a programme must contribute to the overall aims of that programme. This is only possible if the programme fits into a medium term strategic framework, with suitable milestones on the road to a defined end point. In many renewable energy programmes the often unstated end point is market convergence (i.e. renewable energy technologies compete in the open market place). Thus, in these circumstances the question to be asked is what does this project contribute towards the ultimate goal of convergence? It is also the existence of a medium term strategy which underpins the assertion that "programmes work better than collections of projects".

**Use of proven/reliable design or proxy [2].** The ability to have faith in the technology selected is crucial; this can be done by selecting equipment with a track record that has been demonstrated in similar circumstances. In the absence of such real experience proxies can be used, in particular the offering of some form of warranty may be acceptable. In essence the use of demonstrably reliable designs is simply a practical risk management step.

**Acceptable economics (least cost in market) [3].** The economics of a project, particularly in terms of the project being able to show a positive return on cost-benefit criteria is, of course, fundamental to a programme. However, it should be borne in mind that often economic assessment is based on some form of generic assessment (e.g. simple Net Present Value calculations). The often gross assumptions that underpin such assessments hide the particulars of a scheme. Hence it is much better to talk about the programme demonstrating that it presents the "least cost solution in the specified market". In addition the definition of least cost may be wide, so as to capture environmental benefits (e.g. a project is least cost after incorporating a shadow carbon tax element).

**Appropriate finance package(s) [4].** The detail of the finance for the programme is probably more important than the underlying economic case. This is because the real, or perceived, financial risk of the investment will essentially determine the payback conditions. Thus, the ability of the market to support (i.e. pay the investment back) the technology will be dependent upon the nature, and terms, of the overall finance package.

**Adequate market support (staff, maintenance, spares, etc.) [5].** The definition of success used in this study is based on the notion of "sustained and replicated" deployment. This is, of course, only possible if in addition to the introduction of the necessary technology, a support structure is also put in place. Such supporting structures will have to cover a wide range of topics, particularly those relating to the availability of suitably qualified and trained maintenance staff plus arrangements to access a range of compatible spare parts.

**Establish that a market exists [6].** In all but specific cases where social need criteria predominate, the aim of renewable energy programmes is to contribute to the establishment and/or development of energy services markets. The assumption that a market exists does not necessarily mean that it does - it must be proven to exist.

**Do not give free gifts [7].** If the programme relates to the development of energy services markets they must place a value on the commodities traded - free gifts reduce the value of the commodity. This phenomenon is seen in the attitude of "If A got his for nothing, why should I pay for the same goods?". In addition markets in second hand goods are a mechanism for percolating benefits through the community. If new goods are free, then there is no reason to maintain them, or trade in second hand goods, as they effectively have zero value.

**Ensure that a market chain exists [8].** This is another way of saying that all the necessary actors within a programme must be identified, their needs recognised, and their roles within the programme defined. It is only after all the actors have been identified that their responsibilities can be defined, and gaps highlighted and filled.

**Consider site specific factors [9].** No individual programme should ever be treated as exactly equivalent to any other, or a more generic type. It is necessary to demonstrate that the unique challenges and opportunities that arise in real programmes have been addressed.

**Favourable legislative/political/regulatory framework [10].** Perhaps the single biggest factor that affects a programme is the framework within which it is expected to operate. Hence, it is important to identify legislation and regulation as they apply within the target markets and ascertain whether they are essentially friendly or hostile to the type of investment considered. It is also necessary to, as far as possible, take into account how local and national political considerations can affect renewable energy developments.

**Acceptable tariff structure [11].** In renewable energy schemes that have failed, one of the most cited reasons for failure is the fact that the tariff structure is such that costs cannot be recovered. Thus, it is paramount to ensure that tariff structures exist which do allow recovery of investment. Tariff structures can also play a role in controlling demand. The ability to offer variable tariff rates can help create options to refine the markets for energy services, and hence allow maximum utilisation of the installed capacity.

**Publicity/dissemination of programme and results [12].** The need to establish suitable markets based on people wanting the services offered (i.e. "market pull") has already been mentioned. One of the best ways of establishing future demand for renewable technologies is by dissemination of success stories. In addition to building demand such publicity may influence the finance community, and potentially reduce the risk weighting applied to similar investments.

**Adequate project review, feedback, and records [13].** The need for project review, feedback and records is felt at several levels. The primary reason for requiring these is the need to practice, and demonstrate, sound project management throughout. However, in addition to the need to control the project such records can be used to support many other factors such as the need to demonstrate reliable design, acceptable economics, establishment of market support structures, how site specific factors have affected outcomes, provide the basis of dissemination exercises, etc.

**Cater for changes (particularly growth) in demand [14].** It is one of the axioms of energy analysis that demand for energy services will always grow. Thus, a single one-off installation of a renewable energy technology will meet a current demand whilst stimulating a larger future one. How to meet this stimulated demand should be considered. In addition patterns of energy service use can change. In particular after introducing basic domestic energy services the need, at some future point, to introduce energy for productive uses (e.g. powering looms, mechanised food processing, etc.) must be considered.

## 5.3 Critical Success Factors for Funding Bodies (and their Agents).

The thirteen CSFs for Development Agencies are described below. It is to be noted that the order in which they appear is not significant.

**Autonomy from government [15].** In this context autonomy from the government does not necessarily mean outside government control. What this factor implies is that the Development Agency must be capable of autonomous functioning. In particular the *modus operandi* of the agency should be one that shields the programmes from day-to-day political involvement, but on the other hand it should ensure that they fit into the longer term, politically driven, strategy of the government in the energy sector.

**Identify markets and benefits [16].** The science of marketing applies to renewable energy developments. Hence, the basic marketing discipline of analysing the market, segmenting it, and then targeting products at those segments where positive pay backs are possible should be applied. In this way the benefits of renewable energy technologies are offered only in those markets where they can compete and give positive benefits.

