

Specifications for the use of renewable energies in rural decentralised electrification

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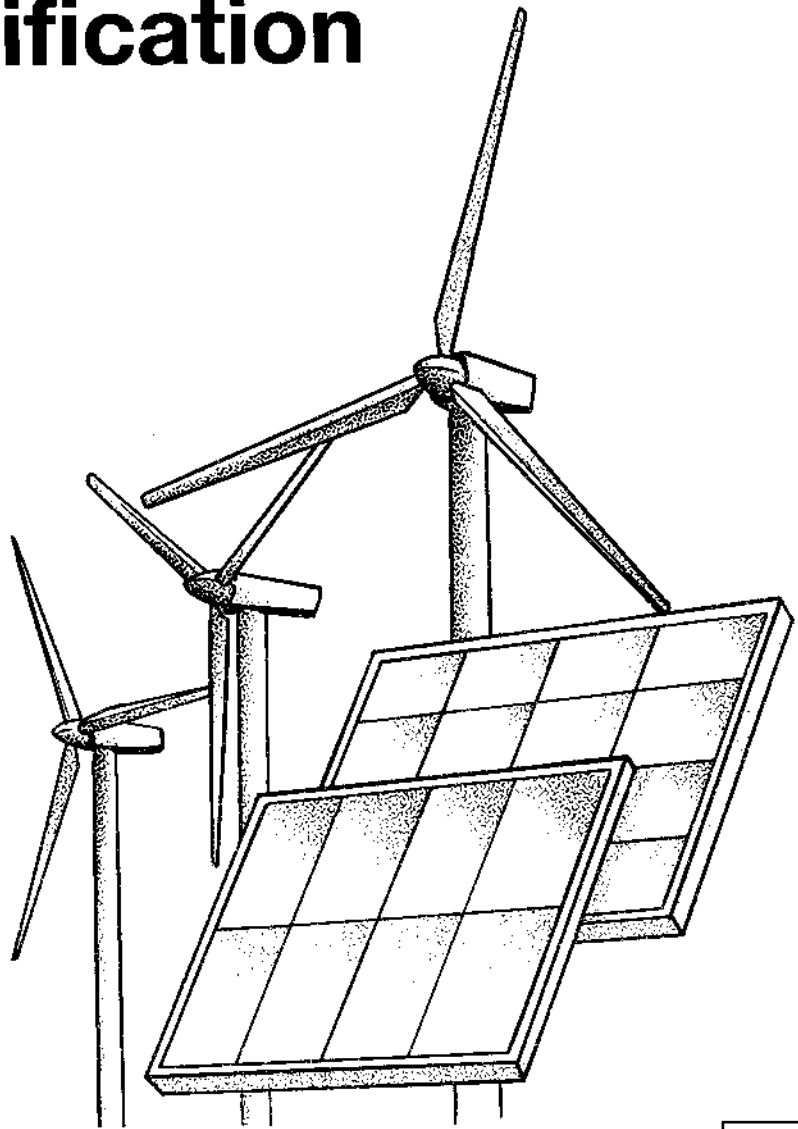


INTERNATIONAL
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IEC/PAS 62111

Specifications for the use of renewable energies in rural decentralised electrification



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FOREWORD

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public and established in an organization operating under given procedures.

IEC/PAS 62111 was submitted by Electricité de France and has been processed by IEC technical committee 82: Solar photovoltaic energy systems.

This PAS is also relevant to the activities of TC 21, Secondary cells and batteries, and TC 88, Wind turbine systems.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:

Draft PAS	Report on voting
82/221/PAS	82/224/RVD

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DRE SPECIFICATIONS

June 1997

Title **Specifications for the use of REN
in Rural Decentralised Electrification**

Summary The General Directives for the use of Renewable Energies in Decentralised Rural Electrification take the form of 24 documents describing the functional specifications on which the design, implementation and exploitation of the constituent parts of these electrification systems should be based.

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SPECIFICATIONS FOR THE USE OF REN IN RURAL DECENTRALISED ELECTRIFICATION

"DRE SPECIFICATIONS"

GENERAL INTRODUCTION

Decentralised Rural Electrification projects are now being implemented in France as well as on the export market (particularly in developing countries) with no guidelines to enable those involved to establish common standards for use as a reference in assessing the quality of the installations.

It is for this reason that professionals in the area concerned have decided to pool their experience in order to establish a set of recommendations which will, when applied, provide a benchmark for the quality of the installations designed, installed and operated on this basis.

A list of those who have contributed to the content of these Directives may be found as an appendix. This document is therefore intended for the use of the **Project supervisor** and, in general, all those responsible for establishing calls for tender (e.g. : EDF - GDF Centres, Services or Electrification Syndicates in France, Independents, Development Aid Associations, etc.), as a guide to analysis of requirements and to improve the clarity of the responses they receive.

It is also intended for **Project Contractor** based in research bureaux, project planners, REN agencies in developing countries, service companies, companies involved in the electrification of villages, etc., as a guide to the presentation of their reasons for the technical options they have made in their response to the call for tender, in a format which would be comprehensible to a Project Supervisor.

Constructor, installers, operators and maintenance contractors will also find proposed product specifications, recommendations for the design and installation of systems, practical guidelines for operating and maintaining the installations in these Directives.

The content of these Directives is intended as a **guide** to the identification of energy requirements, of products which are technically best suited within the economic context ; it will provide a resource for :

- **selecting** an REN system suited to the installation site (adapting the solution to the needs) ;
- **specifying** a system for a pre-determined site (architecture, components, energy management, protection, etc.) ;
- **preparations** for the operation and maintenance of a REN system (guidelines to be applied).

In format, the **DRE SPECIFICATIONS** are divided into five major sections :

- Part A :** From Energy Requirements to Electrification System ;
- Part B :** Guidelines for System Design and Operation ;
- Part C :** Technical Specification of Components ;
- Part D :** Guide to Specification of a System for a Specific Site ;
- Part E :** Product Specifications (planned).

Table 1 provides a brief summary of each of the sections.

Table 1 : List of DRE documents

Part	Title
Series A : From Energy Requirements to Electrification System	
A 1	From the Requirements to be met to the Proposals for a Range of Electrification Systems
A 2	Results expected from the Process of System Design
A 3	Contractual Framework governing the Relationships Involved
A 4	Quality Assurance for Project Design and Implementation
Series B : Guidelines for System Design and Operation	
B 1	Architecture of Electrification Systems
B 2	Guidelines for Production Sub-System Design (planned)
B 3	Guidelines for Distribution Sub-System Design (planned)
B 4	Energy Management Guidelines
B 5	Guidelines for Data Acquisition
B 6	Guidelines for the Protection of Persons and Property from Electrical Hazards
B 7	Guidelines for Operation, Maintenance and Renewal
Series C : Technical Specification of Components	
C 1	Photovoltaic Array
C 2	Building-integration of Photovoltaic Arrays
C 3	Wind Generator
C 4	Electrogenerator Set
C 5	Battery
C 6	Converter
C 7	Energy Management
C 8	Climatic and Environmental Testing
Series D : Guide to Specification of a System for a Pre-Determined Site	
D 1	Methods for Characterising Needs (planned)
D 2	Guidelines for Selecting a System (planned)
D 3	Typical Functional Description of a Private Electrification System (planned)
D 4	Typical Functional Description of a Public Service Electrification System : Micro Power Stations
D5	Typical Functional Description of a Public Electrification System : Micro grids
Series E : Product Specifications (planned)	

The current 1997 edition will be expanded in 1998 by feedback from the application of these recommendations to **DRE** systems now being implemented throughout the world, and by the development of industrial products where the design, installation and implementation have been based on the proposed specifications.

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DRE SPECIFICATIONS - A 1**June 1997**

Title	Part A : From Energy Requirements to Electrification System Section 1 : From the Requirements to be met to the Proposals for a Range of Electrification Systems
Number of pages	14 (including appendices)
Type	Specification
Associated Document(s)	DRE - B1: "Architecture of Electrification Systems".
Summary	This document offers an initial approach to a range of systems for decentralised rural electrification, based on a theoretical analysis of user requirements and of data arising from socio-economic surveys. 8 types of system were selected as responding to three types of need. The electrification systems identified were on stream renewable energy process supply systems, private systems and service systems.
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1. Vocation of Decentralised Rural Electrification Systems

Decentralised rural electrification systems are intended to supply electricity for use throughout rural areas, to sites not connected to the national grid.

The type of use is, in most cases, as follows :

- isolated private dwellings,
- dwellings in village groups,
- public service (public lighting, pumping stations, health centres, places of worship, public buildings, etc.),
- centres of economic activity (workshops, micro-industries etc.).

These systems can be sub-divided into three categories :

- process electrification systems (for example, pumping) ;
- private electrification systems (PES) for single users ;
- public service electrification systems (PSES) for public service users.

