Solar PV-diesel hybrid business planning checklist

For applications in local power distribution systems in off-grid areas in the Philippines

On behalf of

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Abbreviations

COE	Cost of electricity (in PHP/kWh or USD/kWh)
CSP	Competitive selection process
DOE	Department of Energy
DSM	Demand side management
EC	Electric cooperative
EPIRA	Electric Power Industry Reform Act
ERC	Energy Regulatory Commission
FCRR	Full cost recovery rate
FSC	Fuel saver controller
GWh	Gigawatt hour
HOMER	Hybrid Optimization of Multiple Energy Resources
IEC	International Energy Consultants
IRR	Implementing Rules and Regulations
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
LCOE	Levelized cost of electricity
ME	Missionary electrification
MEDP	Missionary Electrification Development Plan
MERALCO	Manila Electric Company
MG	Missionary generation
MHP	Micro hydro power
MW	Megawatt
MWh	Megawatt hour
MWp	Megawatt peak
NEA	National Electrification Administration
NPC-SPUG	National Power Corporation-Small Power Utilities Group
NPP	New power producer
NREL	National Renewable Energy Laboratory
ORED	Office of Renewable Energy Development
PALECO	Palawan Electric Cooperative, Inc.
PHP	Philippine peso
PSA	Power Supply Agreement
PSALM	Power Sector Assets and Liabilities Management Corporation
PSP	Private sector participation
QTP	Qualified third party
RE	Renewable energy
RE Act	Renewable Energy Act of 2008
REMB	Renewable Energy Management Bureau
RESC	Renewable Energy Service Contract
SAGR	Subsidized/approved generation rate
SARR	Subsidized/approved retail rate
SFS	Solar fuel saver
SGG	Small Grid Guidelines
SPV	Solar photovoltaic
TCGR	True cost generation rate
UCME	Universal charge for missionary electrification
USD	US dollar
/d	per day
/h	per hour
/y	per year

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I

Introduction

Primarily based on diesel fuels, electricity generation in the Philippine off-grid areas is foremost an expensive undertaking. With true cost generation rates (TCGR) of diesel generators many times well over 20 PHP per kWh, the price for often poor and interrupted power supply is far higher than the average generation rate for on-grid electricity (5-6 PHP/kWh). Considering the high and continuously increasing cost of diesel-based electricity production, renewable energies (RE) represent an economic alternative for power supply in off-grid areas today and in the future.

RE investors and developers, when preparing investments in the off-grid power supply in the Philippines, are faced with the challenge of improving the availability and reliability of power supply, while reducing the overall cost of power generation by means of applying climate-friendly technologies. The economic rationale of introducing RE in the off-grid power supply is, among other things, to help reduce the universal charge for missionary electrification (UCME), which is paid through a levy by grid-connected electricity consumers in the Philippines and which has to cover the difference between the TCGR of NPC-SPUG and the subsidized/approved generation rate (SAGR) charged to power consumers in off-grid areas through the local distribution networks.

Triggering investments in renewable energies in NPC-SPUG areas needs technically sound hybridization schemes and commercially viable, replicable business models. Therefore, the Department of Energy (DOE), the Climate Change Commission (CCC), and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, as part of their joint "SupportCCC" Project funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety under its International Climate Initiative, developed the solar PV (SPV)–diesel hybrid business planning checklist. It is meant to provide a systematic approach on how to asses and develop PV–diesel hybrid applications. The aim is to guide interested RE developers and energy sector stakeholders through the planning process of technically sound and commercially viable hybrid schemes.

Before entering into the development of a business case for investments on SPV hybrid systems for power generation in off-grid areas, potential investors should be aware of the existing market conditions of power supply in off-grid areas in the Philippines (Section II.1), the legal framework conditions for investments in this sector (Section II.2), and the roles of involved government authorities in the complex licensing and permitting procedures (Section II.3).

On the basis of this information, the here presented business planning checklist (Section III) aims at providing guidance to potential project developers through the process of developing and designing an optimum business case of SPV hybrid applications for off-grid power supply in the Philippines. It is structured in 5 major steps.

1) Identification of potential business cases
2) Assessment of technical feasibility
3) Modeling of optimum systems designs
4) Bankable project documentation
5) Selection of appropriate market option

Each of these 5 steps is subdivided into a number of subsequent tasks as illustrated in Figure 1.

Planning and implementation of SPV–diesel hybrid systems

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2. Assessment of technical feasibility
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   - 2.2 System design options
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5. Selection of appropriate market option
   - 5.1 New power provider (NPP)
   - 5.2 Qualified third party (QTP)
   - 5.3 Joint venture (JV)
   - 5.4 Incentives

Figure 1. Structure of the SPV hybrid business planning checklist
Source: Integration

A comprehensive overview of the checklist is presented in Section III. More detailed instructions on how to develop a SPV hybrid business cases along this checklist are given in Section IV.

II

Background information

Investments in SPV hybrid power generation systems for power supply in off-grid areas in the Philippines should always be based on a sound analysis of:

- Market conditions in the Philippine off-grid sector
- Legal and institutional frameworks for private investments in the sector
- Relevant government authorities and their roles and responsibilities

An introductory overview of these fields is given in the following paragraphs.

II.1 Market conditions in the Philippine off-grid sector

In the Philippines, over 15% of rural households are situated in off-grid areas (NEA, 2015), which are not connected to the national transmission grid. Power supply in these off-grid areas is mandated to electric cooperatives (ECs) operating local distribution grids. Power is usually supplied from diesel generators operated by the National Power Corporation-Small Power Utilities Group (NPC-SPUG).

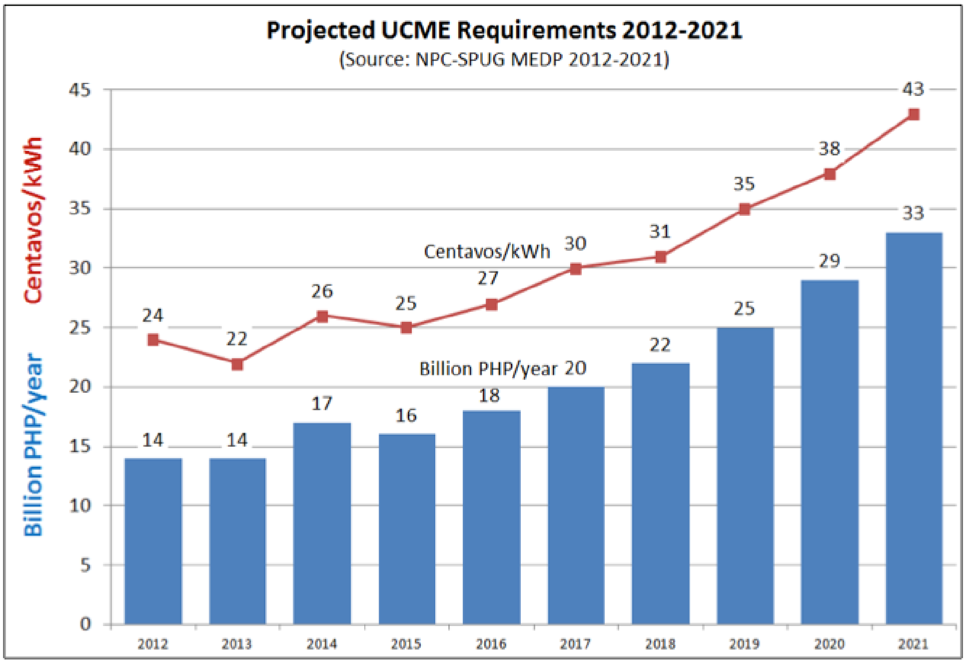


Figure 2. Projected UCME requirements 2012-2021

Figure 2 presents the NPC-SPUG projection of the expected increase of the need for UCME subsi¬dies for the next 7 years. The economic rationale of mobilizing private invest¬ments for RE hybrid power generation applications is thus mainly to reduce the need for subsidies from the UCME for power supplied to off-grid areas.

As of May 2014, 296 off-grid areas are being served by NPC-SPUG as part of its mandate to implement missionary electrification (ME). Diesel generators operated by NPC-SPUG today are often old and low in power generation efficiency. Figure 3 gives examples of diesel generation costs in Philippine off-grid areas. It shows that the TCGR are much higher than effective selling rates and are expected to increase dramatically until 2020.

Area	Genera. 2012 MWh*	Costs 2012 Th PHP**	True Costs 2012	Selling Rate 2012 PHP/KWh***	Predict 2020
1 Basco BATANES	5,378	75,555	14,04	6,59	34,27
2 Lubuagan KALINGA	722	11,942	16,52	5,76	40,10
3 Polillio QUEZON	5,511	76,720	13,92	6,59	33,50
4 Palumbanes CATANDUANES	20	439	21,56	6,59	48,92
5 Cabra MINDORO	47	937	19,80	5,75	42,11
6 Alad ROMBLON	106	2,976	28,03	6,59	67,90
7 Caluya LEYTE	1,433	27,066	18,89	6,84	41,94
8 Camotes CEBU	9,277	142,436	15,35	6,07	37,25
9 El Nido PALAWAN	5,397	80,599	14,93	6,59	37,79
10 Siquijor SIQUIJOR	18,206	281,932	15,49	6,07	n.a.
11 Talicud DAVAO D. NOR.	662	11,175	16,87	6,27	40,32
12 Basilan BASILAN	33,817	463,126	13,70	6,58	32,21
13 Manuk Mankaw TAWI TAWI	168	2,950	17,60	6,27	40,23

Figure 3. Overview on diesel generation, cost of generation, predictions for 2020 and electricity rates in NPC-SPUG areas
* Rounded to MWh; ** rounded to Th PHP; *** rounded to two decimal figures. Source: http://www.spug.ph/MEP2012-2021.asp (May 9, 2013).
Source: GIZ (2013)

Those areas within an EC's franchise, which are declared unviable by this EC, are usually not connected to any power distributioin grid yet. Power supply in these areas, if any, is based on privately owned and operated diesel generators.