**Market pull [17].** All too often technologies are introduced into markets because of the assumption that it is "right for that market". However, this pushing of technologies into markets is often done by inappropriate people (e.g. technology champions) who understand the technology and not the market. This type of technology push approach tends to fail. It is much better to make appropriate technology available to meet a real (and preferably clearly stated) need, and then let market dynamics establish a sustainable level of demand.

**All in market chain win [18].** One of the universal criteria is that all the relevant actors must be present. At the level of the Development Agency a goal should be to try to ensure that all of the actors present achieve a suitable return (financial or other) from involvement in the programme (i.e. win-win relationships are established at all levels).

**Plan to remove any subsidies [19].** If free gifts destroy markets then subsidies distort them. For renewable technologies to achieve sustained and replicated deployment it is necessary to ensure that market distortions are recognised and, as far as possible removed. This applies to both renewable energy and competing technologies. However, the process of removing subsidies also distorts the market and hence there is a need to carefully plan the transition from subsidised market to free market to minimise distortions. It is also to be noted that in general, subsidies which reward performance (i.e. output subsidies) tend to be more effective and easier to phase out than investment subsidies (i.e. capital grants and the like).

**Credible project champion or entrepreneurial capacity [20].** Much has been made of the need to analyse and then utilise appropriate market forces in successful renewable energy programmes. The market knowledge required for this demands a committed local presence. The Development Agency should be looking at how suitable individuals (e.g. local community project champions or NGO's), or local entrepreneurs are to be involved in the programme.

**Access to relevant experience [21].** Renewable energy technologies span a large number of variables, many of which are essentially specialist in nature. Hence, project and programme management can be complex and require specialist input. Thus, there is a requirement to address the need to access relevant experience, for both routine consultation and in the event of unforeseen problems.

**First mover advantage [22].** Establishing a market, or entering it for the first time, presents particular opportunities and problems. The Development Agency needs to be aware of these and address the need to "reward" the early entrants to the market. The crude use of subsidies to achieve this should be avoided, unless plans to phase this out are included (see section on subsidy removal).

**Ability to pay and affordability [23].** It is obvious that that it is important to ascertain if and how payment for energy services rendered will be made. However, this does not make it easy to suggest solutions, especially when providing basic services to the poorest in the community. In these circumstances the unfamiliarity with cash based transactions, problems with regular scheduling of repayments, poor or zero credit rating, and the acceptability of forgoing the energy services offered must all be considered. Under these circumstances simple comparison of lifetime costs of, for example, kerosene lanterns and solar photovoltaic lighting, can be misleading.

**Ability to monitor and respond [24].** The need for project review, feedback mechanisms and record keeping is one of the universal criteria. However, simply collecting this information is not sufficient to result in good programme management. In addition to collecting the data the Development Agency must look for procedures that allow processing and reaction to incoming information in a timely manner.

**Integration with wider development plans [25].** It is to be noted that renewable energy developments do not occur in isolation, they are almost always part of wider development plans. Thus, for example it is necessary to make sure that plans for decentralised electricity generation do not clash with plans for expansion of centralised generation, small scale hydro development does not overlook water use issues, biomass utilisation for energy production does not conflict with deforestation or social issues programmes, etc.

**Clear goals [26].** Again it is axiomatic that the Development Agency will work most effectively when the programme goals are clearly stated and understood (and this aspect also refers back to the position of the agency with regard to government). In addition there is a requirement to ensure that the goals are suitable. For example goals based on norms (i.e. construction of a specified number of plants) are very short term, and will tend to result in achieving the norm, with a low probability of introducing "sustained and replicated" deployment.

**Develop the cheapest first [27].** There is a tendency in developing renewable technologies to develop "showcase" schemes that exhibit the technology rather more than develop their market potential. This can, to some extent, be overcome by making sure that even the showcase schemes are based on a knowledge of the market, memorably phrased as "mining the cheap end of the supply curve".

## 5.4 Critical Success Factors for Managing Agencies

The twelve CSFs for Managing Agencies are described below. It is to be noted that the order in which they appear is not significant.

**Autonomy from government [15].** As with Development Agencies, Managing Agencies should be capable of autonomous functioning within the framework of stated government policy.

**Credible project champion or entrepreneurial capacity [20].** In harnessing and utilising appropriate market forces there is a need for a committed local presence. The Managing

Agency should set out to achieve this either via individuals (e.g. project champions from the local community or NGOs), or through involving local entrepreneurs.

**Ability to monitor and respond [24].** The need for project review, feedback mechanisms and record keeping is one of the universal criteria. However, simply collecting this information is not sufficient to automatically produce good programme management. The managing agency must institute procedures that allow rapid processing and reaction to the incoming information.

**Clear goals [26].** It is axiomatic that the Managing Agency will work most effectively when the programme goals are clearly stated and understood. In addition there is a requirement to ensure that the goals are suitable, understood by all, and are achievable.

**Independent scrutiny [28].** The need to objectively assess the detail of programmes is important if they are to proceed on a sound basis. Thus, the ability of the Managing Agency to either make, or introduce, independent evaluation of key portions of programmes is important.

**Encourage competition [29].** One of the themes of this study is the desirability of setting up and encouraging the development of energy services markets. This implies the need to introduce an element of competition at an appropriate (early) stage. The Managing Agency should take responsibility for ensuing that competition is encouraged.

**Staff commitment [30].** As the Managing Agency will probably play a significant role in the overall programme, it is important to ensure that their staff are committed to the project, and then they in turn, try to make sure that staff at all levels are committed to the success of the programme.

**Appropriate diversification [31].** In essence this factor calls for the agencies to check that organisations that are involved in the programme and are diversifying their interests, are doing so on informed grounds. In particular, organisations getting involved in renewable energy technologies for the first time may need extra support. Industrial history indicates that insufficiently planned diversification can lead to business failure, and thus, this should, as far as possible, be guarded against.