The process electrification systems and private electrification systems have only two sub-systems :

- a sub-system **producing** electrical energy ;
- a sub-system **consuming** this energy.

The public service electrification systems, on the other hand, have 3 sub-systems :

- a sub-system **producing** electrical energy.

By convention, this section is called a "**micro power station**", the term "micro" indicating the modest levels of power produced (from a few kVA to a few dozen kVA) :

- a sub-system **distributing** this power.

By convention, this section is called a "**micro-grid**", the term "micro" indicating the modest levels of capacity.

- a **user** sub-system consisting of user distribution circuits and electrical equipment.

2. User Requirements

Whatever type of use is being supplied, requirements will be of two types :

- **quantitative** :
 - ◊ the **amounts of energy** required over a given period of time and providing the number of hours of use expected from the equipment installed ;
 - ◊ enough **power** to provide simultaneous use from certain installations, if not all installations.
- **qualitative** :
 - ◊ the **availability** of energy use : to be able to use energy whenever it is needed ;
 - ◊ **quality** in supply which does not affect the performance nor the life expectancy of installations.

2.1 Summary of Requirements : Supply

Appendix 1 contains an analysis of consumption typical of the devices currently installed for each of the applications mentioned in §1, and an estimated life expectancy we consider probable for these devices. This analysis was based on our experience with PV systems in France¹⁾ and surveys of requirements in Southern Mediterranean countries.

This analysis has lead us to propose separating quantitative requirements into 4 categories (see Table 1). For each of these categories, requirements in power and in energy have been assessed on the basis of the power specifications of equipment on the market, and on a specific number of hours use for each application.

Table 1 : Quantitative Requirements by Type

	Category	Category 2	Category 3	Category 4
Type of User and Type of Use	• private (lighting, audio-visual, etc.) and low consumption public services • (places of worship, community centres, schools, public buildings, communications systems)	• private (same as category 1 + refrigeration et household appliances) and public services (health centres : lighting and refrigeration)	• private (same as category 2 + washing machines, freezers, DIY, etc.) and public services (public lighting)	public services (pumping stations, etc.) and economic activities (motors, etc.)
Basic Specifications	• few devices low power devices • "flat" consumer profile	• a few more devices, devices more powerful	• a lot of equipment • some powerful equipment • surge and possibly high demand on supplies • "variable" consumer profile	• powerful installations • surge and high demand on supplies
Probable installed Supply	< 200 W	150 à 500 W	0,5 à 2 kW	> 2 kW
Average Supplies required over 24h (to satisfy expected electricity consumption)	< 1 kWh	0,75 à 1,5 kWh	1500 à 4 kWh	n x 10 kWh

Category 1 : Private lighting and/or audio-visual Requirements

Power and energy requirements are low ($P < 200$ W, $E/j < 1000$ Wh). This category includes a certain proportion of private dwellings which can be described as "low consumers" using lighting and/or audio-visual appliances, and public services with the same type of installations. Among the latter are included places of worship, community centres, public buildings and communications systems.

Category 2 : Category 1 + Refrigeration and/or household appliances

Requirements are marginally greater ($150\text{W} < P < 500\text{W}$ et $750\text{Wh} < E/j < 1500\text{Wh}$). This category includes a proportion of private dwellings (lighting, audio-visual, refrigeration and household appliances) and health centres.

Category 3 : Category 2 + freezers and/or washing machine

Energy requirements are more considerable ($500\text{W} < P < 2000\text{W}$, $1500\text{Wh} < E/j < 4000\text{Wh}$). This category includes the so-called "voracious" private consumers. These consumers may have freezers, washing machines (which do not heat water), DIY equipment. Public lighting for larger villages may come under the same category. In effect, and depending on the number of lights required to operate simultaneously in a village, surge demand and energy requirements in larger villages may be compared with the third type of "private" user.

Category 4 : Process and micro-industry

Requirements for power and energy are very large ($P > 2000$ W and $E/j = n \times 10\,000$ Wh). This category includes economic activities such as micro-industry and public services¹ such as pumping stations.

¹ 1) EDF/DER HM-55/96/025 Technical Note, October 1996 : "Feedback on Photo-Electric Systems in France - User Perception and Practice", ORHANT I, SAADAOU L, WAERAAS de SAINT MARTIN G.

2.2 Proposing a Range of Power/Energy Ratios

Depending on the one hand, on how users wish to consume energy, and on the other, on their economic situation, several levels of service can be proposed in response to the quantitative requirements presented in Table 1, and with the following features :

- availability of daily energy levels ;
- conditions for the consumption of this energy.

A range of energy - power ratios is provided in Table 2.

Table 2 : Energy/Power Range

Requirements	Category 1			Category 2		Category 3				Category 4	
E average 24h	< 1 kWh			0,75 à 1,5 kWh		1,5 à 4 kWh				n x 10 kWh	
P installed	< 0,2 kW			0,15 à 0,5 kW		0,5 à 2 kW				> 2 kW	
Services offered	Category 1			Category 2		Category 3				Category 4	
Power Installed	10 W	50 W	100 W	200 W	200 W	500 W	500 W	1 kW	1,5 kW	2 kW	~ 4 kW
Supplies at P max. over 24 h	5 h			3 h		2 h				~ 7 - 8 h	
Max. sustainable supply over 24 h	2 W	10 W	20 W	40 W	25 W	60 W	40 W	80 W	120 W	160 W	~ 1 kW
Energy supplied over 24h	50 Wh	250 Wh	500 Wh	1 kWh	600 Wh	1,5 kWh	1 kWh	2 kWh	3 kWh	4 kWh	n x 10 kWh

2.3 Summary of Needs : Quality

Each type of use can be compared with the increasing demand shown in Table 3, by **availability period** for the energy on demand or required.

Table 3 : Types of need : qualitative

Regularity and nature of energy requirements	Availability
• The user needs an amount E of electric energy over a given period which extends over more than one week (weekly or monthly) • There is no quality requirement for the supply.	• He can do without energy at any time over this period of time (for example : pumping station linked with a water tower)
Every day, the user needs : • several hours of electric power supply at a constant voltage, • to use some of the installations simultaneously	• He can do without electric power for several days in the year. • Cannot (or will not) do without a power supply.

With regard to the **quality of the supply**, user expectation will centre on the points illustrated in Table 4.

Table 4 : Expected quality of supply

Type of equipment	Qualitative Expectations
DC	Voltage measured at equipment ($U \pm \Delta U$) Distortion of signal
AC	Voltage measured at point of supply ($U \pm \Delta U$) Frequency ($F \pm \Delta F$) Harmonics $\cos \phi$ of grid

2.4 Types of Energy Production Sub-Systems

In order to begin the design of an electrification system for any given site, the technically most suitable production sub-system for the level of service required has to be selected.

In the field of decentralised rural electrification (DRE), the various production sub-systems practicable are shown in Table 5.

Table 5 : Types of production sub-systems

Type of use	Sub -system	Description of production sub-system	Constraints	Comments
Production with no storage	S1	REN, no storage, with REN availability	Random	Production is random and depends entirely on availability of the REN resources
	S2	Electrogenerator set (multi-customer systems)	Solid	This mode of production provides daily supplies over a fixed period of time
Production with buffer storage	S3	Hybrid with synchronous coupling (REN + electrogenerator set) and buffer storage	Solid	In this case, the storage associated with the REN is nothing more than a low capacity buffer battery. Resistance is S2, as the role of the battery is not to store the energy produced by the REN but to stabilise the voltage for consumption and to compensate production variations while the set is starting up.
Production with energy storage	S4	REN with energy storage	Flexible	unreliable supplies for several days a year With this mode of production, the storage allied to renewable energy is more flexible than for the above solutions. Because of the vagaries of the climate, this type of system may not be available for several days a year.
	S5	Hybrid (REN + Electrogenerator set) with storage of energy		secure supplies : The use of the electrogenerator set eliminates cuts in supplies due to climate. It guarantees continuity of supply.
	S6	Electrogenerator set with storage		

The following have not been considered :

- use of electrogenerator set only for single-user systems ;
- use of electrogenerator set in public service systems operating 24 hrs a day, linking up with a conventional power station.

The following conclusions may be drawn with regard to the various production sub-systems selected :

- The use of renewable energy alone makes for unreliable production depending on weather conditions.
- Use of the electrogenerator set provides a production unit which completely protects the user from unreliable weather. It guarantees supply. In multi-user systems, used alone (S2) or in conjunction with pseudo on-line production using REN and buffer battery (S3), it only supplies energy over a specific period of time, thus creating rigid conditions of use. (The option of diesel power stations operating 24 hours a day is not discussed in this document).
- Storage of energy adds flexibility for users :
 - ◊ combined with REN alone (S4), it means the user has adequate reserves of power to compensate for the lack of suitable natural resources. However, only over capacity from REN and storage can guarantee continued availability of supplies for the user throughout the year,
 - ◊ combined with a set with or without REN production, it enables the user to consume energy at will, without restrictions as to the period of time. The choice between a {hybrid + storage} solution (S5) and a {set + storage} solution (S6) is the result either of a political decision to use REN or of a decision to minimise operating and maintenance costs.