Only 15 off-grid areas are so far served by the private sector represented by new power producers (NPPs) or qualified third parties (QTPs), depending on whether a service area is served by an EC through a local distribution network (NPP) or whether this area is declared unviable by the lcoal EC. The major differences between these two models for private sector participation in the off-grid power supply are explained more in detail in Section IV.5.

TCGR in NPC-SPUG diesel generator plants are typically in the range from 13 to 28 PHP/kWh. The SAGR, which is billed by the ECs to their customers, amount to only 5-6 PHP/kWh today. The difference has to be sourced from the UCME, which is levied to all power consumers in the country.

II.2 Legal and institutional frameworks for private investments in the sector

Rural electrification is a government's priority because it is seen as a means to spur countryside socio-economic growth. Thus, part of rural electrification is the servicing of the unviable areas and the missionary electrification areas. The Electric Power Industry Reform Act of 2001 (EPIRA) and, likewise, the Energy Regulatory Commission (ERC) define an unviable area as a geographical area within the franchise area of a distribution utility (DU) where immediate extension of distribution line is not feasible. It shall also include those areas that are currently served by the DUs but are deemed unviable and subsequently declared by the DOE as open for participation by QTP.

The RE Act specifies:

- NPC-SPUG and/or QTPs in off-grid areas shall source a minimum percentage of total annual generation from available RE resources. The definition of the minimum percentage of RE is still pending.
- Eligible RE generation in off-grid and missionary areas shall be eligible for the provision of RE Certificates.
- RE developers in off-grid and missionary areas shall be entitled to specific incentives.

RE Act and EPIRA define off-grid systems as:

- Electrical systems not connected to the wires and related facilities of the transmission lines, distribution lines, substations, and related facilities for the purpose of conveyance of bulk power on the grid of the Philippines (not feeding into the three main grids of Luzon, Visayas, and Mindanao).

These off-grid areas are served by NPC-SPUG's missionary generation (MG) program, whereas in most areas, the distribution is managed by the electric cooperatives.

For off-grid RE applications, the NEA Decree of 2013 specifies the supervisory and oversight functions of the National Electrification Administration (NEA) to both stock and non-stock electric cooperatives. The law grants new power to electric cooperatives to improve their corporate fate.

The NEA recently created the Office of Renewable Energy Development (ORED) to assist electric cooperatives that aim to venture in power generation using renewable energy resources.

Electric cooperatives are empowered:

- To participate in a bid on an existing NPC-SPUG generating facility.
- To enter into business cooperation models such as a joint venture.
- To become QTPs, as long as they have created an affiliate or subsidiary that has a complete business, operational and functional separation.

The Small Grid Guidelines (SGG) establish the basic rules, procedures, requirements, and standards that govern the operation, maintenance, and development of the small grid systems that are not connected to the national grid. The SGG ensures the safe, reliable, and efficient operation of the small grid systems in the Philippines.

The SGG defines the technical aspects of the working relationship between and among NPC-SPUG, generators, distributors and all users of the high-voltage and medium-voltage lines outside the national grid. NPC-SPUG, generators and distributors must deliver electric energy to the users at acceptable levels of power quality and customer service performance. The SGG has no mention of renewable energy as a power source in small grid areas.

II.3 Relevant government authorities and their roles and responsibilities

The private sector program in delivery of services in the off-grid areas stemmed from the reform of institutional arrangements in the electricity sector through the EPIRA and RE Laws. An overview of the resulting institutions and their roles is given in the Table 1.[1]

1 Rural Electrification with PV Hybrid Systems, overview and recommendations for further deployment, Report IEA-PVPS T9-13, CLUB-ER Thematic Paper, July 2013.

Table 1. Institutions and their roles regarding missionary electrification (ME), private sector participation (PSP) and renewable energy (RE)

Institution	Principal Role in ME	Specific Role in PSP	Specific Role in RE
DOE	• Policy and strategy formulation and oversight: Review and approve NPC's Missionary Electrification Plan • Preparation of Missionary Electrification Development Plan • Integration of Distribution Development Plans (DDPs) for off-grid areas of DUs with the MEDP	• Coordination of NPP and QTP Programs • Certification of CSP • Pre-qualification of QTP	• Qualification of RE developers and issuance of service/operating contracts
NEA	• Supervision of ECs • Technical, financial and institutional capacity development of ECs • Review and analysis of DDPs of ECs	• Capacity development of ECs on least-cost generation planning and power supply contracting	• Encouragement of ECs to go into embedded generation • Technical, financial and institutional capacity development of ECs
ERC	• Approval of PSAs and QTP Agreements • Approval of tariffs and UCME subsidies • Determination of UCME rate • Issuance of Small Grid Guidelines	• Issuance of permits and Certificates of Compliance • Approval of NPP-TCGR • Approval of FCRR and SARR For QTPs	• Approval of cash generation-based incentive for RE Developers
NPC-SPUG	• Generation in missionary areas if no QTP qualifies to provide electricity service. • Transmission in missionary areas • Prepare Missionary Electrification Plan • Petitioner of UCME • Petitioner of SAGR and SARR	• Consolidate UCME requirements of NPPs and QTPs • Payment of UCME to NPPs and QTPs • Collaboration with DUs/ECs on privatization of SPUG generation function	• Consolidate UCME cash incentives requirements of RE Developers • Source a minimum percentage from renewable resources
PSALM[28]	• Receiver of UCME • Payment of available UCME to NPC-SPUG	-	• Payment of RE Cash Incentives to RE Developers
DUs / Electricity Coopera-tives	• Preparation of Distribution Development Plan • Collection of UCME from end-users • Network operations • Implement projects	• Determination of unviable areas and their qualified waiving for QTPs • Select power provider (in SPUG areas) • Option to become either as a supplier or a QTP	• RE Developer • Sourcing of a minimum percentage from RE resources

Source: GIZ (2014).
PSALM, Power Sector Assets and Liabilities Management Corporation

II.3.1 National Power Corporation-Small Power Utilities Group (NPC-SPUG)

In the event that no QTP qualifies to provide electricity service to a declared unviable area, ERC Resolution No. 22, Series of 2006, mandates NPC-SPUG to perform the functions of a QTP.

II.3.2 Distribution utilities/electric cooperatives (ECs)

Electric cooperatives may participate in a bid on an existing NPC-SPUG generating facility, and their qualified bid shall be given preference in case of a tie. Further, a cooperative can enter into business cooperation models such as a joint venture, if it creates a subsidiary.

In the ERC QTP Guidelines, ERC has allowed the DUs to become QTPs as long as the DUs create a subsidiary that has a complete business, operational and functional separation. The NEA recently created the ORED to assist electric cooperatives that want to venture in power generation using RE resources.

Business planning checklist

Based on the structure presented in Figure 1, the following checklists elaborates for the major parameters related to the development of technically feasible and economically viable SPV hybrid business cases for power generation in off-grid areas. For each of these parameters, this checklist presents general specifications and critical issues/recommendations, which should be taken into consideration.

Table 2. Business planning checklist

Key parameters	Specifications	Methods / recommendations / critical issues
1. Identification of potential business cases		
1.1 Solar resource potential	☐ Annual solar irradiation per sqm ☐ Monthly solar irradiation per sqm ☐ Daily solar irradiation per sqm ☐ Under optimum conditions (0° South, 10-15° tilt angle)	☐ Acquisition of satellite-based solar irradiation data (e.g. Meteonorm or NASA) referring to a close location ☐ Collection and evaluation of data from neighboring weather stations, if available If significant solar irradiation data are not available, own measurements should be carried out.
1.2 Load profiles	☐ Daily load profiles ☐ Daily peak load ☐ Daily base load ☐ Daily energy consumption ☐ Seasonal/weekly/daily variations	☐ Match the daily load curve of the grid and the daily profile of PV power generation ☐ Load profiles must cover 24/7 operation (legal requirement on NPPs and QTPs) ☐ Average daily energy demand in the grid (kWh) ☐ Time and value of daily/weekly/monthly/annual peak load (kW) ☐ Average and maximum power demand (kW) during solar irradiation hours ☐ Power demand during the night hours (kW)
1.3 Demand survey	☐ Current total energy demand of all consumer groups ☐ Spatial distribution of consumers ☐ Demand side management potentials - Load shifting - Peak shaving - Energy savings	☐ Load curves and power demand of specific consumer groups (e.g. private, productive, commercial, administrative, public services, tourism) ☐ Demand side management potentials ☐ Consumer-group specific questionnaires ☐ Personal interviews

Key Parameters	Specifications	Methods / recommendations / critical issues
1.4 Load and demand forecast	☐ Number of households connected ☐ Number of households not yet connected ☐ Classification of typical load profiles of specific consumers / consumer groups	☐ Forecast scenarios on future electricity and peak demand development provided e.g. by DOE, NPC-SPUG or the local DU ☐ Energy master plans or future development plans compiled by local government units (LGU) ☐ Verification of upcoming productive uses of energy ☐ Projections on yearly growth of population and income ☐ Connection rates in the grid-connected area and in neighboring not yet connected areas ☐ Personal interviews
1.5 Current power generation cost	☐ True cost of generation rate (TCGR) ☐ Subsidized/approved generation rate (SAGR) ☐ Daily service hours ☐ Fuel cost on site ☐ Connection rates	☐ Potential cost drivers are: - Increase of connection rate - Increase of daily service hours - Changes of consumer behavior - Development of productive activities and uses - Increasing fuel cost and demand - De-rating of worn-out diesel gensets - Replacement of outdated diesel gensets
1.6 Present state of power generation and distribution system	☐ Output power of the existing diesel generator plant ☐ Fuel consumption ☐ Remaining life span of installed diesel generators ☐ Retrofit efforts required ☐ Operating hours of the gensets grid voltage, current and frequency ☐ Overhead lines and connection points ☐ Grid infrastructure design	☐ Quality inspection of the existing power generation infrastructure ☐ Estimation of retrofitting efforts and costs ☐ Execution of quality measurements for voltage, frequency and power quality fare-out connection points ☐ Examination of grid transformer technical specification and life span ☐ Quality inspection of overhead lines and connection points ☐ Identification of suitable land/roof space to build up a PV solar power system
1.7 Socio-economic assessment	☐ Population ☐ Income and ability to pay ☐ Willingness to pay ☐ Property ownership ☐ Livelihood sources ☐ Number of households with members working out of town/overseas	☐ Relevant information for identification of different user groups: - Size of family, education level, occupation - Income and expenditures - Sex, ethnicity and religions - Age groups, gender issues ☐ Current energy consumption and expenditures ☐ Expectation and impacts of the introduction of electricity supply (energy consumption, energy mix, productive use of electricity) ☐ Acceptance of the proposed hybrid system ☐ Ability and willingness to pay for energy ☐ Consumers' preferred billing and collection methods ☐ Ownership and management of existing diesel generators and/or the proposed new RE hybrid system
2. Assessment of technical feasibility		
2.1 Selection of appropriate components	☐ PV modules ☐ PV inverter ☐ Battery inverter ☐ Battery storage ☐ Diesel generator units	☐ Quality and operation behavior of the components ☐ Ability to operate in harsh environmental conditions in remote areas ☐ Life span and maintenance requirements under local conditions