**Identify and address choke points [32].** The process of bringing a technology to the market place throws up a variety of technical and non-technical barriers. The process of anticipating and addressing these needs to be planned for from an early stage. For example the handover of plant from developer to manufacturer, and from manufacturer to end user, all throw up specific problems (the majority of which are predictable, and hence addressable if planned for).

**Output focus [33].** It is crucial that the Managing Agency clearly understands what the output of the programme is (e.g. MWh of electricity generated) and incorporates suitable incentives into the programme.

**Competence of developers and managers [34].** The Managing Agency must, of course, itself be competent. In addition it needs to be capable of ensuring that those within its direct remit (i.e. contractors and developers) are themselves competent to carry out the tasks assigned to them.

**Accounting and arbitration procedures [35].** In most programmes contractual obligations will be entered into. In setting up these arrangements it is prudent to ensure that the accounting practices of all parties are sufficient to stand up at independent audit. In the event of disputes between parties, systems should be in place to handle conflict, e.g. acceptable arbitration procedures.

### 5.5 Critical Success Factors for the Provision of Basic Energy Services

The eighteen CSFs applicable to the provision of basic energy services are described below. It is to be noted that the order in which they appear is not significant.

**Autonomy from government [15].** Programmes aimed at providing basic energy services are normally based on introducing energy services for the first time to the poorest elements of society. Hence, they are often politically motivated. However, once the basic criteria have been defined, suitable social need programmes work best if they are allowed to run with minimal day-to-day interference from government.

**Markets and benefits identified [16].** Certain aspects of marketing apply as much in the most basic energy services market as elsewhere. Hence, analysis of the market, segmenting it, and then targeting products at those segments where renewable energy technologies can make the most effective contribution should be undertaken.

**Market pull [17].** Once the market niches in this sector have been identified it is then necessary to introduce the technologies in a manner which makes the recipients "want them". As in more developed markets it is much better to make appropriate technology available to meet an expressed need than to push an unwelcome technologically based solution.

**All in market chain win [18].** One of the universal criteria is that all the relevant actors must be present. One of the best ways of developing a market pull is by putting in place systems that try to ensure that all of the actors present achieve a suitable return (financial or other) from involvement in the programme (i.e. establish win-win relationships at all levels).

**Credible project champion or entrepreneur [20].** In harnessing and utilising appropriate market forces there is a need for a committed local presence. This is particularly the case when community level decisions have to be made.

**Ability to pay and affordability [23].** In the case of providing basic energy services the main aim of such programmes need not necessarily be the encouragement of energy services markets. However, once a basic level of energy service is available it is desirable to encourage the development of competitive markets for suitable renewable energy systems. Hence there is a need to understand the dynamics of the recipients in order to try to anticipate future problems such as; unfamiliarity with cash based transactions, regular scheduling of repayments, poor or zero credit rating, etc.

**Ability to monitor and respond [24].** The need for project review, feedback mechanisms and record keeping is one of the universal criteria. However, simply collecting this information is not sufficient to result in good programme management. There is a need to have systems in place that allow rapid reaction to the reality of day-to-day operations.

**Integration with wider development plans [25].** The observation that renewable energy developments do not occur in isolation, but are part of wider development plans is perhaps more applicable in the provision of basic energy services than anywhere else. The social drivers of such programmes make this so. Hence it is crucial that energy projects are placed within the wider context of overall societal development programmes.

**Clear goals [26].** As in most cases there is a requirement to ensure that the goals are suitable, understood by all, and are achievable. In the context of the provision of basic energy services the social goals of the programme should clearly be stated.

**Resource/Fuel known to be available [36].** The fuel cycle must be considered in the widest context. For example in collecting biomass the sort of factors that need to be considered includes; long term availability of the feedstock, transport and storage of the fuel, and matching fuel supply with demand.

**Consistent or predictable load [37].** Once installed it is of course desirable to obtain maximum benefit from the investment. This entails matching supply and demand in terms of both the service required and when it is available. For example in many of the more successful small hydro schemes, water is used to drive mechanical equipment during the working day, and produce electricity at night. However, the demand for electricity will not be consistent over the period of darkness, and water flow will vary with season.

**Full or part indigenous sourcing [38].** One of the probable elements of development plans in the poorest communities is the development of a basic industrial infrastructure. Hence it is important that elements of the programme that can generate local employment and the associated education, training and related infrastructure development are encouraged.

**Access to a range of customers [39].** In building energy services markets it is necessary to consider how they will attract sufficient customers to be viable. It is generally true that markets take some time to develop and hence the ability to generate sufficient business to support the infrastructure may be viewed as a barrier. Thus, until business has developed sufficiently it is necessary to ensure that the customer base can be sufficiently spread to diversify the risks arising from accessing a single small market.

**Right and targeted incentives [40].** Provision of basic energy services can very rarely be said to have positive economics using classical definitions. Hence there is a need to use incentives to encourage the eventual development of an energy services market. These incentives must be targeted to produce maximum return, encourage rather than stifle market forces, and should plan for the day when they are no longer necessary.

**Holistic view of benefits [41].** The social nature of this type of programme and its integration within wider development plans means that the assessment and implementation procedures should take a wide view of the predicted and possible benefits.

**Potential cash vs. development dilemma [42].** One of the classic dilemmas of basic development is the need to trade off the immediate benefits of locally utilising resources (for the direct benefit of the community) against the need of the community to generate revenue (i.e. produce cash crops). For example the use of land for the production of biomass fuel is a laudable aim, but if the farmer wishes to grow a cash crop (e.g. sugar cane) instead, then market pull will be difficult to establish.