2.5 Matching Decentralised Production Capacities to Needs : Selection of Energy Production to Match Needs

Figure 1 illustrates how the possibilities offered by the various production sub-systems possible can be matched to user requirements.

Where user is satisfied by weekly or monthly energy supplies, with no demands as to quality, production based on renewable energy (REN) would be suitable.

Where the user requires daily supplies and accepts several days a year without operation because of weather changes, a solution consisting of storage combined with renewable energy would be suitable.

Where the user requires daily supplies completely protected from weather changes (implying the use of a set or of over capacity with REN, plus storage) several solutions would be suitable :

- an electrogenerator set (for multi-user systems) or a hybrid solution (set + REN), with synchronous coupling and buffer storage (set combined with pseudo-continuous REN). If this is the case, the user will first have to accept that supplies will be provided over a set period of time.
- production with storage, consisting either of a set on its own or of hybrid production (set + REN) or of REN alone with, in this case, over- capacity from the REN, plus storage. These solutions provide the user with operational flexibility for his system. He can consume his energy quota at will, any time of the day or night.

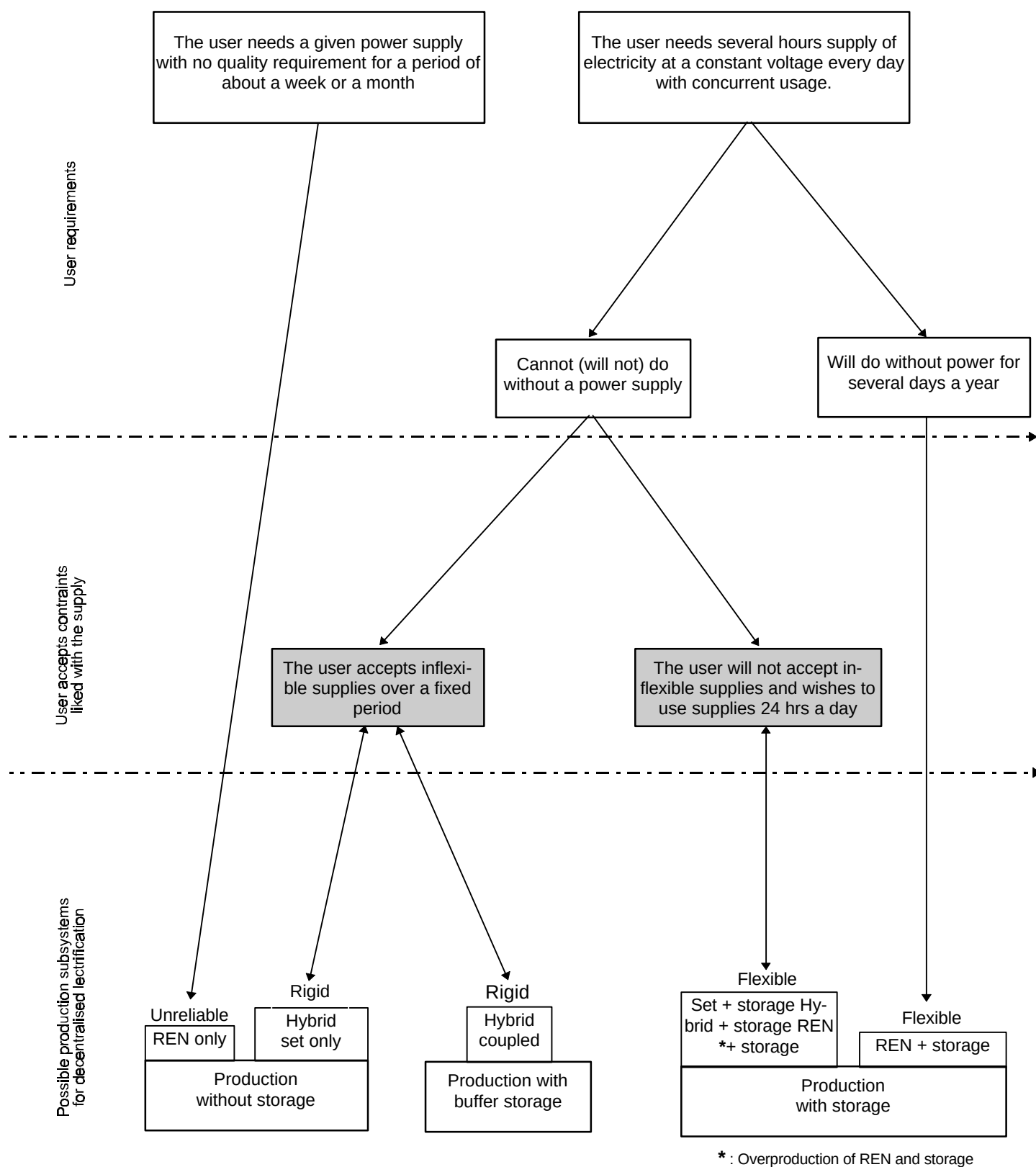


Figure 1 : Matching production possibilities to needs in decentralised systems

3. Proposing a Range of Decentralised Rural Electrification Systems

Selection of the production sub-system is carried out on the basis of the **qualitative requirements** in energy availability and acceptance by the user of the constraints connected with the proposal. Secondly, the **capacity of the production and distribution sub-systems** must be adjusted to meet the **qualitative requirements**.

Once the production sub-system matching the requirements has been selected, the type of electrification system (single or multi-user) adopted is the economically acceptable one with respect to the overall costs of investment, operation, maintenance and/or replacement, adapted to the required operational timescales. Of course, other criteria must also be born in mind, environmental protection for example.

The various types of production sub-system considered lead to the identification of eight types of **system** for decentralised rural electrification. Table 6 introduces the eight types and for each of them proposes contractual agreement to be established between Project Contractor and project designer.

The architectures of these systems are described in document DRE - B1: "Architecture of Electrification Systems". The different types of decentralised electrification systems are set out in Table 6.

Table 6 : Types of decentralised electrification systems

System Category	Type	System Description	Proposed Agreement between Site Foreman and Project Contractor
Supplies from REN sources	T1	REN dependent production system	Commitment to supply for x months out of 12, and y week out of 52, the contracted power supplies (or their equivalent in terms of results) every month, week, etc.
Private electrification systems (PES)	T2	Private REN production system with energy storage	Commitment to supply : ⇒ n days out of 365 (or n weeks out of 52) a weekly (or monthly) contractually agreed energy supply ⇒ a contractually agreed level of power.
	T3	Hybrid private production system with energy storage	
	T4	REN micro-power station with energy storage, supplying a micro-grid	Commitment to supply : ⇒ n days out of 365 (or n weeks out of 52) a daily contractually agreed energy supply for a minimum of a certain number of hours. ⇒ a contractually agreed level of power
	T5	Hybrid micro-power station with energy storage supplying a micro-grid	
	T6	Hybrid micro-power station with synchronous coupling and buffer battery supplying a micro-grid.	
Public service electrification systems (PSES)	T7	Diesel micro-power station with storage, supplying a micro-grid	Commitment to supply a contractually agreed power supply 365 days a year over a set time-scales between time 0 and time 1.
	T8	Diesel micro-power station supplying a micro-grid	

As we have seen, a comparison of the features of the single and multi-user systems described may be summarised by the main points given in Table 7.

Table 7 : Advantages and disadvantages of the single and multi-user systems proposed

	Advantages	Disadvantages
PES systems	the user manages his own power supply. He can vary consumption from one day to the next.	the user runs the risk of the consequences of poor management of supplies
PEES systems	- guaranteed availability of a fixed supply of energy daily - long-term possibility (with suitable management systems) of saving on a certain amount of energy without affecting the guaranteed quota the next day	no possibility of consuming more than the contractually agreed supply

A quantitative requirements analysis leads to the establishment of a power/energy ratio which can be proposed to customers for each of these systems, depending on the nature and the number of devices taking up the supply. These are illustrated in Table 8.

Table 8 : Proposed range of power/energy ratios

Agreed supply	10 W	50 W	100 W	200 W	200 W	500 W	500 W	1 kW	1,5 kW	2 kW	~4 kW
Energy supplied over 24h	50 Wh	250 Wh	500 Wh	1 kWh	600 Wh	1,5 kWh	1 kWh	2 kWh	3 kWh	4 kWh	n x 10 kWh

Table 9 summarises the proposed range of electrification systems. With reference to the various levels of service provided, we give :

- the type of production system recommended ;
- the type of source used by the production system ;
- the type of decentralised rural electrification system using these production systems ;
- the most probable use for each of them.