Key Parameters	Specifications	Methods / recommendations / critical issues
	☐ Control and management unit	☐ Availability of after-sales technical services and spare part supply ☐ Technical risk assessment and risk minimization strategy (e.g. training of local staff, planned maintenance, spare parts on stock)
2.2 System design options	☐ Up to 20% SPV penetration rate: SPV hybrid systems are usually designed without any power storage component ☐ High tolerance for voltage and frequency ranges ☐ Integrated management functions for a weak grid (reactive power)	☐ Safeguard the diesel gensets building the electrical network (stabilizing the grid) ☐ Safeguard the ratio between PV peak power and genset nominal power should be up to 20% ☐ Consideration of sufficient load demand during day operation ☐ Realization without additional control unit needed
	☐ › 20% PV penetration rate: SPV hybrid may be designed without power storage component ☐ Reverse power protection ☐ Integrated management functions for weak grid (reactive power)	☐ Safeguard the diesel gensets building the electrical network ☐ Check whether power demand in the grid is sufficient during solar hours to absorb the produce SPV power ☐ An additional control unit is usually needed ☐ In-time adjustment (control) of genset and SPV operation to ad hoc variations in power demand and/or solar irradiation ☐ Spinning reserve for diesel generator in the system design ☐ Diesel generators have to operate at least above 30% of installed diesel capacity in order to avoid inefficient operation
	☐ If a power storage component is included in the system, SPV penetration can be up to 100% and beyond ☐ The SPV can be integrated in the system: on the DC side via the charge controller or on the AC side via the inverter ☐ In diesel off-mode, the battery connected via the inverter can serve as the voltage source (building the grid) ☐ Reverse power protection is necessary ☐ Integrated grid management functions have to be built in, in particular for weak grids (reactive power)	☐ SPV penetration and storage capacity can be extended to the economic optimum; diesel off-mode may be supported ☐ An additional control unit is needed ☐ Ensure power quality and grid stability (voltage, frequency, reactive power) ☐ Storage may substitute for spinning reserve and idle genset operation ☐ Power sharing among generation units may help to meet the load demand in the most economical way ☐ Diesel generators have to operate at least above 30% of installed diesel capacity in order to avoid inefficient operation
2.3 Operation conditions	☐ Load factor ☐ Battery - Cycles - Charge schemes -Llife span - Depth of discharge ☐ Battery inverter - System manager	☐ Load factor of the gensets should be optimized for efficient operation (above 30%) ☐ Design of the storage cycle may influence the life time and the performance of the batteries ☐ Batteries (lead acid) must be protected against deep discharge and must not stay in low state of charge over longer periods ☐ Temperature restrictions for lead acid batteries must be taken into consideration

Key Parameters	Specifications	Methods / recommendations / critical issues
		☐ Inverters or charge controllers must be able to manage the battery, including regular equalization and float charge to maximize storage life span
3. Modeling of optimum system designs		
3.1 Economic optimization and sensitivity analysis	Modeling input data (HOMER) ☐ System structure configuration ☐ PV module ☐ PV inverter ☐ Charge controller ☐ Storage technology ☐ Diesel generator ☐ Load profile ☐ Load factor ☐ Solar irradiation ☐ Project lifetime ☐ Cost of components ☐ Fuel cost ☐ O&M costs ☐ Life span of components ☐ Interest rate	☐ Chronological simulation and optimization of a project over the entire project life cycle ☐ Modeling technical and economic options ☐ Comparison of cost and feasibility of different configurations ☐ Sensitivity analysis of levelized cost of electricity (LCOE) ☐ Sensitivity analysis of uncertain factors such as fuel prices, life span of components, O&M costs, interest rates
3.2 Performance modeling	PV-hybrid web tool input data (SMA) ☐ PV module ☐ PV inverter ☐ Diesel generator ☐ Load profile ☐ Load factor ☐ Solar irradiation ☐ Cable loses ☐ Project lifetime ☐ PV investment costs ☐ Fuel cost ☐ OpEx PV as a percentage of CapEx/year ☐ Equity ratio ☐ Debt ratio ☐ Interest rate	☐ Collection and evaluation of meteorological input data for the project location, or to another location close by ☐ Modeling technical and economic options ☐ Sensitivity analysis of uncertain factors such as fuel prices, PV investment, O&M costs, interest rates, debt ratio ☐ Assessment of the return of investment ☐ Determination of levelized cost of electricity (LCOE) with sensitivity analysis
3.3 Levelized costs of electricity (LCOE)	☐ All cost over lifetime ☐ Initial investment ☐ Operations and maintenance ☐ Cost of fuel ☐ Cost of capital	☐ Estimation of true cost of generation rate per kWh for the entire hybrid system
4. Bankable project documentation		
4.1 Investment costs	☐ PV system	☐ Include storage replacement during project lifetime in the calculations

Key Parameters	Specifications	Methods / recommendations / critical issues
	☐ Retrofitting of diesel generator ☐ New diesel generator ☐ Balance of system (BOS) ☐ Grid infrastructure ☐ Storage technology ☐ Intelligent control unit ☐ Monitoring	☐ Due to small project volume and uncertain framework conditions, transaction cost may be relatively high ☐ Fiscal incentives should be taken into consideration for the assessment of economic feasbility; probable delays in availing these incentives should be taken into consideration ☐ Deviations from the optimum technical systems design may be reasonble if they help reduce investment cost and resulting LCOE substantially ☐ Establishing SPV installations on commercial land or on existing roofs may help avoid delays in project development due to land use or IP issues.
4.2 Operation and maintenance costs	☐ Labor costs ☐ Travel expenses ☐ Spare parts ☐ Repair costs ☐ Transport costs ☐ Communication costs ☐ Head office staff support costs	☐ Ensure sufficient cash flow over the entire project life cycle ☐ Involve local capacities in O&M ☐ Employ and train local staff for the operation of all components of the SPV hybrid plant ☐ Establish lean and efficient billing and collection system ☐ Ensure a realistic assessment of O&M cost for SPV arrays, inverters, chargers and storage, and avoid overestimations of the relevant cost. ☐ Implement an adapted planned maintenance concept in order to avoid system outages and to reduce unplanned repair cost
4.3 Cash flow	☐ Investment cost ☐ Transaction cost ☐ Personnel cost ☐ Administration cost ☐ Billing and collection cost ☐ Planned maintenance cost ☐ Repair cost ☐ Cost for replacements ☐ Fuel cost ☐ Tax, levies, fees, etc. ☐ Revenues from power sales (SAGR) ☐ Transmission fees (QTPs), UCME, generation-based cash incentive ☐ Cash effects of increasing demand (forecasts) ☐ Cash effects of inflation and in particular of the increase of fuel cost ☐ Expenses for the continuous upgrade and extension of the local grid	☐ Comprehensive cash flow analysis has to include all foreseeable cash in- and out-flows over the project lifetime ☐ Economic risk assessment and risk mitigation strategy is requested in order to be able to avoid illiquidity and other disturbance of the cash flow
4.4 Internal rate of return	☐ Profitability of the investment ☐ Payback time	☐ Preparation of financial concept with sufficient high internal rate of return ☐ Elaborate a comprehensive risk analysis and risk mitigation strategy to avoid illiquidity and all potential disturbances of the cash flow

Key Parameters	Specifications	Methods / recommendations / critical issues
5. Selection of appropriate market option		
5.1 New power producer (NPP)	☐ Provide services (generation) in NPC-SPUG areas ☐ Register with the DOE as a RE developer ☐ Qualify as new power producer (NPP)	☐ For foreign companies - selection of local partner (which will own majority or 60% of the partnership) ☐ Determination of an appropriate range of NPP services ☐ Enter into appropriate contractual setting with the EC/DU and NPC-SPUG (including UCME) ☐ Develop an appropriate investment strategy
5.2 Qualified third party (QTP)	☐ Provide services (generation and distribution) in areas declared unviable or remote by an EC ☐ Register with the DOE as a RE developer ☐ Qualify as qualified third party (QTP)	☐ For foreign companies - selection of local partner (which will own 60% of the partnership) ☐ Develop an integrated business model for both power generation and distribution, including establishment of the grid ☐ Determine an appropriate investment strategy ☐ Enter into appropriate contractual setting with the EC/DU and NPC-SPUG (including cash incentive and/or UCME)
5.3 Joint venture (JV)	☐ JV agreement between private investor and the electric cooperatives (EC) ☐ The JV has to act as a private NPP or QTP	☐ Willingness of EC to enter into JV with the private sector is the critical issue
5.4 Incentives	☐ Fiscal and non-fiscal incentives from RE Law ☐ Cash generation-based incentive ☐ UCME	☐ Registration with the DOE and enter into a RE service contract (RESC) with the DOE in order to qualify for the availing of fiscal and other incentives ☐ Enter into contractual setting with the NPC-SPUG for availing of the cash incentive and/or UCME)

How to develop a SPV hybrid business case for off-grid power supply in the Philippines along the business planning checklist

IV

IV.1 Identification of potential business cases

Special emphasis should be given on identifying and using key economic and technical parameters that are needed to design feasible business cases for PV hybrid power plants. This includes solar resource, power needs, socio-economic conditions and technical parameters.