**Bureaucratic streamlining [43].** Provision of basic energy services is typically based on the introduction of a large number of items (e.g. individual solar PV lighting units for an entire village). Hence the ability to price the item suitably could be adversely affected if a large bureaucratic overhead is present. This can happen when there are many agencies working along side each other, or it may be that the institutions are not set up to deal with individuals (e.g. banks may not find it cost effective to process applications for loans for domestic solar hot water systems). Thus, programmes which minimise bureaucratic overheads should be favoured.

**Appropriate and flexible design [44].** Once a technology has been introduced it must be capable of evolving to fill appropriate niches. This implies the need for local artisans to be able to modify the device design. For example a technology that produces electricity may need to be modified to produce motive power for direct mechanical use, or *vice versa*.

## 5.6 Critical Success Factors for Rural Electrification (based on renewables).

The fifteen CSFs applicable to renewables based rural electrification programmes are described, in no set order, below. It is to be noted that rural electrification differs from the provision of basic energy services in that rural electrification should aim at market enablement, rather than the most basic market establishment driver for provision of basic energy services programmes.

**Autonomy from government [15].** Rural electrification programmes represent an area where independence from government interference is important. This is associated with the need to focus such programmes on market enablement rather than social need. Once this basic distinction has been made suitable programmes will work best if they are allowed to run with minimal day-to-day interference from government.

**Markets and benefits identified [16].** Marketing rules apply in the rural electrification market as elsewhere. Hence, analysis of the market, segmenting it, and then targeting products at those segments where renewable energy technologies can make a cost effective contribution should be undertaken.

**Market pull [17].** Once the basic market has been identified it is then necessary to introduce the appropriate technologies in a manner which makes the recipients want them. As in more developed markets it is much better to make equipment available to meet expressed needs than to push unwelcome solutions.

**Credible project champion or entrepreneurial capacity [20].** In harnessing and utilising appropriate market forces there is a need for a committed local presence.

**Ability to pay and affordability [23].** It is obvious that it is important to ascertain if, and how, payment for energy services rendered will be made. Problems with regular scheduling of repayments, poor or zero credit rating, and the acceptability of foregoing the energy services offered must all be considered (and possibly the unfamiliarity with cash based transactions). It is to be borne in mind that under such circumstances simple comparison of lifetime costs of, for example, kerosene lanterns and solar photovoltaic lighting, can be misleading.

**Integration with wider development plans [25].** It is to be noted that renewable energy technology developments do not occur in isolation, they are almost always part of wider development plans. Thus, for example it is necessary to make sure that plans for decentralised electricity generation do not clash with plans for expansion of centralised generation, small scale hydro development does not overlook water use issues, biomass utilisation for energy production does not conflict with deforestation or social issues programmes, etc.

**Develop the cheapest first [27].** There is a tendency in developing renewable technologies to develop "showcase" schemes that exhibit the technology rather to develop their market potential. This can, to some extent, be overcome by making sure that even the showcase schemes are based on a knowledge of what will become competitive (i.e. the cheapest available) in the marketplace.

**Encourage competition [29].** One of the basic aims of rural electrification programmes should be setting up and developing energy services markets. This implies the need to introduce an element of competition at an appropriate (early) stage.

**Competent contractors/suppliers [34].** Equipment must be selected on the basis of quality and fitness for purpose, so must the contractors and suppliers. Hence, it is possible to incorporate after sales service and other less tangible returns into the overall assessment process.

**Resource/Fuel known to be available [36].** The fuel cycle must be considered in the widest context. For example in collecting biomass the sort of factors that need to be considered include; long term availability of the feedstock, transport and storage of the fuel, and matching potentially seasonal variation in fuel supply with demand.

**Consistent or predictable load [37].** Once installed it is of course desirable to obtain maximum benefit from the investment. This entails matching supply and demand in terms of both the service required and when it is available. For example capacity to cover industrial demand during the harvest may be catered for, but this may result in under use at other times.

**Appropriate and flexible design [44].** Once a technology has been introduced it must be capable of evolving to address the changing needs of the market, and to enter emerging new sectors. This may be addressed by looking at the basic design of the technologies offered.

**Informed and appropriate (technology) selection possible [45].** Part of the process of establishing a market pull is making the right choice of technology, and not simply taking the technology with the strongest push. The selection must be made on an informed basis against clearly set out user requirements.

**(Sustained) Job creation [47].** If the renewable technologies introduced to the market place are to be self sustaining and replicating it is important that those elements of the programme that can generate local employment, and the associated education, training and infrastructure development, are encouraged.

**Ensure appropriate standards [53].** Part of the process of encouraging competition is lowering the barriers to entering the market. One way of doing this, whilst also ensuring quality and reliability remain high, is to set and monitor equipment design and performance against minimum performance standards. Turning the standards into specifications should be avoided, as working only to meet a specification discourages innovation and bettering the specification.

## 5.7 Critical Success Factors for Renewable Energy Technologies

Critical success factors have been extracted from the case studies for each of the individual renewable energy technologies. These are summarised, and shown as function of technology, in Table 3. It is to be noted that Table 3 shows that not all the CSFs were identified for each technology. This may be a reflection of the differing priorities given to them by different users, or it may be that they simply do not apply. Thus, in this section the technology CSFs are generally discussed, and their application illustrated where particularly applicable. In order to aid clarity of this report no detailed discussion of why many of the CSFs were not more generally identified is presented here.

It is to be noted that the order in which the CSFs appear is not significant. For each CSF the short descriptor is followed by square brackets, which contain the appropriate number from Table 2.

**Autonomy from government [15].** Issues such as land use tend to attract the attention of government. The result of this is that there are often attempts to influence or control such factors. Whilst, in the case of land use, this can be valuable in addressing issues such as deforestation it can be problematic when trying to introduce new crops and markets for specialist crops and crop derivatives. Thus, the ability to influence land use without having to address or change government policy is beneficial.

**Markets and benefits identified [16].** Marketing applies in renewable energy markets as elsewhere. Hence, analysis of the market, segmenting it, and then targeting products at those segments where products such as solar PV, or biomass use via combustion can make a cost effective contribution should be undertaken.