Table 9 : Initial review of decentralised electrification systems

Needs	Proposed production system			Electrification systems		Proposed contractual agreements between site foreman and Project Contractor	Comments
	REN	St	GE	PES	PSES		
The user needs an amount E of electric energy over a given period which extends over more than one week (weekly or monthly) There is no quality requirement for the supply. He can do without energy at any time over this period of time (for example : pumping station linked with a water tower)	X			T1		⇒ Commitment to supply for x months out of 12, and y weeks out of 52, the contracted power supplies (or their equivalent in terms of results) every month, week, etc.	The supplies may vary depending on the month or the season
Every day, the user needs : - several hours of electric power supply at a constant voltage, - to use some of the installations simultaneously He can do without electric power for several days in the year.	X	X		T2	T4	PES Commitment to supply : ⇒ n days out of 365 (or n weeks out of 52) a weekly (or monthly) contractually agreed energy supply ⇒ a contractually agreed level of power.	Days when power is cut do not include any breakdowns of the system. This includes : - either system maintenance - adjustments to the set (if there is one) - weather changes (the number of consecutive days without sun or wind) where REN production + storage is used
Every day, the user needs : - several hours of electric power supply at a constant voltage, - to use some of the installations simultaneously He cannot (will not) do without power supplies. He hopes to use energy on demand 24 hrs a day. Every days, the user needs - several hours of electric power supply at a constant voltage ; - to use some of the installations simultaneously He can do without electricity for several days in the year He accepts the restrictions of a supply during certain hours every day.	X X	X X X	X X	T2 T3	T4 T5 T7	PSES : Commitment to supply : ⇒ n days out of 365 (or n weeks out of 52) a daily contractually agreed energy supply for a minimum of a certain number of hours. ⇒ a contractually agreed level of power	The PSES make it possible to offer the user savings over several days (from 3 to 5 days) in the event of the full quota not being used. This option is of interest mainly where the customer has a variable consumption profile from day to day (this generally means high power installations)>
Every day, the user needs : - several hours of electric power supply at a constant voltage, - to use some of the installations simultaneously He can do without energy for several days in a year. He accepts to only have energy at allocated times in the day	X	X	X X		T6 T8	⇒ Commitment to supply a contractually agreed power supply 365 days a year over a set time-scales between time 0 and time 1.	The hybrid system has a low capacity buffer battery. Periods of non availability are inclusive of maintenance and adjustments of the set. They do not include any breakdowns of the system.

Appendix 1 : Analysis of the types of device installed for different types of usage - Domestic use

Domestic Use : Summer							Category I (lighting and audio-visual)				Category II (Category I + refrigeration + household appliances)				Category III (Category II + washing machine, freezer & DIY)			
E _{Ij} (Wh/j)							90	205	325	515	885	975	1085	1175	1735	3105	3205	3555
	Appliance	Unit Power (W)	No.	Used for : hrs/day	Power rating (W)	Daily supply (Wh/j)												
Lighting	bulbs	10	3	3	30	90	1		1		1		1		1			
		10	6	3	60	180		1		1		1		1		1	1	1
Audio-visual	Radio	5	1	5	5	25		1	1	1	1	1	1	1	1	1	1	1
	TV	70	1	3	70	210			1	1	1	1	1	1	1	1	1	1
	Video	50	1	2	50	100				1			1	1			1	1
Cold storage	Refrigerator	70	1	8	70	560					1	1	1	1	1	1	1	1
	Freezer	160	1	8	160	1280										1	1	1
Labour saving	Household appliances	200	1	0,5	200	100							1	1	1	1	1	1
	Washing machine	500	1	1,5	500	750									1	1	1	1
	DIY	700	1	0,5	700	350												1
P _{inst} (W)							30	65	105	185	175	205	425	455	875	1065	1115	1815

Domestic Use : Winter							Category I (lighting and audio-visual)				Category II (Category I + refrigeration + household appliances)				Category III (Category II + washing machine, freezer & DIY)			
E _{Ij} (Wh/j)							180	385	555	835	975	1155	1175	1355	1825	2965	3065	3415
	Equipment	Unit Power (W)	No.	Used for : hrs/day	Power rating (W)	Daily supply (Wh/j)												
Lighting	Bulbs	10	3	6	30	180	1		1		1		1		1			
		10	6	6	60	360		1		1		1		1		1	1	1
Audio-visual	Radio	5	1	5	5	25		1	1	1	1	1	1	1	1	1	1	1
	TV	70	1	5	70	350			1	1	1	1	1	1	1	1	1	1
	Video	50	1	2	50	100				1			1	1			1	1
Cold Storage	Refrigerator	70	1	6	70	420					1	1	1	1	1	1	1	1
	Freezer	160	1	6	160	960										1	1	1
Labour saving	Household appliances	200	1	0,5	200	100							1	1	1	1	1	1
	Washing machine	500	1	1,5	500	750									1	1	1	1
	DIY	700	1	0,5	700	350												1
P _{inst} (W)							30	65	105	185	175	205	425	455	875	1065	1115	1815

Appendix 1 (cont) - Analysis of the types of appliances installed for different types of usage : Public
Service Usage

(examples of data for Mediterranean villages)

HEALTH CENTRE

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	3	6	30	180
Refrigerator	70	1	8	70	560
Steriliser	400	1	0,5	400	200
E/day(Wh/day)					940
Pinst (W)					500

PLACE OF WORSHIP

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	3	2	30	60
Mike & amplifier	50	1	1	50	50
E/day (Wh/day)					110
Pinst (W)					80

COMMUNITY CENTRE

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	4	6	40	240
TV	70	1	5	70	350
E/day (Wh/day)					590
Pinst (W)					110

SCHOOL

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	6	6	60	360
E/day (Wh/day)					360
Pinst (W)					60

Appendix 1 (end) - Analysis of the types of appliances installed
for each type of usage : Public Service Usage

PUBLIC BUILDINGS

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	2	6	20	120
				E/day(Wh/day)	120
				Pinst (W)	20

COMMUNICATIONS SYSTEM

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
System	100	1	2	100	200
				E/day (Wh/day)	200
				Pinst (W)	100

PUBLIC LIGHTING

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Bulbs	10	30	12	300	3600
				E/j (Wh/j)	3600
				Pinst (W)	300

PUMPING STATION

Equipment	Unit power (W)	No.	Used for : (h/day)	Rated power (W)	Energy per day (Wh/day)
Pump	1500	4	12	6000	72000
				E/day (Wh/day)	72000
				Pinst (W)	6000

DRE SPECIFICATIONS - A 2

June 1997

Title	Part A - From Energy Requirements to Electrification System Section 2 : Results expected from the Process of System Design
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Number of pages	20
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Type	Specification
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Associated Document(s)

Summary	This document presents proposals for the information to be supplied with a dossier estimating the capacity of a system and submitted to a Project Supervisor in a format he is able to utilise. While leaving individual designers free choice in the method applied for estimating the system capacity, we offer a framework for a response which will improve clarity when considering the offers.
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1. Implementation of Decentralised Rural Electrification Systems

Decentralised rural electrification systems are intended to supply electricity for use throughout rural areas, to sites not connected to the national grid.

The type of use is, in most cases, as follows :

- isolated private dwellings,
- dwellings in village groups,
- public service (public lighting, pumping stations, health centres, places of worship, public buildings, etc.),
- centres of economic activity (workshops, micro-industries etc.).

These systems can be sub-divided into three categories :

- process electrification systems (for example, pumping) ;
- private electrification systems (PES) for single users ;
- public service electrification systems (PSES) for public service users.

The process electrification systems and private electrification systems have only two sub-systems :

- a sub-system **producing** electrical energy ;
- a sub-system **consuming** this energy.

The public service electrification systems, on the other hand, have 3 sub-systems :

- a sub-system **producing** electrical energy.
By convention, this section is called a "**micro power station**", the term "micro" indicating the modest levels of power produced (from a few kVA to a few dozen kVA) ;
- a sub-system **distributing** this power.
By convention, this section is called a "**micro-grid**", the term "micro" indicating the modest levels of capacity.
- a **user** sub-system consisting of user distribution circuits and electrical equipment.

Finally, document A1 of the present directives proposes classifying the electricity supply system at isolated sites into eight categories :

Table 1 : Types of decentralised electrification systems

System Category	Type	Description of electrification system
Process supply dependent on REN	T1	REN production system "REN dependent"
Private electrification systems (PES)	T2	Private REN production system with energy storage
	T3	Private production system with energy storage
Public Service Electrification system (PSES)	T4	REN micro-power station with energy storage, supplying a micro-grid
	T5	Micro-power station with energy storage, supplying a micro-grid
	T6	Hybrid micro-power station with synchronous coupling and buffer battery, supplying a micro-grid
	T7	Diesel micro-power station with storage, supplying a micro-grid
	T8	Diesel micro-power station supplying a micro-grid

2. Purpose of this Document

This document presents proposals for the information to be supplied with a dossier estimating the capacity of a system.