IV.1.1 Solar resource potential

The Philippines' position just above the equator provides vast potential for solar energy applications. The daily solar irradiation varies between 4.5 and 5.5 kWh/m²*day (see Figure 4). The average value for the country is 5.1 kWh/m²*day.

The solar data can also be collected from diffent databases available on Internet platforms.

The following methods are recommended:

- ☐ Acquisition of satellite-based solar irradiation data (e.g. Meteonorm or NASA) referring to a close location
- ☐ Collection and evaluation of data from neighboring weather stations, if available

If significant solar irradiation data are not available, measurements should be carried out.

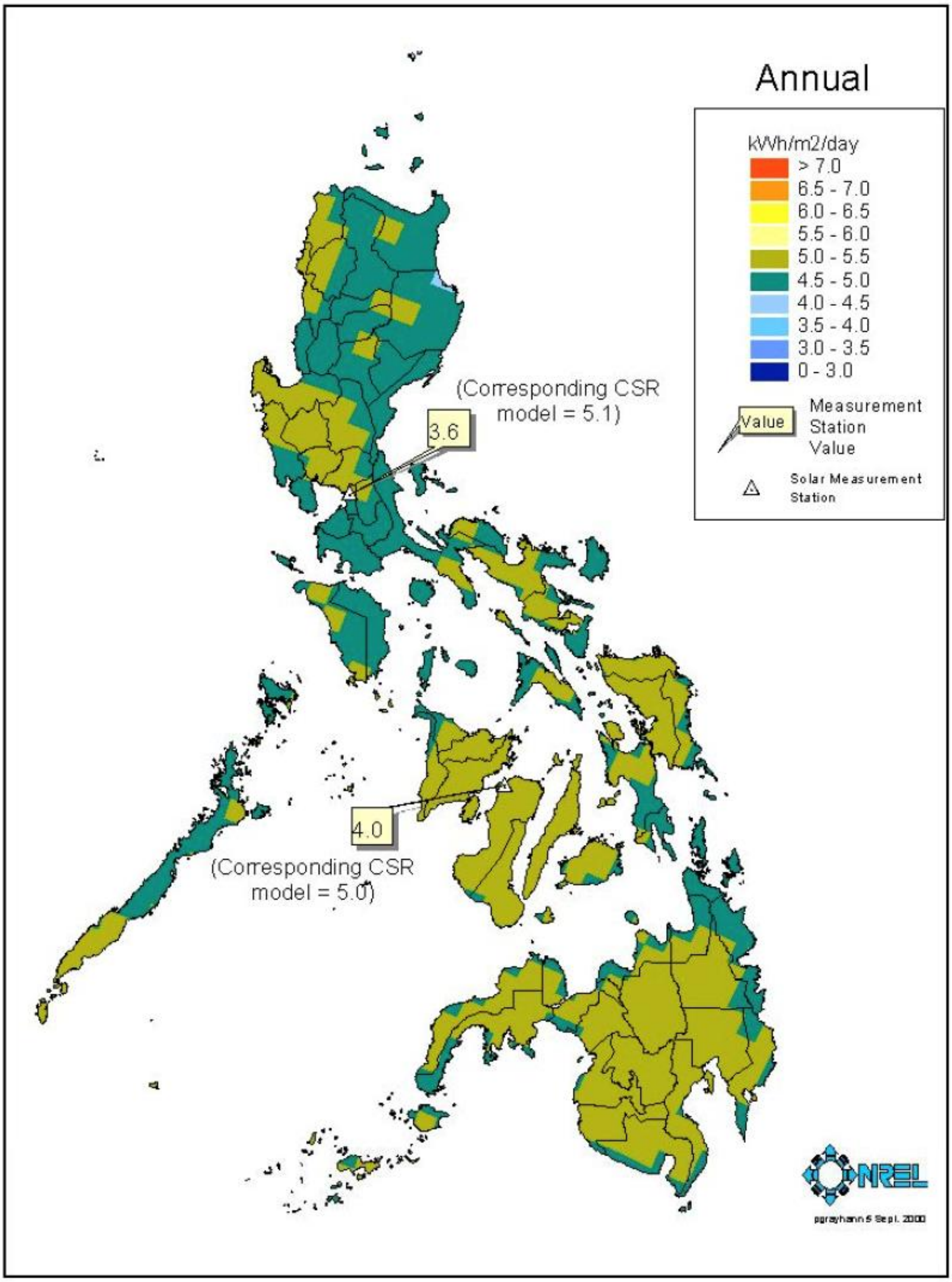


Figure 4. Solar potential in the Philippines
Source: NREL (2000)

IV.1.2 Load profiles

Reliable information on the local load curve is essential because the load curve determines, in most cases, the design of the SPV–diesel hybrid system in off-grid applications.

Compared to interconnected national grids, local distribution grids (mini-grids) have a relatively small number of customers, often with similar consumer behavior. This means that the concurrency of demand may be high and the load profile highly volatile with steep peaks in demand. A typical mini-grid load curve is presented in Figure 5, with some productive use of power during the day, a peak from lighting and TV during the evening hours, and little demand during early morning hours.

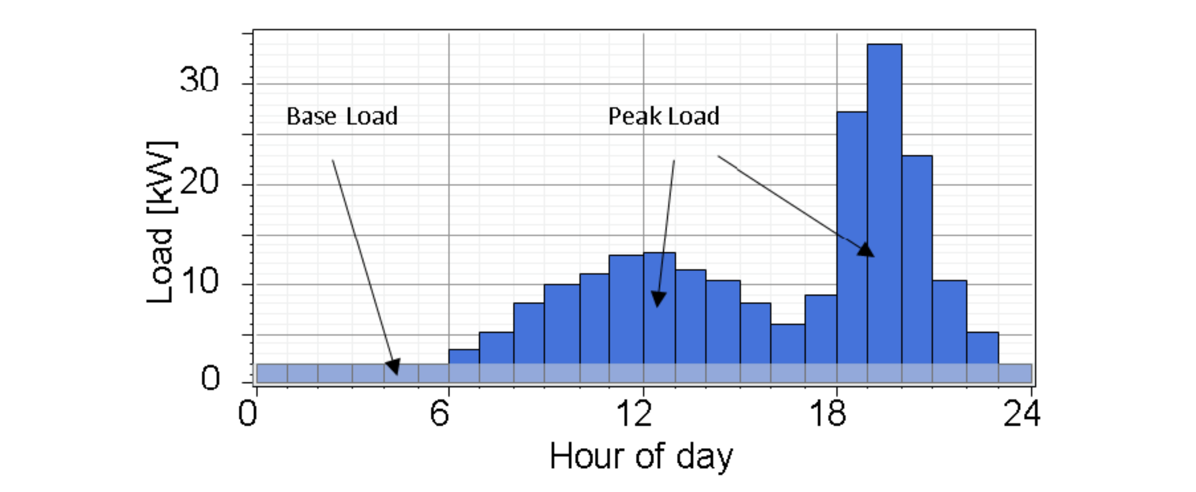


Figure 5. Typical daily load profile in rural areas
Source: Mini Grid Policy Toolkit, GIZ

Different to the above-presented schematic overview, in many local distribution grids in the Philippines, there is no constant base load. Figure 6 shows the daily load profile for one of the NPC-SPUG areas in the Philiipines, where the diesel generators operate from 4 a.m. to 7 a.m. and 2 p.m. to 9 p.m.

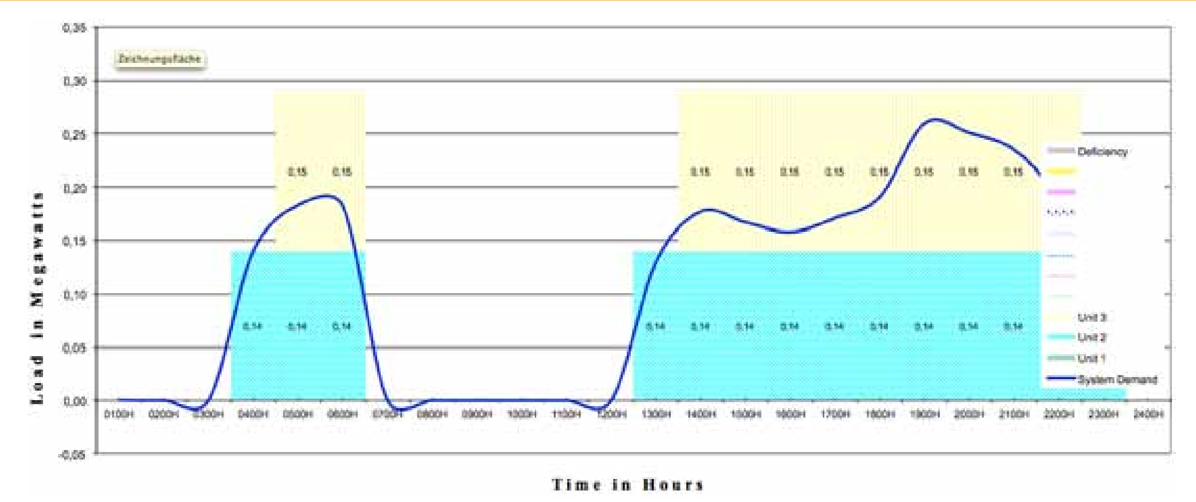


Figure 6. Daily load profile in a SPUG area
Source: NPC

Figure 7 shows an exemplary load profile of a mini-grid operating in 24/7 mode. SPV power can, in this situation, substitute for power generated in diesel gensets. If there is a surplus power production from the SPV plant (mismatch) during the day, this can be used to charge a battery and to use the stored power during night hours. With sufficient storage capacity, the operation of a diesel genset can be reduced or even stopped during night hours.