## Table 3. Critical Success Factors for Renewable Energy Technologies

| Critical Success Factor | | Technology | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Wind | Small Hydro | Solar PV | Solar Thermal | Biogas | Biomass | Cogen-eration |
| Autonomy from government | 15 | | | | | | ✓ | |
| Identify markets and benefits | 16 | | | ✓ | | | ✓ | ✓ |
| Market pull | 17 | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| All in market chain win | 18 | | ✓ | | | | ✓ | |
| Plan to remove any subsidies | 19 | | | | | | ✓ | ✓ |
| Access to relevant experience | 21 | | ✓ | | | | | |
| First mover advantage | 22 | | | ✓ | | | | |
| Ability to pay and affordability | 23 | | ✓ | ✓ | ✓ | | ✓ | |
| Ability to monitor and respond | 24 | | | | | | ✓ | ✓ |
| Integration with wider development plans | 25 | ✓ | | | | | ✓ | |
| Clear Goals | 26 | | | | ✓ | | | |
| Develop the cheapest first | 27 | | ✓ | | | | | |
| Encourage competition | 29 | ✓ | | ✓ | | | | |
| Staff Commitment | 30 | | ✓ | | | ✓ | ✓ | |
| Appropriate diversification | 31 | | | | | | | ✓ |
| Identify and address choke points | 32 | | | | | | ✓ | |
| Output focus | 33 | | ✓ | | | | | |
| Competence of developers and managers | 34 | ✓ | ✓ | ✓ | | | ✓ | |
| Resource/Fuel known to be available | 36 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Consistent or predictable load | 37 | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Full or part indigenous sourcing | 38 | ✓ | | | | | | |
| Access to a range of customers | 39 | | ✓ | | | | | |
| Right and targeted incentives | 40 | | ✓ | | | | ✓ | |
| Holistic view of benefits | 41 | | ✓ | | ✓ | | ✓ | |
| Potential Cash Vs Development dilemma | 42 | | | | | | ✓ | |
| Bureaucratic streamlining | 43 | | ✓ | ✓ | | | ✓ | ✓ |
| Appropriate and flexible design | 44 | | | ✓ | ✓ | | ✓ | ✓ |
| Informed and appropriate selection possible | 45 | | ✓ | ✓ | ✓ | ✓ | | |
| Competent contractors/suppliers | 46 | ✓ | ✓ | | | ✓ | ✓ | |
| (Sustained) Job creation | 47 | | | ✓ | | | | |
| Environmentally acceptable | 48 | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Training | 49 | ✓ | | | | | | |
| Demand for, and arrangements to ship, power | 50 | ✓ | | | | | | ✓ |
| Suitable site with access | 51 | | ✓ | | | ✓ | | |
| Ease of operation | 52 | | ✓ | | | ✓ | | |
| Ensure appropriate standards | 53 | ✓ | | | | | ✓ | |

**Market pull [17].** In developing renewable sources of energy it is necessary to demonstrate, to the appropriate market, the benefits of such investments. In these circumstances users will pull the technology into the market, rather than manufacturers or other interested parties pushing it in (an inherently less efficient process).

**All in market chain win [18].** One of the universal criteria is that all the relevant actors must be present. At the technology level a complementary goal should be to try to ensure that all of the actors present achieve a suitable return (financial or other) from involvement in the programme (i.e. establish win-win relationships at all levels).

**Plan to remove any subsidies [19].** Free gifts destroy markets, and subsidies distort them. If renewable technologies are to achieve "sustained and replicated deployment" then it is necessary to ensure that market distortions are recognised and then, as far as possible removed. However, the process of removing subsidies also distorts the market and hence there is a need to carefully plan the transition from subsidised market to free market. In biomass based applications this problem can be especially large, because of the "subsidy culture" that is often entrenched in farming communities.

**Access to relevant experience [21].** Typically renewable energy developments (and in particular small scale hydro ones where each project tends to be unique in character) need to consider a range of site specific factors. Hence, project and programme selection and management can be complex and require specialist input. Thus, there is a requirement to address the need to access relevant experience, and to ensure that best practice is applied.

**First mover advantage [22].** Establishing a market, or entering it for the first time, presents particular opportunities and problems. For example solar photovoltaic technologies are currently aimed at introducing power to new and remote locations. There is a need to encourage (and reward) the players that enter and establish these markets. It is to be noted that use of subsidies to achieve this should be avoided, unless plans to phase them out are also included.

**Ability to pay and affordability [23].** It is obvious that that it is important to ascertain if, and how, payment for energy services provided will be made. The possibility of unfamiliarity with cash based transactions, problems with regular scheduling of repayments, poor or zero credit rating, and the acceptability of foregoing the energy services offered must all be considered at an early stage.

**Ability to monitor and respond [24].** The need for project review, feedback mechanisms and record keeping is one of the universal criteria. However, simply collecting this information is not sufficient to produce good programme management - particularly when managing the sort of complex and interlinked programmes that are often associated with exploiting biomass resources.

**Integration with wider development plans [25].** Renewable energy based schemes usually take place within the context of wider development plans. This is true whether it is a single installation for remote power applications or a multi MegaWatt installation feeding a centralised electricity grid.

**Clear goals [26].** In virtually all situations there is a requirement to ensure that the goals are suitable, understood by all, and are achievable. However, in some applications introduction of a particular technology can bring multiple benefits. For example active solar heating schemes can provide domestic hot water (and hence obviate the need for firewood collection and use) and simultaneously improve drinking water quality. In such circumstances it is very important that the underlying goals of the programme are recognised, and clearly stated so that all can identify them and work towards them.