While leaving individual designers free choice in the methods used for estimating the system capacity, the aim is to establish a framework for any hypotheses applied to justify estimates of capacity, and the type of results to be fed back to the principal in a format he can utilise.

The application by system designers of common rules governing the presentation of results should allow any Project Supervisor to establish an objective comparison between the various offers based on one and the same set of technical specifications,

On the other hand, the profession must be encouraged to incorporate technical and economic indicators for "good" capacity estimates so as to improve clarity in offers submitted.

3. Those Involved in Estimating Capacity

The process of estimating capacity for an installation demands the active participation of a certain number of players (see Table 2).

Care should be taken that they are required to include in the project notes on the information and decisions they provide or are responsible for.

Table 2 : Those Involved in Estimating Capacity

Nature of involvement	Responsibilities of players in the process of estimating capacity
The end user of the installation	Expresses his needs
The Project Supervisor	Defines the requirements to be met
The project designer	Establishes capacity estimate

4. Points of Comparison for Different Offers

The Project Supervisors must be given tools for comparing the various offers ; we therefore propose indicators which all designers should provide with their offer so as to improve clarity.

In this instance the fact is that the fundamental basis is provided by the establishment of technical specifications for the energy requirements to be met ; using this criteria the offer has to demonstrate, by means of the most objective data possible, that the estimated capacity of the production plant will satisfy the given energy requirements "at the right price"

In addition, it is well known that, because of uncertainty with the weather, estimates of capacity can only be based on **estimated** resources and that there is therefore a **risk** that the **reality** will differ from the forecasts.

It is the designer's responsibility to take account of this risk without at the same time burdening the project with excessive "backup" costs.

This therefore implies that a "good" capacity estimate is one which, bearing in mind the available climatic data and the degree of uncertainty involved, minimises at the lowest possible cost the risk the customer runs of having to do without the expected supply.

We propose that comparison of the various offers should be based on the following basic points :

- the **hypotheses** on which the capacity estimates for the energy source are based ;
- the technical **data** resulting from the process of estimating the capacity ;
- the **measures** adopted to minimise the **risks** of not achieving the expected levels of service ;
- the current **cost** of the proposed installations ;
- a **guarantee** from the designer covering work on subsequent deviations in performance levels of equipment, malfunctions, costs involved after commissioning, and attributable to his work.

This proposal should mean that designers will respect the three following provisions when presenting their offer :

- **present** results and costs in accordance with a minimum list of information to be provided ;
- **explain** the major points they have based their proposals on : the hypotheses concerning consumption and the weather, provision they have made to minimise the risk of cuts in the expected levels of service.
- **agree** on the measures they will apply in the case of breakdowns (technical or economic) which cannot be ascribed to weather conditions, conditions of use, conditions of installation, maintenance or upkeep.

4.1 Presenting Results and Costs

4.1.1 Presenting the Results

The results are expressed as **specifications for the components** used in the system and as **agreements on supply** for the system as a whole.

- ◇ technical specifications for the main components (see details in Part C of the present specifications)

Table 3 : Technical specifications to be provided for the main components

• • photovoltaic panels	number and type of panel power generated nominal voltage proportion of energy supplied daily by the photovoltaic installation
• • wind generators	model nominal power nominal voltage
• electro-generator set	model power daily operating period proportion of energy supplied daily by the set
• charger	type power
• • batteries	type capacity as a function of the discharge rate no of cycles
• converter	type power

- ◇ agreements regarding supply

These agreements are listed in Part A1 of the present directives ; the major points can be summarised as follows :

Table 4 : Proposed agreements

System Category	Type	Description of the electrification system	Proposed agreement between the Project Contractor and the Project Supervisor
Process supply dependant on REN	T1	REN production system "REN dependent"	Agreement to supply x months/12, y weeks /52, the contractually agreed quantities of energy (or the equivalent in terms of process results) over one month, one week, etc.
Private electrification systems (PES)	T2	Private REN production system with energy storage	Agreement to supply : ⇒ n days/365 (or n weeks/52) a weekly (or monthly) a contractually agreed quantity of energy ⇒ a given level of power
	T3	Hybrid private production system with energy storage	
Public Service electrification systems (PSES)	T4	REN micro-power station with energy storage, supplying a micro-grid	Agreement to supply : ⇒ n days/365 (or n weeks/52) a contractually agreed quantity of energy daily, at least, over a fixed timespan. ⇒ a given level of power
	T5	Hybrid micro-power station with energy storage, supplying a micro-grid	
	T6	Hybrid micro-power station with synchronous coupling and buffer battery supplying a micro-grid	
	T7	Diesel micro-power station with storage, supplying a micro-grid	
	T8	Diesel micro-power station supplying a micro-grid	Agreement to supply a contractually agreed level of power for n days/365, over a fixed time period from t0 to t1

◇ additional indicators

Additional indicators for estimating the capacity of the production sub-systems may include :

- a user "energy supply satisfaction " coefficient

Estimates for the capacity of the installation rely on the probability of production plant generating adequate supplies of power over a given period of time to meet the energy requirements, in conformity with the hypothetical needs assessment analysis carried out beforehand.

- an estimated surcharge for REN investment.

Bearing in mind the resource hypotheses adopted, this surcharge will be :

$$\frac{\text{probable quantities of energy the installation can produce with the REN (*)}}{\text{expected energy consumption (*)}}$$

(month by month)

(*) measured at the same point

4.1.2 Presenting the Costs

The costs supplied to the Project Supervisor must be current costs.

Rules on updating the costs are provided in Part D2 of the present Directives.

Components of these costs are as follows :

- the cost of the initial investment (equipment and installation) ;
- the cost of renewal (ditto) ;
- the operating costs (labour and consumables) ;
- the cost of recuperation and dismantling.

4.2 Explaining the Basic Hypotheses used for Estimating Capacity

Details of the hypothetical basis for estimating capacity provide information by which the Project Supervisor can appreciate the margins included by the designer to account for uncertainties.

4.2.1 Estimated Resources and Estimated Consumption Data used to Construct the Estimated Capacity

The table below illustrates various levels of detail in the knowledge of customer and REN resource consumption (in this case, sunlight).

• Data on consumption	
Level 1	Very precise knowledge of consumption levels over time, with information on the consumption = f (battery voltage)
Level 2	Daily consumption distributed throughout the day on the basis of day/night consumption
Level 3	Daily consumption with averages for "weekdays " and "weekends"
Level 4	Daily consumption, monthly averages
Level 5	Daily consumption, annual averages
• Data on resources	
• General data on sunlight	
Level 1	Diffuse - direct sunlight measured at short intervals on a horizontal surface with ambient temperature and wind speed - direction, at a given site.
Level 2	Daily sunlight (direct - diffuse components?) on a horizontal surface, at a given site
Level 3	Average monthly sunlight per day on a horizontal surface, at a given site
Level 4	Average monthly sunlight per day for a given geographical area, on a horizontal surface (taken from an atlas or from satellite measurements)
• Data on sunlight for the site concerned	
Case 1	The site is one for which general data is available
Case 2	The site is "close", from a meteorological point of view, to other sites for which general data is available (except for level 4)
Case 3	The site is as described for level 4.
• Background depth for data	
	N years
• Site specification	
	Take into account local micro-climate conditions, masking effects, albedo, inclines selected, etc.

The designer will be asked to stipulate what degree of accuracy he was working under, as each class is said to represent a uniform consumption/resource ratio with respect to the establishment of energy management schedules (see table 5).

Table 5 : Class of accuracy of consumption/resource ratio

		Level of detail for information on resources			
		Level 1	Level 2	Level 3	Level 4
		Hourly records of sunlight for a specific site	Daily sunlight levels for a specific site	Daily sunlight levels (monthly average) for a specific site	Daily sunlight levels (monthly average) indicative of a specific geographical area
Information on consumption levels		Degree of coherence in the levels of detail in resource and consumption level data used as a basis for estimating capacity			
L 1	very specific knowledge of the consumption rates over time	●	○	□	
L 2	knowledge of daily consumption levels	○	○	□	✕
L 3	average daily consumption levels	□	□	□	✕
L 4	daily consumption, monthly averages	□	□	□	✕
L 5	daily consumption, annual averages		✕	✕	✕

●	Class 1	the most accurate
○	Class 2	
□	Class 3	
✕	Class 4	the least accurate
	no coherent data	

The designer is also asked to specify the productivity levels adopted for the panels, as a basis for assessing the proportion of the daily energy requirements they are destined to provide.