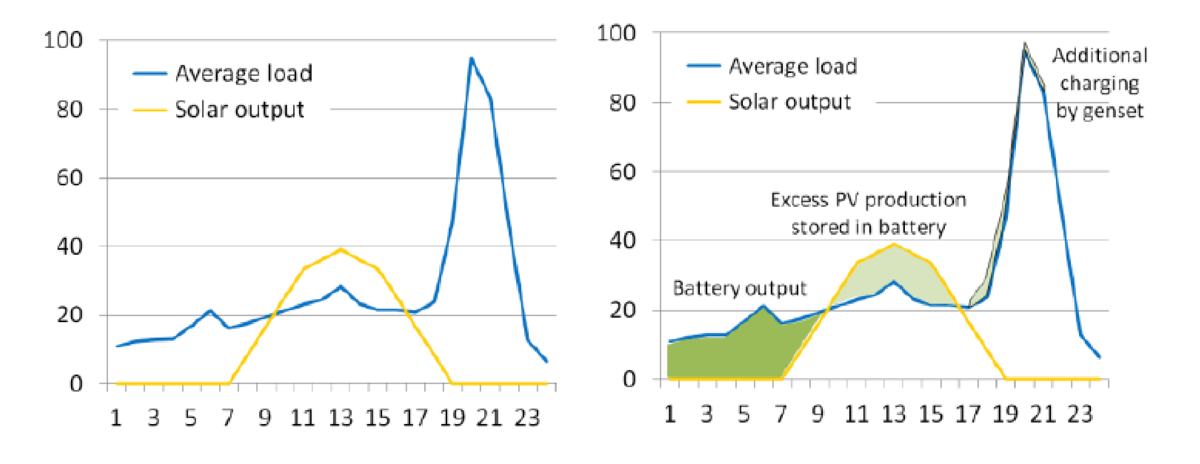


Figure 7. Average daily load curve, solar output, battery, and genset use
Source: IEA PVPS Task 9

When designing a hybrid system, more data on the load profile are required than for a simple genset-based power plant.

The following methods are recommended:

- ☐ Match the daily load curve of the grid and the daily profile of PV power generation
- ☐ Load profiles must cover 24/7 operation (legal requirements on NPPs and QTPs)
- ☐ Average daily energy demand in the grid (kWh)
- ☐ Time and value of daily/weekly/monthly/annual peak load (kW)
- ☐ Average and maximum power demand (kW) during solar irradiation hours
- ☐ Power demand during the night hours (kW)

IV.1.3 Demand survey

If there is no reliable information on the actual local load profile, a demand survey should be carried out.

To ensure that the achieved data are representative, the demand and load survey should include at least 30% of the households selected at random and all public facilities connected to the current grid. The energy demand of each consumer group has to be classified according to the amount and type of energy used. The spatial distribution of consumers is of interest for the mapping of loads – whether centralized, semi-centralized, or distributed.

A proper demand survey will provide a sound basis also for demand side management (DSM, see Figure 8). Load control and DSM can contribute to a better rate of utilization of the available power station capacity. This in turn improves the efficiency of the overall plant and, thus, limits the need for an oversized power station capacity and stabilizes electricity costs and prices. Sound DSM may contribute in different ways to a reduction of total power demand and to the reduction of peak loads:

- **Peak shaving** refers to the reduction of utility loads during peak demand periods. This can delay the need for additional generation capacity. The net effect is a reduction in both peak demand and total energy consumption. Peak clipping can be achieved by direct control of customers' appliances.

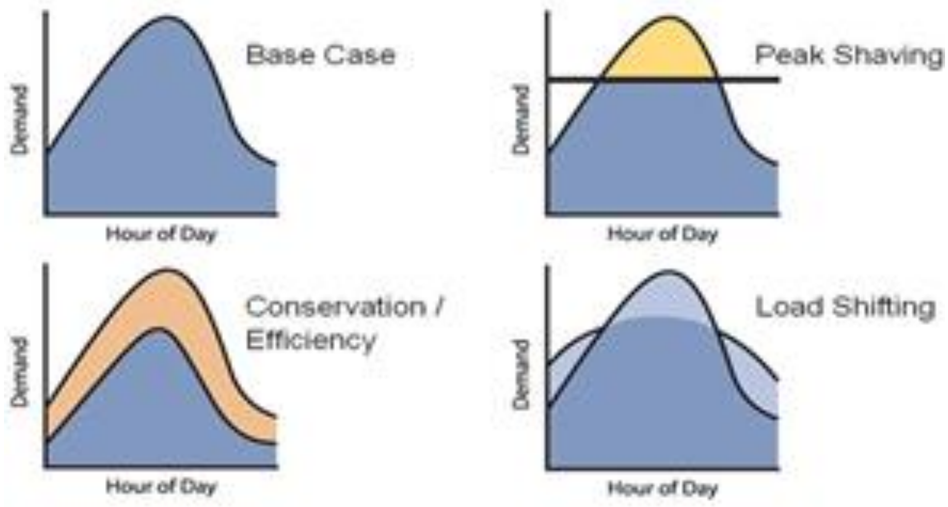


Figure 8. Demand side management techniques
Source: http://www.powerwise.gov.ae

- **Conservation** refers to reduction in consumption by consumers. This leads to a net reduction in both demand and total energy consumption. Strategic conservation can be implemented by motivating customers to use more energy-efficient appliances. The promotion of energy-efficient appliances and customer information regarding rational use of energy should be a part of any mini-grid project.
- **Load shifting** involves shifting loads from on-peak to off-peak periods. The net effect is a decrease in peak demand but not a change in total energy consumption. (See more at: http://www.powerwise.gov.ae/en/research/programmes-projects/demand-side-management.)

The following methods are recommended:

☐ Load curves and power demand of specific consumer groups (e.g. private, productive, commercial, administrative, public services, tourism)
☐ Demand side management potentials
☐ Consumer group-specific questionnaires
☐ Personal interviews

IV.1.4 Load and demand forecast

Knowing the characteristics of demand and supply, and their future development is vital in planning, optimization and operation of technically and economically sustainable RE hybrid off-grid systems. One of the main risks for mini-grid systems is an unplanned increase of the load. The forecast of the power demand should therefore be done as accurately as possible. A poor forecast readily leads to designing inadequate systems that will face early obsolescence. Normally, there are two different types of demand forecast scenarios available:

- Forecast scenarios on future peak load
- Forecast scenario on future electricity demand

Analyzing these scenarios with regard to their plausibility and validity needs a sound understanding of major local developments and trends.

The interest in being connected to electricity grid supply is usually high among people who are not yet connected to a local distribution grid.

The following methods are recommended:

- ☐ Forecast scenarios on future electricity and peak demand development provided, e.g. by DOE, NPC-SPUG or the local DU
- ☐ Energy master plans or future development plans compiled by local government units (LGUs)
- ☐ Verification of upcoming productive uses of energy
- ☐ Projections on yearly growth of population and income
- ☐ Connection rates in the grid-connected area and in neighboring not yet connected areas
- ☐ Personal interviews

IV.1.5 Current power generation costs

The most critical issues for the future development of power generation cost without the use of a solar source are expected to be increases of power demand in the local distribution grid and an increase of the fuel cost for diesel generators.

To be taken into consideration:

- ☐ Potential cost drivers are:
  - Increase of connection rate
  - Increase of daily service hours
  - Changes in consumer behavior
  - Development of productive activities and uses
  - Increasing fuel cost and demand
  - De-rating of worn-out diesel gensets
  - Replacement of outdated diesel gensets

IV.1.5.1 Impact of rising fuel costs

The price of diesel fuel on-site is higher than the price of fuel on filling stations in the cities. The true cost of fuel on-site includes additional cost for transport to the site, which may be exceptionally high in off-grid areas. In NPC-SPUG areas, the actual fuel cost on-site may amount to up to 12 PHP[2] per kWh of generated electricity, which is actually close to an equivalent of 1 USD per liter.

Uncertainty regarding the future development of the fuel cost of diesel generators is high but have to be taken into consideration.

The GIZ International Fuel Prices Data Base indicates an average annual increase of the diesel price by 12.75%[3] for the Philippines during the period of 2002-2012. As no reliable forecast on the future development of fuel prices is possible, it may be assumed that the past trend in the increase of fuel prices will continue.

IV.1.5.2 Impact of rising energy demand

The forecast of the energy demand should be done as accurately as possible and the results should be considered when designing the system solution. The future development of the local load curve has to be assessed, taking into account the expected increase of connected consumers on-site, the potential increase of individual power consumption and new demand emerging, e.g. as a consequence of the development of additional productive uses of power.

Every forecast on the development of local peak load or power demand should be extended to at least 5-10 years after a system's installation date.

IV.1.6 Present state of power generation and distribution system

Usually, diesel gensets in remote areas are run on a limited time per day and during additional operating hours on weekends, and special occasions and holidays. The technical equipment of the power generation is usually positioned in a powerhouse at the center of a village. The generators produce three-phase alternating current (AC) electric¬ity with a nominal frequency of 60 Hz. The use of three-phase data loggers enables measurement of the most important values (voltage, current, frequency, power,

2 Data referring to San Vicente, data source: NPC-SPUG; see also GIZ case study: Technical-Economical Analysis of the Integration of Renewable Energies in the Power Supply System of San Vicente, Palawan, published in October 2014.

3 See https://energypedia.info/wiki/Fuel_Price_Data_Philippines.

power factor) and associated values for the evaluation of the existing infrastructure and their quality, availability and robustness. Comprehensive information about the current condition of the infrastructure is of relevance to optimize and implement energy-saving strategies. Photo 1 shows a typical local power distribution and diesel power supply infrastructure in remote areas.