**Develop the cheapest first [27].** There is a tendency in developing renewable technologies to develop schemes that exhibit the technology rather than concentrate on the development of their market potential. This can, to some extent, be overcome by making sure that all schemes are based on a knowledge of the technologies that may become the cheapest in the marketplace. For example in the case of small hydro development the obvious place to undertake such an exercise is by installing energy recovery equipment on spillways from existing water impoundments.

**Encourage competition [29].** One of the themes of this study is the desirability of setting up and then encouraging the development of energy services markets. This implies that there is a need to introduce an element of competition amongst manufacturers and developers at an appropriate (early) stage.

**Staff Commitment [30].** To achieve sustained deployment programmes require a high level of commitment from the staff involved. For example in the case of small hydro schemes the management of the water collection (i.e. pound or water flow diversion barrier) installations, and water quality management (i.e. removal of silt and foreign bodies) are heavily dependent upon the level of staff commitment to the continued success of the programme.

**Appropriate diversification [31].** This calls for organisations involved in programmes to ensure that if they are diversifying their interests, they are doing so on informed grounds. In particular, organisations getting involved in renewable energy technologies for the first time may need extra support. This is since industrial history indicates that insufficiently planned diversification can lead to business failure (and associated loss of investor confidence), and this should, as far as possible, be guarded against.

**Identify and address choke points [32].** The process of bringing a technology to the market place throws up a variety of technical and non-technical barriers. Mechanisms to anticipate, and address, these need to be planned into projects from an early stage. In particular given its complexity biomass based fuel cycles can be problematic (i.e. the need to look at production, transport, and storage as well use).

**Output focus [33].** Renewable energy technologies, such as small hydro power developments can have several deliverables - electrical power, direct mechanical power, provision of irrigation and drinking water, or flood control. It is necessary to concentrate the programme on delivering the optimum mix of required deliverables, and then delivering the maximum amount of these.

**Competence of developers and managers [34].** The developers of renewable energy projects ought to have a demonstrated capability and competence in the field. This need is particularly marked in the small hydro area because of the need to incorporate a range of variables into essentially semi-customised designs. New developers entering the market may need to demonstrate how they will manage risks associated with their lack of experience (e.g. in the form of warranties or other guarantees).

**Resource/Fuel known to be available [36].** Before renewable energy developments are undertaken it is necessary to ensure that all the necessary input materials are accessible. In the case of exploiting the individual technologies the following apply:

- for wind there must be a demonstrated (measured) wind resource;
- for small hydro the local geography and hydrological resource must have been demonstrated to be suitable and appropriate technology available (implying the need to obtain fairly detailed topographical and long term climatological data so that water flow patterns and trends can be assessed);
- for solar PV and Thermal technologies the insolation levels must be suitable; and
- before biomass can be utilised it is necessary to make sure that the whole fuel chain is viable. For example the collection of the feedstock, transport and storage of the fuel, and the matching of seasonal variation (i.e. harvesting patterns) in fuel supply with demand, all need to be considered.

**Consistent or predictable load [37].** Many renewable energy technologies have an associated temporal variation in output. In the case of small scale hydro schemes there is a seasonal variation in water flow, that can be magnified by climatological variation; solar technologies only operate when insolation levels are high enough; whilst wind and biomass availability vary seasonally. Add to this daily and seasonal variation (for both power demand and the resource), and the ability to predict future load patterns, in order to maximise benefit from the scheme, becomes an important factor.

**Full or part indigenous sourcing [38].** It is important that elements of the programme that can generate local employment and the associated education, training and infrastructure development are encouraged.

**Access to a range of customers [39].** In the case of small scale hydro schemes there are several possible outputs (e.g. electricity, mechanical power, irrigation water, etc.). This diversity in itself can present problems. However, establishing the right conditions to create, and then balance, the market pull from the different customer groups is necessary (i.e. balance quantity and quality demands).

**Right and targeted incentives [40].** A direct result of the varied benefits that can arise from renewable energy development is that it is difficult to carry out rigorous economic assessments that include all benefits (i.e. energy and non-energy benefits). Hence there is a need to look at how the judicious use of incentives can be used to address the deficiencies of simple economic assessments. Such incentives must, of course, be targeted to produce maximum return, encourage rather than stifle market forces, and should plan for the day when they are no longer necessary.

**Holistic view of benefits [41].** As indicated above it is difficult to include all the benefits of renewable energy projects in a traditional economic assessment. This does not however imply that it is not important to identify and state those benefits which have not been monetarised as part of the case for proceeding with the programme.

**Potential cash vs. development dilemma [42].** One of the classic dilemmas of basic development is the potential need to trade off the immediate benefits of utilising resources for the direct benefit of the community and the need to produce cash crops. For example the use of land for the production of biomass fuel may be desirable, but the farmer may need to grow a cash crop (e.g. sugar cane). Thus the replacement of cash crop based cash streams is a problem in itself.

**Bureaucratic streamlining [43].** Renewable energy developments, such as small scale hydro developments, can attract the attention of a range of state and national government agencies. The aims and operations of these agencies are very rarely co-ordinated, so that it is quite common for developers to have to answer to multiple bureaucracies with often conflicting demands, e.g. water and power regulatory/taxing authorities. Hence, it is axiomatic that complex bureaucratic procedures will exist, or rapidly become established. The imposition of large bureaucratic overheads can cripple projects. Hence it is important that measures to reduce the potential impact of such bureaucratic distractions should be part of the overall package.

**Appropriate and flexible design [44].** Once a technology has been introduced it must be capable of evolving to address the changing needs of the market, and of entering new sectors. This may be addressed by looking at the basic design of the technologies offered. For example with solar photovoltaic systems there is benefit in using modular designs with standard connectors, as this approach will the development of secondary markets. Similarly there is a need for local artisans to be able to "customise" the devices. For example it may be desirable at a future date to modify the operation of a biomass fired plant to accommodate changing local crops.