4.2.2 Measures taken to Minimise the Effects of Changing Weather on the Quality of the Service Provided

The designer will need to take care to specify here the precise parameters he used to estimate the capacity of the system :

- ◇ reduction in the estimated sunlight resources, why?
- ◇ selection of a specific timespan of sunlight hours, which? why?
- ◇ increase in the estimated consumption, why?
- ◇ selection of a period for autonomous operation, when? why?
- ◇ opting for the use of a set, why?
- ◇ etc.

4.3 Agreement on Measures Envisaged to Correct Possible Errors in Estimated Capacity

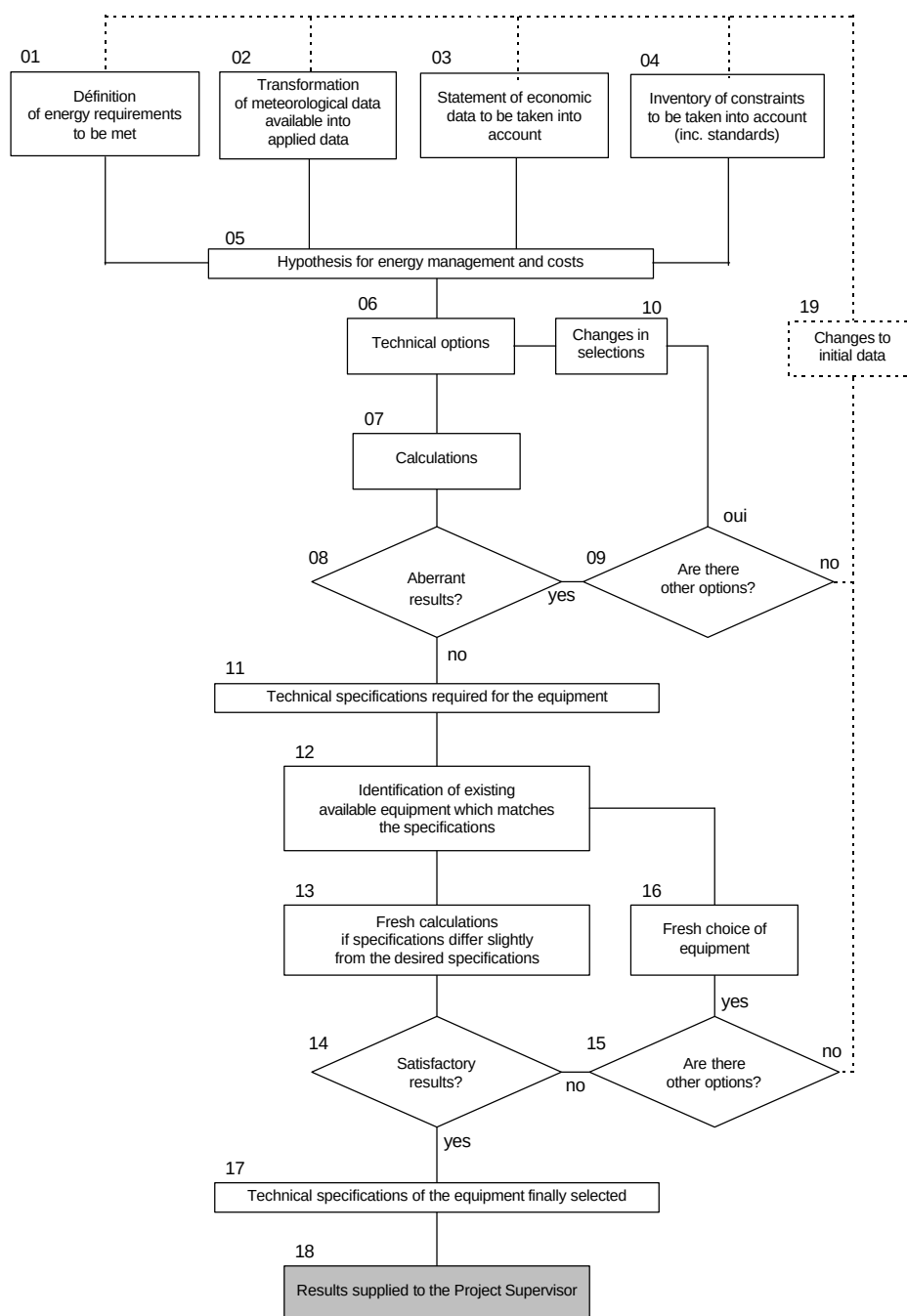
The designer will be given the opportunity to prove whether results can be guaranteed and therefore the applicability of the measures he undertakes to carry out if there is a recognised fault in estimates of capacity.

5. Proposed Procedure for Estimating Capacity

The procedures recommended for establishing an estimate of the capacity of an REN production installation is described in the diagram below.

(Each of the stages in this process has a reference number and is the subject of notes given immediately below the diagram.)

Diagram illustrating the process for estimating capacity



Comments on the proposed procedures for estimating capacity

It would be desirable for stages 01 to 05 (information gathering and establishment of working hypotheses) to be based on guidelines common to the whole of the profession.

Stages 06 to 16 provide a proposed methodology : however, the information sources and the way this information is handled are part of the skill of each designer. We cannot here propose detailed guidelines applicable to all.

It would also be desirable to base the form and content of the results provided at the outcome of the procedures for estimating capacity (stages 17 and 18) on common guidelines applicable throughout the profession.

Stage 01 : Definition of the energy requirements to be met

The energy requirements to be met are described by :

- **qualitative data** including :

- ◊ the type of energy consumption (the types of device requiring supply) :

We propose that the inventory of applications included in the project should be set out as described in Table 6.

Table 6 : Description of types of use requiring power supplies

Existing or potential type of customer		Type of equipment supplied
Type 1	private individuals	domestic appliances and equipment (lighting, audio-visual and cold storage equipment, etc.)
Type 2	economic activities	equipment used for professional purposes (motors, processes, etc.)
Type 3	public services	public service equipment (pumping stations, street lighting, etc.)

- ◊ the type of energy to be supplied (based on the type of user equipment) :

- ◆ direct current (DC)
- ◆ and/or single phase alternative current (AC)
- ◆ and/or three phase alternative current(AC)

- ◊ the priority levels to be given to the various types of usage in case of conflict between demand and overall availability of power

- **quantitative data** as follows :

- ◊ grid specifications
- ◊ the number of supply points for each type of usage
- ◊ specification for agreed supply
 - ◆ the maximum power levels to be connected at the point of supply, for each type of usage
 - ◆ the maximum level of energy available over a given period (e.g. 24 hrs) at each point of supply
- ◊ specifications for consumption
 - ◆ the consumption profile (power and energy) for each supply point over a specific period

The relevant timespan where energy management is concerned, is one hour.

The ideal would be for the timespan used to measure consumption should be as close as possible to this.

If the real values at time H are not known, the values for time H-1 should be used.

- * the timespan (over a given period of time) during which energy supplies must be provided
- * For this, a choice will have to be made as described in the Table 7.

Table 7 : Example of how supplies are allocated

The overall time-span supplies are required for	Example of how supplies are allocated
24 h / 24	Supplies to all customers
12 h / 24	Supplies to economic activities during the day (8h) Supplies to private persons in the evening (4h)
4 h / 24	Supplies to private persons

For each point of delivery, the quantities of energy consumed (predicted) will be estimated by :

- exact assessment of consumption for each device, given the supply source ;
- as precise an assessment as possible of the length of time each device is used for, taking the season into account where necessary ;
- an assessment of the average daytime energy demand profile : the day itself may be split into periods (day/night, for example, or work/leisure), or even into hours ;
- an assessment profile for the occupation of buildings : continuous or occasional occupation (known or unknown levels of occupation) ;
- a definition of possible "peak" or "surge" consumption characterised by sudden short-term demand for power.

Stage 02 : Transformation of available meteorological data into applied data

The type of meteorological data available should be specified, from as close as possible to the installation site and with a degree of precision matching the level of knowledge of energy requirements.

In the absence of very detailed data, and with the purpose of transparency of information for all those concerned, any corrections to the available data must be indicated.

An information sheet will be established showing the data from the calculations so as to provide background information on the process of estimating capacity. This sheet could be of the type illustrated in Table 8.

Table 8 : Meteorological data used in estimating capacity

Equipment concerned	Data to be collected	Ideal data	Data available	Corrections made	Data applied in the calculations
panels	◇ Average sunlight on a horizontal surface, in kWh/m ² /j * overall * direct * diffuse ◇ Number of days per year without sun ◇ Masking effect ◇ Albedo	average/h no of consecutive days status of the panels/h coefficient/ time of year			
battery	◇ Temperatures : night-time/daytime or min/max	average/ h			
wind generator	◇ wind speed (m/s) (and height of measuring point) ◇ Average Weibull factor distribution form ◇ Wind rose ◇ No of calm days per month ◇ Site terrain (obstacles, relief over a specific area, type of vegetation) ◇ Maximum wind speed	av./mnth av./day annual no of consecutive days av. over 10 years			

Stage 03 : Statement of economic data to be taken into account

With a view to the establishment of the current overall cost of the installation at a specific date, it will be necessary to assess the cost components illustrated in Table 9 for each scenario involving an estimate of capacity.