Photo 1. Local power distribution and generation facilities in Carabao Island
Source: Wollny Consulting

The following methods are recommended:

- ☐ Quality inspection of the existing power generation infrastructure
- ☐ Estimation of retrofitting efforts and costs
- ☐ Execution of quality measurements for voltage, frequency and power quality fare-out connection points
- ☐ Examination of grid transformer technical specification and life span
- ☐ Quality inspection of overhead lines and connection points
- ☐ Identification of suitable available land/roof space to build up a PV solar power system

IV.1.7 Socio-economic assessment

The primary objective of the socio-economic assessment is to ensure the provision of economically viable, socially acceptable and well-managed PV hybrid power generation systems. The assessment of socio-economic conditions in the off-grid area should rely on both secondary and primary data. Secondary data may be available at the LGU Planning and Development Offices, and primary data are to be obtained from surveys and interviews.

To be taken into consideration:

- ☐ Relevant information for identification of different user groups:
  - Size of family, education level, occupation
  - Income and expenditures
  - Sex, ethnicity and religions
  - Age groups, gender issues
  - Livelihood sources
  - Number of OCW/migrant workers
- ☐ Current energy consumption and expenditures
- ☐ Expectation and impacts of the introduction of electricity supply (energy consumption, energy mix, productive use of electricity)
- ☐ Acceptance of the proposed hybrid system
- ☐ Ability and willingness to pay for energy
- ☐ Consumers' preferred billing and collection methods
- ☐ Ownership and management of existing diesel generators and/or the proposed new RE hybrid system

The assessment also looks at the management aspects of the current and proposed power generating system, such as the owner and the operational practices of the current system, as well the respondent's preference on ownership and operational practices of the proposed system.

IV.2 Assessment of technical feasibility

IV.2.1 Selection of appropriate components

IV.2.1.1 PV modules

Solar PV modules are made up of PV cells, which are most commonly manufactured from silicon. Cells can be based on either wafers (manufactured by cutting wafers from a solid ingot block of material) or "thin film" deposition of material over low-cost substrates. The decision whether to use the more expensive crystalline modules or less expensive thin film modules often depends on the available space, as thin film modules need more space per installed kWp (see Figure 9).

In any case, only PV panels certified according to the IEC 61215 (crystalline silicon PV modules) or IEC 61646 (thin film modules) should be selected.

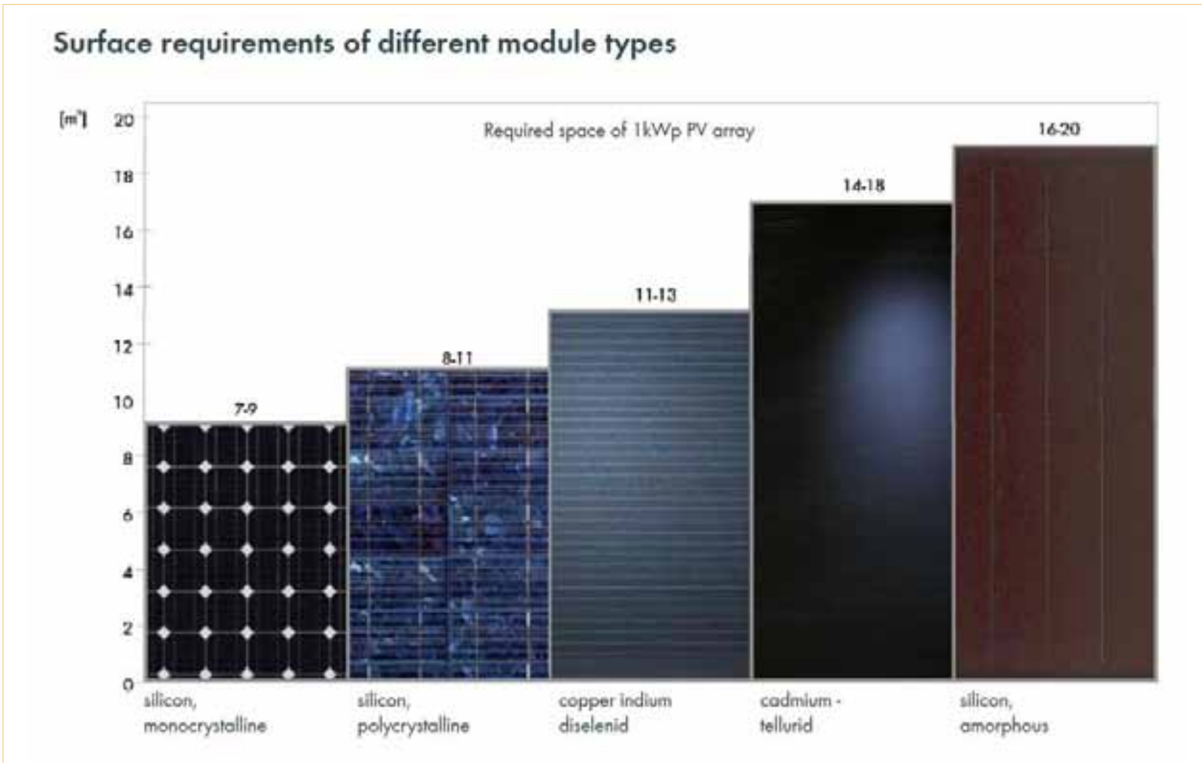


Figure 9. Different module technologies and the required surface
Source: SMA (2013)

Solar PV panels have a long life span (more than 20 years), but their yield gets slightly reduced over time. This parameter has to be computed in the economic analysis across the project time frame. PV panel manufacturers generally guarantee 90% of the initial performance after 10 years and 80% after 25 years. The actual possibility of resorting to the guarantee, if needed after a few years, remains critical in areas where distributors are not established in the close vicinity.

IV.2.1.2 PV inverter

In general, there are two main classes of inverters: central inverters and individual string inverters. Central inverters are connected to a number of parallel strings of modules, whereas individual string inverters are connected to one or more series of strings. Even though central inverters remain the preferred configuration for most utility-scale PV projects, both configurations have their pros and cons. The key advantages of the individual string inverters are that they are smaller and easier to maintain than a central inverter. If one string inverter fails, the others remain on the grid. Numerous individual string inverters are required when setting up a large plant. Both inverter types can give enhanced power plant performance on sites. PV inverters do not utilize the grid, and therefore, a voltage source (diesel generator of public grid) for proper operation is needed. Figure 10 shows the operational diagram of the PV inverter. The PV inverter converts the DC energy from the PV module to grid-compatible AC current.

An PV inverter's life span can reach more than 10 years. The replacement of a failing component has to be undertaken by a technician from the supplying company. Risks associated with the failure of an inverter should be considered, especially in remote locations or countries with very limited presence of specialized suppliers.

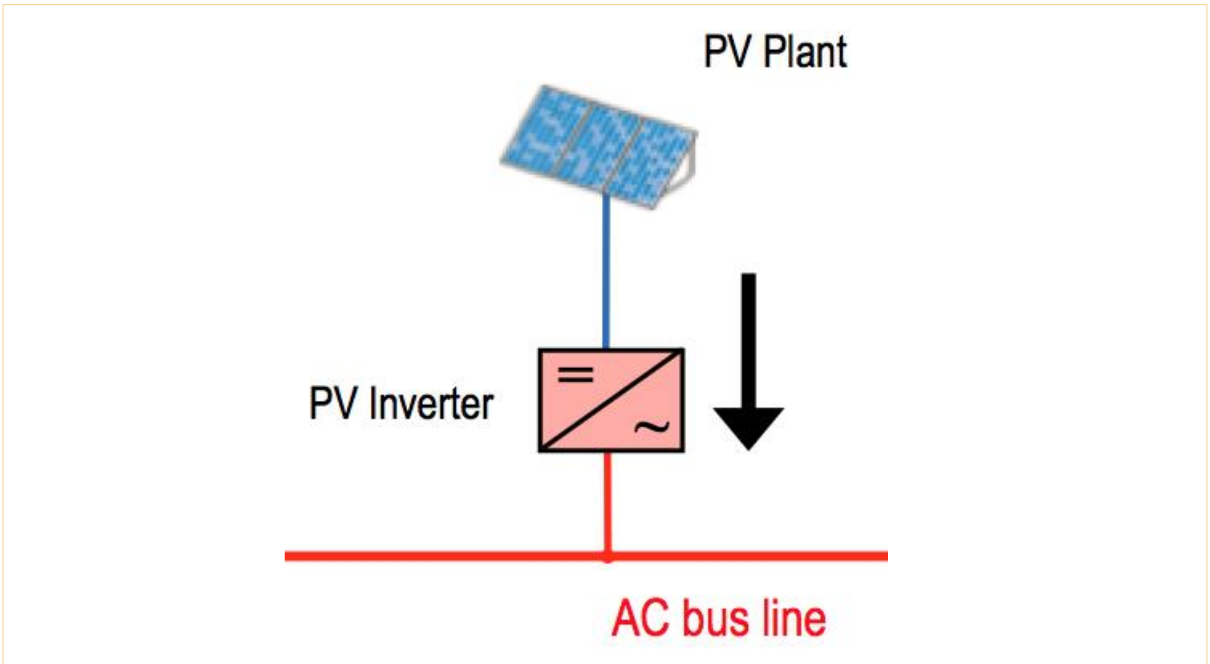


Figure 10. PV inverter operation diagram
Source: Wollny Consulting

IV.2.1.3 Battery inverter

The battery or stand-alone power inverter is the heart of the AC-coupled system with storage battery. It ensures that generated energy and load power are balanced at all times. If too much energy is generated, the inverter stores this surplus energy in the batteries. If energy demand exceeds supply, the inverter discharges energy from the batteries. Figure 11 shows the operational diagram of this type of inverter.

A battery inverter's life span can reach up to 10 years, but this component is a high-technology product and the replacement of a failing component has to be undertaken by a technician from the supplying company. The specific complexity of the inverter often requires that a proper after-sales service plan has to be implemented to ensure long-term sustainability of the system.