**Informed and appropriate selection possible [45].** Part of the process of establishing a market pull is offering the right technology, and not simply taking the technology with the strongest push. This applies to the choice between renewable and non-renewable energy sources, as well as between different types of renewables. In all cases the selection must be made on an informed basis against clearly set out user requirements.

**Competent contractors/suppliers [46].** Just as capital goods are selected on the basis of their quality and fitness for purpose, so must contractors and suppliers. This is important during the installation phase of renewable energy installations, but it equally applies to after sales service and other less tangible aspects of contractor/ supplier service.

**(Sustained) Job creation [47].** If renewable energy technologies are introduced to the market place on a self sustaining and replicating basis, it is important that elements of the programme that can generate local employment be considered. This can relate to the need to encourage development of capabilities in education, training, infrastructure development, and electrical installation (including motor/battery maintenance).

**Environmentally acceptable [48].** The environmental impact of renewable energy projects tends to be much lower than for traditional, larger, schemes. However, all schemes have an impact on the local environment. Hence suitable environmental acceptability criteria have to be developed and applied as appropriate.

**Training [49].** The continued operation of installations is essentially dependent upon manufacturers and developers leaving sufficient trained staff in the field to support their installations. Ideally the skills of such staff will eventually be transferred to locals.

**Demand for, and arrangements to ship, power [50].** Renewables produced power can be intermittent in nature, and this can cause problems. For example, in wind developments that are situated in relatively remote locations it may be difficult to access a suitable grid for power export. This is an important consideration as often it is only via such grid connections that connection to appropriate demand locations is possible. In addition, how connection to a grid is made (i.e. physical connections) and power carriage conditions (i.e. phasing, carriage terms, etc.) must also be addressed. Similarly cogeneration feeds heat and power markets and, whilst plants are designed with some flexibility in heat to power ratio, such variation is limited. Hence, the export of heat and power may be constrained according to time of day or year; this can make attracting external customers difficult.

**Suitable site with access [51].** In exploiting renewable energy resources, such as small scale hydro, it is tempting only to analyse the supply side of the equation (e.g. the water catchment part of a hydro scheme). This can give misleading results as there must be an ability to physically connect the demand sites. For example the type of geography that favours small scale hydro (i.e. relatively high water flow and fall) can make it very difficult to connect the supply site with a sufficiently diverse range of external consumers to make the scheme attractive.

**Ease of operation [52].** The need for committed staff to run projects has already been noted. Attracting and retaining such staff is made considerably easier if they can be convinced that the scheme is designed with their requirements in mind.

**Appropriate standards [53].** Part of the process of encouraging competition is lowering the barriers to entering the market. One way of doing this, whilst also ensuring quality and reliability remain high, is to monitor equipment design and performance against minimum performance standards. Turning the standards into specifications should be avoided as working to meet only the simple specification tends to discourage innovation and reduces the incentive to better the specification.

## 6. SUMMARY AND CONCLUSIONS

This study has set out to analyse a range of situations where renewable energy technologies have, or may have, a role to play in servicing energy markets. The analysis has been carried via a diverse range of case studies (listed in Table 1), which in turn are based on meetings with a large number of people who are involved with renewable energy programmes and developments. This collection of input from such a variety of sources is a major strength of the study as it illustrates the spectrum in which renewable energy programmes are expected to operate.

The case studies clearly demonstrate the diversity of renewable energy applications. They have looked at: a range of capacities from Watt level (in solar photovoltaic lanterns) to the MegaWatt level (in small hydro and wind farm developments); potential markets ranging from provision of a minimal level of community lighting, to full commercial integration in national power grids; and per capita income from subsistence farming to G7 levels.

Taken together the results of the case studies contain an enormous amount of data on the multiplicity of markets and technologies that are accessible. In addition the study has also looked at the wide range of institutions that are evolving to support renewable energy markets and programmes.

Throughout the study the fundamental goal has been to extract information on what makes renewable energy attractive, and what makes for successful investment in renewable energy. The result of this has been a number of individual Critical Success Factors (CSFs) for each case study. These individual CSFs have in turn been analysed and 53 different CSFs identified. As these CSFs have been derived from extensive discussion with actors in the renewable energy markets they tend not to represent original or unique thinking. However, a unique factor in this study is the fact that a range of sources of "viewpoints and conventional wisdom" have been bought together and synthesised into a single set of factors. For example it is noteworthy that the only case studies to produce more than 20 of the final CSFs were those involving the World Bank (20 CSFs based on 11 meetings with development experts), and "Miscellaneous Indian Bodies" (23 CSFs based on extracting non-core information from 12 man-weeks of intensive meetings and site visits in India). This alone, illustrates the strength of the multiple case study approach used.

The original and unique aspect of this work has been the analysis of the CSFs, and the successful identification of pertinent themes from within the wealth of available detail. These themes can be used to structure the CSFs, so that instead of having to analyse all 53 themes for every project or programme, only those actually relevant to the situation under review need to be addressed.

In order to be comprehensible, and hence useful, this wealth of information has been processed into a more compact and "user-friendly" format. In particular it has been possible to extract a range of CSFs which appear to apply in all cases (even though they were not stated in all cases). These universal CSFs are:

- A medium term strategy ought to be in place
- The programme will use a proven or reliable design (or a proxy for this)
- The investment has acceptable economics
- That an appropriate finance package can be put together
- That there is provision for a market support structure (i.e. maintenance, spares, etc.)
- Establish that the target market actually exists
- Do not give free gifts
- Ensure that a chain exists (i.e. ensure that all the necessary actors from fuel suppliers to financial intermediaries to end users exist)
- Site specific factors have been considered
- That there is a favourable legislative/political/regulatory framework in place
- That there is an acceptable tariff structure (i.e. costs can be recovered)
- That there are mechanisms to dissemination/publicise the programme and its results
- A system of project review, including provision of feedback, and suitable record keeping has been established
- That the programme has built into it the ability to cater for future changes in demand (particularly growth)

Underneath these universal CSFs, further groups of CSFs have been extracted which reflect the various roles and associated mind sets of the actors in renewable energy markets. In particular CSFs that apply to funding bodies and their agents, or agencies that manage renewable energy programmes have been identified. Then the nature of the market that the technologies are targeted upon was split out. The very early stages of introducing energy services present particular problems, particularly when social need is the driving force (i.e. provision of very basic services), or when attempting to establish markets (i.e. rural electrification). Finally, there are those CSFs which apply to each individual technology whatever market it is deployed in. These factors are summarised in Table 4.