Table 9 : Proposed types of costs to be taken into account

◇ the cost of design		◇
◇ investment costs	sources, batteries, converters, equipment for protection, management, monitoring	◇ cost of equipment utilised on site (purchases, transport, reception of materials, civil engineering) ◇ technical inspection ◇ cost of project design
◇ operating costs	operations, upkeep, maintenance of equipment, servicing	◇ cost of consumables on site (diesel, demineralised water, etc.) ◇ cost of on-site services ◇ insurance
◇ renewals	changes to equipment because of wear or modification to meet new needs	proportion of the initial costs allocated for contingencies
◇ the costs of dismantling		◇ cost of dismantling the batteries

Stage 04 : Inventory of constraints to be taken into account

Table 10 provides a list of constraints, the presence of which has to be checked in every case.

For each site, care should be taken to list the particular aspects taken into account when estimating capacity.

Table 10 : Inventory of site constraints

	Type of constraint	Features to check	Features of the site which have an impact on estimating capacity
1	Geographical environment	climatic disturbances (rain, sun, sand, frost, etc.)	
		extremes of heat and humidity	
		access routes to the site / access times	
		nature of the terrain	
		position of supply points	
2	Biological environment	fauna	
		flora	
3	Technical environment	type of grid possibly already in place (overhead, underground)	
		civil engineering	
		quality of existing buildings	
		local maintenance possible on site	
		equipment present	
4	Sociological environment	standard of living of the customers supplied	
		customary power consumption	
5	Economic environment	existing economic activities	
		solvability of customers	
		various legal provisions	
		budget limit	
6	Local government environment	site classification	
		contractual specifications	
		constraints regarding nuisance (noise, etc.)	

Stage 05 : Management hypotheses

◇ Energy management

Managing energy, means checking the production REN/consumption figures and taking the relevant action where necessary

- in the interests of the end user (to keep as close as possible to the commitment to supply energy)
- and inspecting the equipment for signs of ageing (so that the investment is exploited throughout the period it was designed to cover)

Table 11 illustrates the impact which management hypotheses can have on capacity estimates and installation.

Table 11 : Effects of energy management hypotheses on capacity estimates and installation

Hypotheses	Effects of estimates of capacity
◇ number of consecutive days without REN ◇ choice of battery life ◇ expected role of the electrogenerator set – extra charging of the battery (included in the output) – source of emergency supply if the REN fails, battery or converters – rate of use of the set ◇ authorised (or not) load shedding and certain usage, under certain conditions, ◇ load shedding priorities ◇ special constraints for certain usage (e.g. : high demand for power, constraints on operating hours, etc.) ◇ constraints on objectives affected by the life-cycle of equipment ◇ political will to use REN	- expected battery life - type of battery - power of the set - fuel storage capacity ; battery life - battery capacity and/or GE - battery capacity - choice of models, equipment and battery capacity

◇ Cost Management

For each case, it is desirable to seek a compromise which will work across the whole range of "investment costs + operating costs + renewal costs".

Depending on the customer, the balance can be varied according to the technical and financial possibilities, and user requirements ; in each case, care should be taken to stipulate the main objectives which the technical options sought to achieve :

- minimum cost of investment?
- minimum operating cost?
- minimum cost of renewal?

and to specify the estimated proportion of each of these overall.

Table 12 illustrates the impact cost management hypotheses can have on estimating the capacity of the installation.

Table 12 : Effects of cost management hypotheses on estimating the capacity of an installation

Hypotheses	Effects on estimates of capacity
◇ maximum / normal / minimum life of the equipment ◇ normal / minimum maintenance – number and complexity of the maintenance operations involved – frequency of maintenance operations – rate of use of the set ◇(extend list)	- type of battery, battery capacity, management of recharging and discharge, type of electrogenerator set - type of battery/ type of set - battery capacity and type of battery - management of recharge/discharge - model of set - model of set

Stage 06 : Technical options

The following are covered by the term technical options :

- options with regard to architecture
 - ◊ main layout plans of the installations designed to produce, dispatch and distribute energy
 - ◊ the use or not of converters, if yes, how many, of what power, and how are they organised.
 - ◊ siting and type of circuit breakers/protection
- options relating to the technical specifications of the equipment (panels, wind generator, electrogenerator set, batteries etc.)
 - ◊ options selected from among the possible range and which are available in equipment already on the market.

Several repeat drafts will undoubtedly be necessary before settling on the option or options to be recommended to the Project Supervisor.

The initial options will be "a priori" options based on the experience of the designer.

It may be that the range of choice available is very limited, particularly when the requirement is to re-use existing equipment or to use certain brands of equipment or models (requirements described in [04] above).

Several sets of data should be used, including the conclusions drawn from analysis of the results of calculations and data testing the range of performance of one installation against options other than the initial selection.

Recommendations :

- single phase production if the output is <5 kVA
- three phase production if the output is >10 kVA
- direct current distribution if peak power (photovoltaic) < 1 kWc
- for economic activities :

if these are marginal : it would be preferable to deal with the problem of three phase supply case by case (specific backup supply) rather than involving investment in the entire grid ;

if these are developing or if they are to be encouraged, the possibility of three phase distribution must be looked at (over the whole grid or via a separate grid).

Stage 07 : Calculations

The calculations are carried out on the basis of the technical and economic hypotheses which have been adopted ; they are used to establish energy schedules and to assess the costs of installations which will meet these schedules.

The type of models used to demonstrate the operation of the installation and the selection of the initial data processing algorithms are left to the designers.

The calculations must demonstrate coherence and precision as well as an in-depth knowledge of the energy requirements and REN output.

Whatever tools are used, they must, establish basic values on the basis the hypotheses listed under Stages 01 - 06, including :

- estimated average rate of coverage for the installation (this value is taken into consideration for lack of anything better)
- estimated level of service for the installation (to be held in reserve until another version can be reached, since tools currently available cannot determine this value)
- budget required to obtain these values
- sensitivity of the budget to variations in these values

Stage 08 : Analysis of Results

Analysis of the results must reach a decision on whether the technical options taken can meet the technical and economic objectives required for the installation.

The results will be judged to be "aberrant" if any of the following criteria has not been followed :

- any of the stages 01 to 06 of the diagram illustrating the procedures for estimating the capacity has not been followed
- the recommendations have not been adhered to
- the investment costs exceed the budget estimated or provided

Stage 09 : Examining the viability of other options

If an unfavourable conclusion is reached about the results obtained from the calculations, the possibility will be examined of using other technical options to those already selected under [06] to meet customer requirements.

If this is so, go to stage [10] to re-examine the technical options, otherwise go to stage [19] to re-negotiate the initial conditions (where this is possible).

Stage 10 : Modifying the technical options

This is a question of modifying the specifications for the architecture or the initial estimates of capacity for the equipment, in order to bring a new set of data into the calculations.

Stage 11 : Defining the technical specifications required for equipment

These specifications formed the initial basis for the establishment (or deduction, depending on the algorithms used) of acceptable technical and economic schedules, that is.....*(please complete)*

Stage 12 : Identification of existing and available equipment which matches the specifications

Using the required specifications as a basis, a list will be made of equipment which could effectively be used in the installation, bearing in mind actual availability on the market and the timescales required for completion of the installation.

Stage 13 : Fresh calculations

This stage may be necessary if the opportunity presents itself to use equipment close to specification when compared with the equipment listed under stage [12], and which, for all sorts of reasons, is suddenly available or is offered at a good price. In this case, the calculations should be repeated to establish what the differences in results would be compared with the differences in specification between the equipment selected under stage [12] and that which is now being proposed.

Stage 14 : Analysis of results

This stage is of the same type as stage [08] :

The analysis of results must show to what extent the technical options exercised will satisfy the technical and economic objectives of the installation.

The results will be judged to be "aberrant" if any of the following criteria has not been followed :

- any of the stages 01 to 06 of the diagram illustrating the procedures for estimating the capacity has not been followed
- the recommendations have not been adhered to
- the standards have not been applied
- the investment costs exceed the budget estimated or provided
- the updated cost is not the lowest (compared with other possible solutions)

Stage 15 : Examining the viability of other options

This stage is of the same type as stage [09]

Stage 16 : Selection of other equipment

This stage is of the same type as stage [10]

Stage 17 : Technical specifications for the equipment finally selected

These specifications are for the equipment finally selected for a scenario submitted to the Project Supervisor.