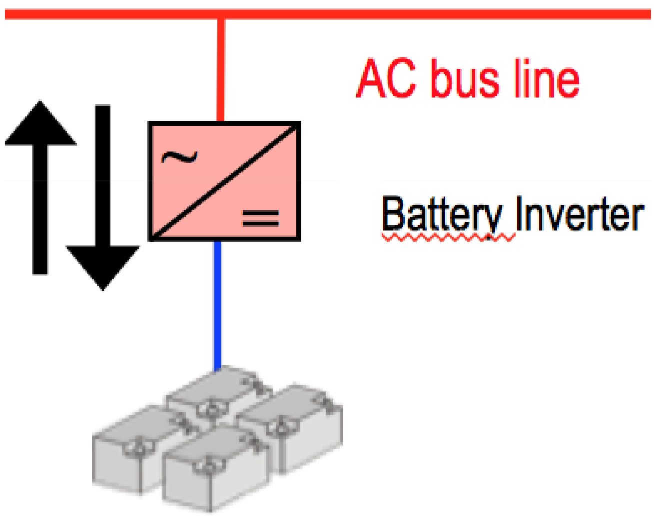


Figure 11. Battery inverter operation diagram
Source: Wollny Consulting

IV.2.1.4 Battery storage

Usually, the battery storage for SPV hybrid mini-grids is still based on lead acid batteries. The optimum design of the battery unit and the life span of the battery depend on many parameters related to the way they are operated and to external conditions, in particular, the ambient temperature and the discharge cycle of the battery. For optimum battery dimensioning, planners have to refer to the producers' fact sheets. Some battery manufactures provide their own calculation tools (e.g. www.batterysizingcalculator.com).

Table 3. Advantages and constraints of storage technologies

Storage Technology	Advantages	Constraints
Lead-acid batteries	Widely available, moderate costs, modular	Limited lifetime, must be disposed of properly, must be maintained properly
Li-Ion batteries	Rapid technological improvement, compact in size	Rupture risk, little experience with use in electric grids
Na-S batteries	Can be used for ancillary services, high roundtrip efficiency	Suitable only for larger electricity systems, corrosive chemicals
Flow batteries	Can be fully discharged, somewhat modular	Still under development, higher capital costs
Flywheels	Modular, low maintenance	Expensive
Pumped Hydro	Technically proven, low costs	Very large scale, significant environmental impacts of construction
CAES	Moderate costs	Very large scale, uses natural gas
Hydrogen	Can be used as a transportation fuel, compatible with fuel cells	Low roundtrip efficiency, expensive

Source: IRENA

IV.2.1.5 Diesel generator

Gensets in the range of 30 kVA to 200 kVA typically need a major maintenance operation after 15,000 to 25,000 running hours. Major maintenance operations should be considered with respect to the cost and availability of the replacement parts.

Figure 12. Diesel generator
Source: Wollny Consulting

IV.2.1.6 Intelligent control unit

The intelligent control unit acts as a demand-driven controller of solar power feed-in to the interface between the diesel generator, PV array and power load. The intelligent control unit records the energy flows in the stand-alone grid and uses that information to determine the maximum permissible PV power (see Figure 13).

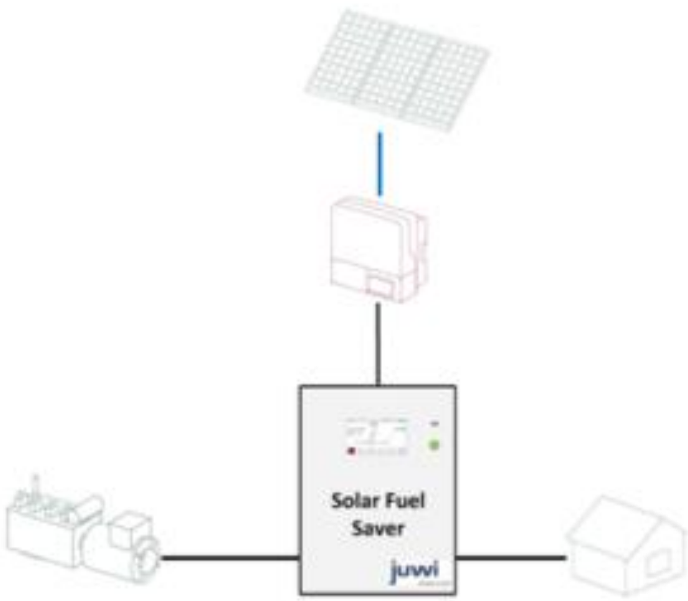


Figure 13. Intelligent control unit (solar fuel saver) operation diagram
Source: Juwi

To be taken into consideration:

- ☐ Quality and operation behavior of the components
- ☐ Ability to operate in harsh environmental conditions in remote areas
- ☐ Life span and maintenance requirements under local conditions
- ☐ Availability of technical services and spare parts supply
- ☐ Technical risk assessment and risk minimization strategy (e.g. training of local staff, planned maintenance, spare parts on stock)

IV.2.2 System design options

PV-diesel solutions are a convincing alternative for already existing diesel-powered mini-grids. Already today, there is a significant cost advan¬tage of PV-diesel hybrid systems compared to conventional stand-alone diesel gensets. In principle, two main basic system solutions are suitable and commercially available on the market.

- Hybridization without storage technology (AC-coupled photovoltaic)
- Hybridization with storage technology (DC-coupled or AC-coupled photovoltaic)

IV.2.2.1 PV-diesel hybridization without storage technology

The diesel gensets together with the connected load are the overlaid system and build the electrical network. That is still valid even if the PV is going to supply energy into this grid. The PV can be seen as a negative load.

Integration of a PV plant with up to 20% PV penetration rate (ratio between PV peak power and genset nominal power) is possible. The diesel grid acts as a voltage source for the PV string inverter; this allows a stable operation without energy flow back to the generators. Figure 14 shows the principle of the system design.

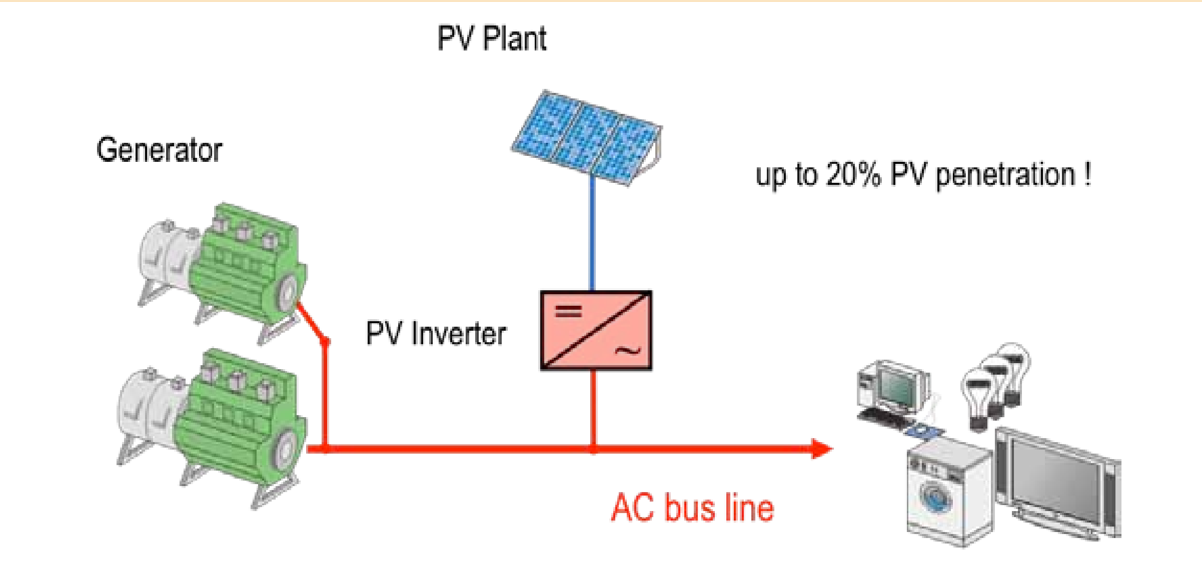


Figure 14. PV-diesel hybridization with up to 20% penetration rate of PV
Source: Wollny Consulting

To be taken into consideration for systems with up to 20% PV penetration rate:

- ☐ Safeguard the diesel gensets building the electrical network (stabilizing the grid)
- ☐ Safeguarding the ratio between PV peak power and genset nominal power should be up to 20%
- ☐ Consideration of sufficient load demand during day operation
- ☐ Realization without additional control unit needed

For a higher portion of PV, an additional control unit is needed to guarantee a stable operation.

An additional intelligent control unit such as the fuel save (FS) controller unit can be integrated into both new and existing power supply systems. The integration of a fuel save controller unit allows a significantly higher PV penetration level (see Figure 15). The PV inverter will be limited to the measured load (minimum diesel load).