It is interesting to compare qualitatively the results of this study with what development literature has tended to say about what makes development projects succeed. The qualitative result of this process is that in the past people have tended to seek global solutions and criteria, but that overall CSFs do not change dramatically with time. It is however, quite obvious that the relative weighting given to each does evolve. For example this study has thrown up three strands that have risen up the agenda in recent years.

- **Market economics.** This study has unashamedly analysed renewable energy programmes from the standpoint that the establishment and nurturing of energy services markets should be the primary goal of all investment in renewable energy. This emphasis has led to the stressing of factors relating to studying potential markets, establishing that appropriate technologies and services are targeted, and removing or avoiding market distortions.
- **Financing mechanisms.** The ability to obtain an appropriate financial package is one of the most important of the success factors. It is probably more important than the underlying economic case because of the often constrained availability and high cost of finance. For example it may be argued that one of the reasons that wind power has proved so successful in India is because Indian financial institutions view such investment as mainstream and do not add risk premia.
- **Institutions.** The nature and role of institutions in developing renewable energy has emerged as one of the paramount CSFs. This is because it is the often unstated roles and duties of the involved (public and private sector) institutions that governs the success or failure of programmes.

The end result of the study is what we believe to be a manageable, structured, list of CSFs (as summarised in Table 4 and amplified in Section 5 of the report). The derived hierarchy, with its associated interactions between the various categories and factors, is such that it should be possible to select manageable and pertinent lists of factors for the majority of situations. Thus, it is hoped that this report can act as a guidebook on good practice in renewable energy developments. Such a guidebook will be of value to those considering designing a renewable energy programme, and those tasked with evaluating such proposals.

In conclusion it is argued that the proposed logical and structured approach to identifying what needs to be present to maximise the probability of successful deployment of renewable energy will help to disseminate best practice in renewable energy programmes. Then as best practice becomes established, the virtuous circle of good proposals leading to good programmes leading to successful deployment will become established.

## Table 4: Summary of Critical Success Factors

| Critical Success Factor | Agencies/Markets* | | | | Technologies** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | A | B | C | D | E | F | G |
| Autonomy from government | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | |
| Identify markets and benefits | ✓ | | ✓ | ✓ | | | ✓ | | | ✓ | ✓ |
| Market pull | ✓ | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ |
| All in market chain win | ✓ | | ✓ | | | ✓ | | | | ✓ | |
| Plan to remove any subsidies | ✓ | | | | | | | | | ✓ | ✓ |
| Credible project champion/entrepreneurial capacity | ✓ | | ✓ | ✓ | | | | | | | |
| Access to relevant experience | ✓ | | | | | ✓ | | | | | |
| First mover advantage | ✓ | | | | | | ✓ | | | | |
| Ability to pay and affordability | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | |
| Ability to monitor and respond | ✓ | ✓ | ✓ | | | | | | | ✓ | ✓ |
| Integration with wider development plans | ✓ | | ✓ | ✓ | ✓ | | | | | ✓ | |
| Clear Goals | ✓ | ✓ | ✓ | | | | | ✓ | | | |
| Develop the cheapest first | ✓ | | | ✓ | | ✓ | | | | | |
| Independent scrutiny | | ✓ | | | | | | | | | |
| Encourage competition | | ✓ | | ✓ | ✓ | | ✓ | | | | |
| Staff Commitment | | ✓ | | | | ✓ | | | ✓ | ✓ | |
| Appropriate diversification | | ✓ | | | | | | | | | ✓ |
| Identify and address choke points | | ✓ | | | | | | | | ✓ | |
| Output focus | | ✓ | | | | ✓ | | | | | |
| Competence of developers and managers | | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | |
| Accounting and arbitration procedures | | ✓ | | | | | | | | | |
| Resource/Fuel known to be available | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Consistent or predictable load | | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Full or part indigenous sourcing | | | ✓ | | ✓ | | | | | | |
| Access to a range of customers | | | ✓ | | | ✓ | | | | | |
| Right and targeted incentives | | | ✓ | | | ✓ | | | | ✓ | |
| Holistic view of benefits | | | ✓ | | | ✓ | | ✓ | | ✓ | |
| Potential Cash Vs Development dilemma | | | ✓ | | | | | | | ✓ | |
| Bureaucratic streamlining | | | ✓ | | | ✓ | ✓ | | | ✓ | ✓ |
| Appropriate and flexible design | | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ |
| Informed and appropriate selection possible | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | |
| Competent contractors/suppliers | | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | |
| (Sustained) Job creation | | | | ✓ | | | ✓ | | | | |
| Environmentally acceptable | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ |
| Training | | | | | ✓ | | | | | | |
| Demand for, and arrangements to ship, power | | | | | ✓ | | | | | | ✓ |
| Suitable site with access | | | | | | ✓ | | | ✓ | | |
| Ease of operation | | | | | | ✓ | | | ✓ | | |
| Ensure appropriate standards | | | | | ✓ | | | | | ✓ | |

* i Funding Bodies and their Agents
ii Managing Agencies
iii Provision of Basic Energy Services
iv Rural Electrification

** A Wind Power
B Small Scale Hydro Developments
C Solar Photovoltaics
D Solar Thermal
E Biogas
F Direct Combustion of Biomass
G Cogeneration