Stage 18 : Results supplied to the Project Supervisor

The results of the exercise for estimating capacity must provide the Project Supervisor with the following key information :

Table 13 : Information specific to estimating the capacity of an installation as submitted to the Project Supervisor

The data on which the capacity estimate is based :	- specified energy requirements taken into consideration - values for REN resources used for the design (with reference to meteorological data) - site constraints taken into consideration - energy management hypotheses - cost management scenarios
Operational features of the installation (energy, power, autonomy)	- estimated coverage rate for the installation (month by month) - autonomy of battery - autonomy of the system when supplying peak power
Operational plans of the installation	position of each piece of equipment
Description of the main items of equipment to be installed	descriptive list of the proposed equipment
The budget required for the acquisition and the implementation of the installation over N years	- investment costs - estimated operating costs - renewal costs - distribution in time of renewals which will have to be made

6. Technical specifications of the main equipment proposed

The tables below propose technical specifications for each main type of equipment (generators, batteries, converters) which the designer can then use as a basis for recommending models for this equipment to the Project Supervisor.

6.1 Specifications for the photovoltaic array**6.1.1 Photovoltaic Panels**

Results supplied to the Project Supervisor			
◇ number and type of panels (in accordance with the requirements of the Charter Standards)	◇ nominal voltage for the panel ◇	◇ panel surface	◇ site constraints taken into account
◇ unitary peaking capacity			
Technical specifications leading to the final selection of panel modules			
total peaking capacity	• nominal voltage	generator • electrical specifications $I = f(V)$	• site constraints taken into account

6.1.2 Support structure for the panels

Results supplied to the Project Supervisor			
◇ number of structures ◇ type of structure (roof, etc.)	◇	◇ no of panels	◇ installation of panels
Technical specifications on which the final selection of the structure is based			
• no of modules/structure • materials	• means of attachment • angle of the panels (°/horizon)	• direction of the panels (°/North) • site constraints taken into account	• area occupied

6.2 Specifications for wind generators**6.2.1 Wind generator**

Results supplied to the Project Supervisor			
◇ wind-generator model ◇ rated power	◇ nominal voltage	◇ rated frequency	
Technical specifications on which the final selection of the wind generator is based			
• rotator diameter • no of vanes • output curve	• adjustment system • directional system • start-up wind speed (to start rotating)	• interrupt wind speed • destructive wind speed	• site constraints taken into account [04]

6.2.2 Support structure

Results supplied to the Project Supervisor			
◇ type of support	◇ general plan	◇ ground area covered by the installation	
Technical specifications on which the final selection of the support structures is based			
• type of support • height of support	• access to the pod for maintenance • means of attachment	• volumes of concrete	

6.3 Specifications for the electrogenerator set

Results supplied to the Project Supervisor			
◇ model of set (type and brand)	◇ set environment ◇ fuel storage method	◇ start-up ◇ operating period	
Technical specifications on which the final selection of the electrogenerator set is based			
- power in kVA - cosφ - voltage (single/three phase) - operation :	backup/emergency - Reliability : normal or with backup - speed	- type of fuel - type of cooling - environmental constraints taken into consideration [04] - safety factors taken into consideration (electrical, vandal-proofing, etc.)	- operational constraints taken into consideration - energy management constraints taken into consideration - factors governing installation

6.4 Specifications for the battery

(please complete)

Results supplied to the Project Supervisor			
(type and make)			
Technical specifications on which the final selection of the battery is based			

6.5 Specifications for the converters

Results supplied to the Project Supervisor			
model of converter	(type and make)		
Technical specifications on which the final selection of the DC/DC converters is based			
- nominal input voltage - rated input voltage - nominal output voltage - rated output voltage	- rated output power (and corresponding % load) - maximum output power (and corresponding % load) - efficiency rating with respect to load - consumption with no load	- existence and calibration of converter protection (particularly protection against polarity reversals) - conforms with standards - range of operating temperatures	- dimensions and volume - type of connections
Technical specifications on which the final selection of the DC/AC converters is based			
- nominal input voltage - rated input voltage - rated output voltage - nominal output voltage - nominal output frequency - rated output voltage	- type of output signal (wave form) - max relative harmonic content - rated output voltage (for corresponding type and % load) - voltages higher than rated and duration of effect acceptable - rated and maximum current acceptable at output	- efficiency rating as a function of the load - empty running - existence of protective devices for converter - existence of output protection for the converter - existence of a potentially adjustable "wait" mode	- conforms with standards - operating temperature range - dimensions and volume - type of connections
Technical specifications on which the final selection of reversible DC/AC converters is based (charger function)			
as above with the following in addition : - max. voltage on input - minimum input voltage	- max output current - rated output voltage	type of load control	existence of temperature adjustment for load control

6.6 Specifications for energy management

Results supplied to the Project Supervisor			
Technical specifications on which the final selection of energy management is based			
•	•	•	

6.7 Specifications for couplings

Results supplied to the Project Supervisor			
Technical specifications on which the final selection of couplings is based			
•	•	•	

DRE SPECIFICATIONS - A 3**June 1997**

Title	Part A : From Energy Requirements to Electrification System Section 3 : Contractual Framework governing the Relationships Involved
Number of pages	10 (including appendices)
Type	Specification
Associated document(s)	DRE - A 1 : "From the Requirements to be met to the Proposals for a Range of Electrification Systems". DRE - A 2 : "Results expected from the Process of System Design". DRE - A 4 : "Quality Assurance for Project Design and Implementation". DRE - B 5 : "Guidelines for Data Acquisition". DRE - B 6 : "Guidelines for the Protection of Persons and Property from Electrical Hazards". DRE - B 7 : "Guidelines for Operation, Maintenance and Renewal".
Summary	This document lists the various parties involved in an electrification operation in a rural area or in isolated locations. It defines the contractual relationships between them and details the particular responsibilities which each of them must undertake in order to produce a successful outcome for the operation.
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INTRODUCTION

There are two possible solutions for the electrification of isolated locations :

- 1) an extension of the grid
- 2) the installation of stand-alone electricity generators, especially those using renewable energy

This second solution is chosen depending on its economic viability compared with the conventional solution of extending the grid.

A certain number of parties are involved in the electrification of isolated locations. These appear in the rest of this document under the designations laid out in paragraph 2.

This document deals in one part with the principal general technical clauses and in the other part with the contractual relations between the different parties involved. Its purpose is to establish clearly the responsibilities of each one of the parties listed below with regard to the construction, management and operation of stand-alone electrification installations in isolated locations. Simplified model of maintenance contracts for power stations equipped with small wind generators or photovoltaic generators are offered in document DRE - B 7 : "Guidelines for Operation, Maintenance and Renewal". In the case of a mixed installation, by starting from the proposed models it is simple to produce a contract taking both types of generator into account.

In every case a Project Contractor is appointed by the Project Supervisor and it is he who is responsible for the conformity of the installation to the specifications, even when there are several companies involved in the construction work.

The Project Supervisor is responsible for deciding whether or not to adopt quality assurance procedures (see document DRE - A 4 - "Quality Assurance for Project Design and Implementation").

Also in every case a single organisation or a single person takes charge of the operation and maintenance of the installation. This is the most important requirement for its continuing successful operation.

Note. - In France two situations can arise :

- 1) The project is eligible for assistance from FACE (Fond d'Amortissement des Charges d'Electrification - Fund for the reduction of electrification costs).

In rural areas the choice of those who are to obtain contracts for these installations is made by the Electrification Syndicates. These then become the Project Supervisors based on the following principal criteria :

(main residence, carrying on economic activity, actions of benefit to the community

- economic interest with regard to the extension or improvement of electrical supplies

The execution of the project is carried out in accordance with standard public procurement tendering procedures.

The Project Supervisor (The Electrification Syndicate) appoints an independent Project Contractor who is responsible for the call for tenders and for the construction programme. If the Project Supervisor decides to include the DRE Specifications in the call to tender, the Project Contractor is responsible for the load of these provisions.

The work is then accorded the status of an EDF concession (EDF - the French State Electricity Company).

- 2) The project is undertaken by another organisation or person and does not go through the public tender procedures.

If it takes place in the framework of the DRE Specifications the Project Contractor appointed by the Project Supervisor is once again responsible for the application of the provisions of the DRE specifications. In the absence of the appointment of a Project Contractor by the Project Supervisor, one of the companies concerned if there are several of them (for example the project planners or the designers) will take on this project management role by agreement with all the other partners in the project.

If only one company is involved, it will undertake the project management and the responsibility for observing the provisions of the DRE specifications.

In both cases, the Contractors, after the call for tenders, will install the equipment which will be under the control of an operating company. This will be EDF, when the installation has been financed by FACE and it has been accorded concession status, and could be a state organisation, an independent company or an person proprietor of an installation.

The operating company will sign a contract with a maintenance contractor which relates to maintenance and the replacement of live components. This contract will naturally involve fees for its performance.