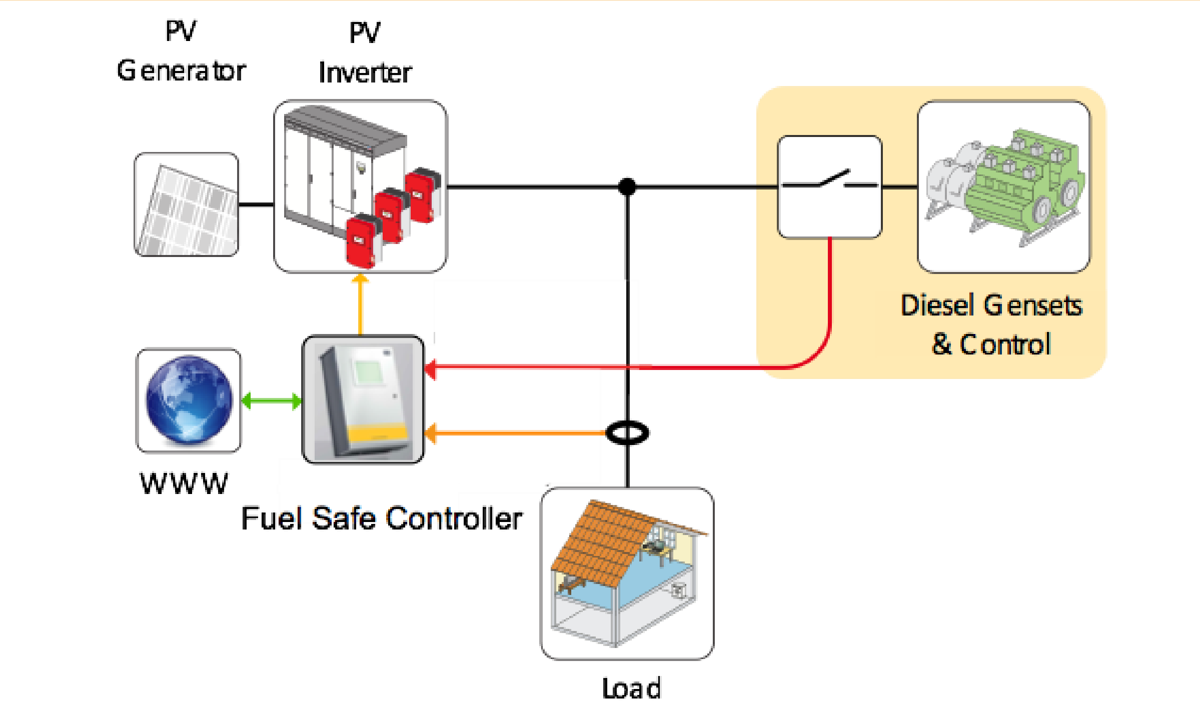


Figure 15. Intelligent and fast interfacing between load, genset, and PV inverter, fuel save controller
Source: SMA

Figure 16 shows a load profile over the day as an example. The PV power is limited to allow a minimum genset load (in this example: minimum of 30% of genset real power). To avoid energy flows back from the PV plant to the diesel generator or ignore the spinning reserve of the diesel system, an intelligent and fast interfacing between load, genset and PV inverter is required. The fuel save controller unit does not control the gensets; it controls the PV power system to keep the gensets within allowed operation conditions.

Figure 15 also shows the interplay between the diesel generator and the solar power output as regulated by the intelligent control unit, i.e. fuel saver. When the diesel generator output is at its minimum partial load, the solar output is throttled by the FS. This temporary reduction of the solar power ensures the efficient operation of the diesel generator. The solar fuel saver acts as interface between the solar plant and the diesel generator, regulating the solar power output to ensure an efficient operation of the diesel generator.

Thus, the genset operates in a reliable and stable state even with high levels of photovoltaic. A ratio up to 60% photovoltaic penetration is possible (ratio between PV peak power and genset nominal power). For each MW installed genset capacity, a photovoltaic plant with 600 kW can be added to the genset power supply system. The fuel save controller manages feed-in of PV, and the diesel genset remains unaffected.

A multi-genset system allows for more fuel savings because the controller can even switch off individual generators, in case that there is short-term storage capacity (lead acid or others) available.

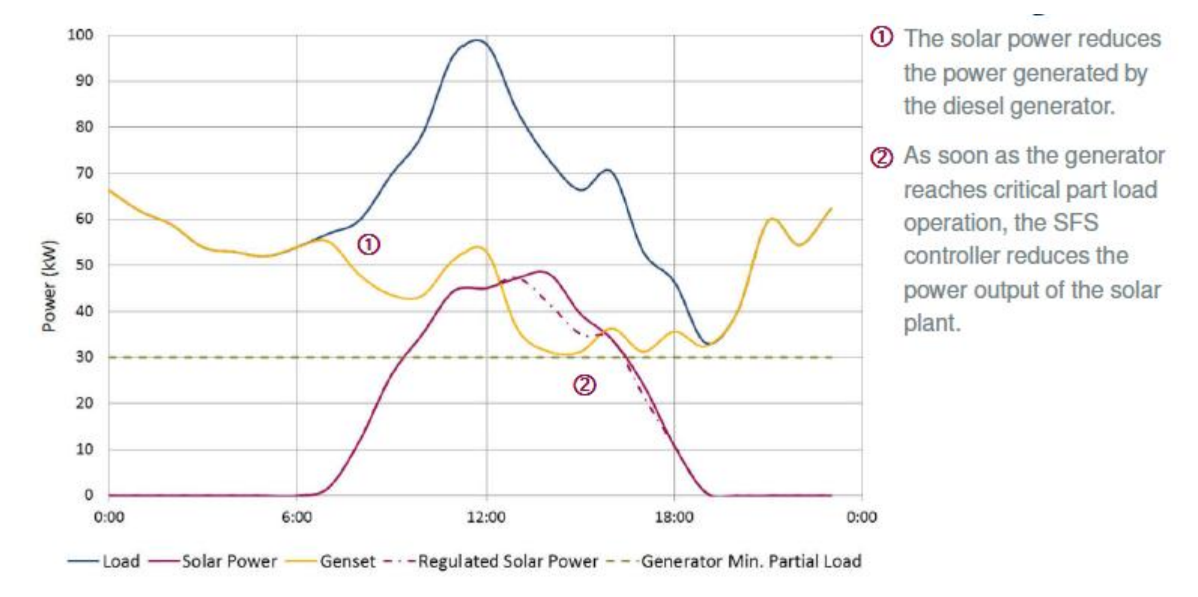


Figure 16. Interaction between the diesel generator and the solar power output as regulated by the SFS controller
Source: Juwi

To be taken into consideration for systems with more than 20% PV penetration rate:

- ☐ Safeguard the diesel gensets building the electrical network
- ☐ Check whether power demand in the grid is sufficient during solar hours to absorb the produced SPV power
- ☐ An additional control unit is usually needed
- ☐ In-time adjustment (control) of genset and SPV operation to ad hoc variations in power demand and/or solar irradiation
- ☐ Spinning reserve for diesel generator in the system design
- ☐ Diesel generators have to operate at least above 30% of installed diesel capacity in order to avoid inefficient operation

IV.2.2.2 PV-diesel hybridization with storage technology

The battery storage power can compensate for the fluctuations in load and irradiation to further increase the overall system efficiency by providing spinning reserves and facilitating optimized genset operation.

The increasing share of solar energy production reduces the availability of conventional power plants that can provide these ancillary services. However, these ancillary services can also be provided by storage systems. Ancillary services include frequency-dependent control of active power feed-in, voltage stability, black start capability after a grid failure and grid congestion management. These services provide renewable energy with the same grid-stabilizing characteristics as conventional power plants. Thus, storage systems enable the provision of high-quality energy at any time and balance the fluctuations caused by the rapid rise in solar energy use. The same storage system can also be used for other purposes, such as an uninterruptible power supply. As generators become more adjustable and controllable, the number of conventional units can be significantly reduced while future grid requirements can still be met and supply reliability can be guaranteed at any time.

Figures 17 and 18 show the principle booth integration of a PV application into a hybrid system structure. Booth technologies are used in applications worldwide.

PV–diesel hybrid power systems can be classified according to their type of voltage (DC or AC). In DC-coupled systems, the PV generator is connected via a special DC/DC charge controller (see Figure 17). In AC-coupled systems, a conventional PV inverter is used for feeding power into the AC grid (see Figure 18).

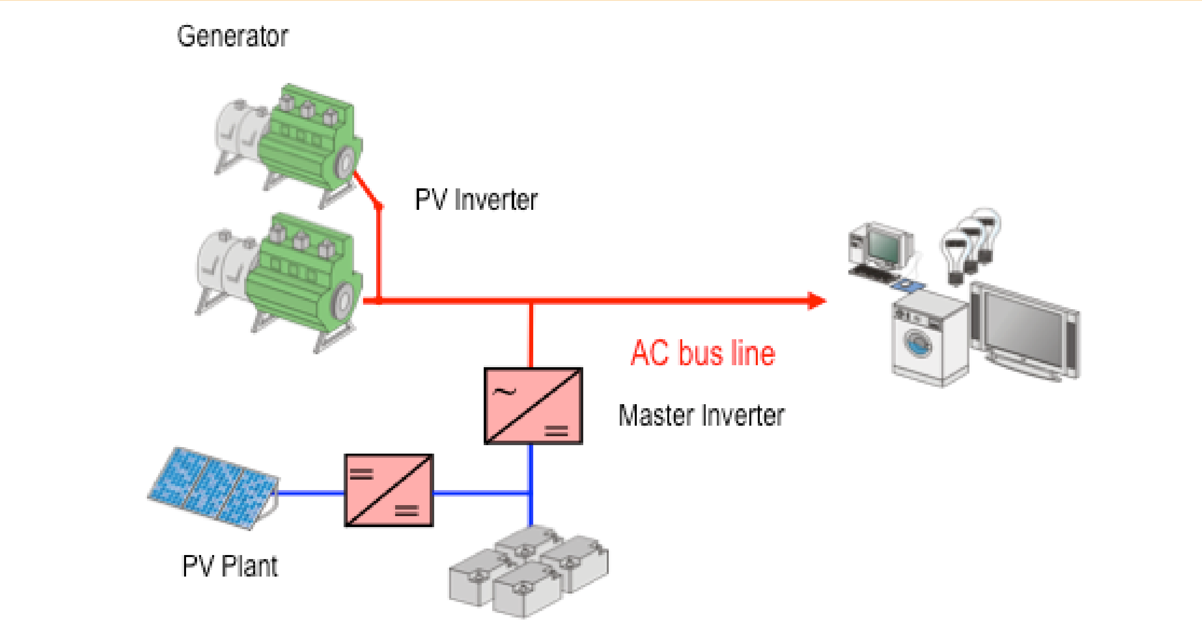


Figure 17. PV-diesel hybridization with storage and DC-coupled PV
Source: Wollny Consulting

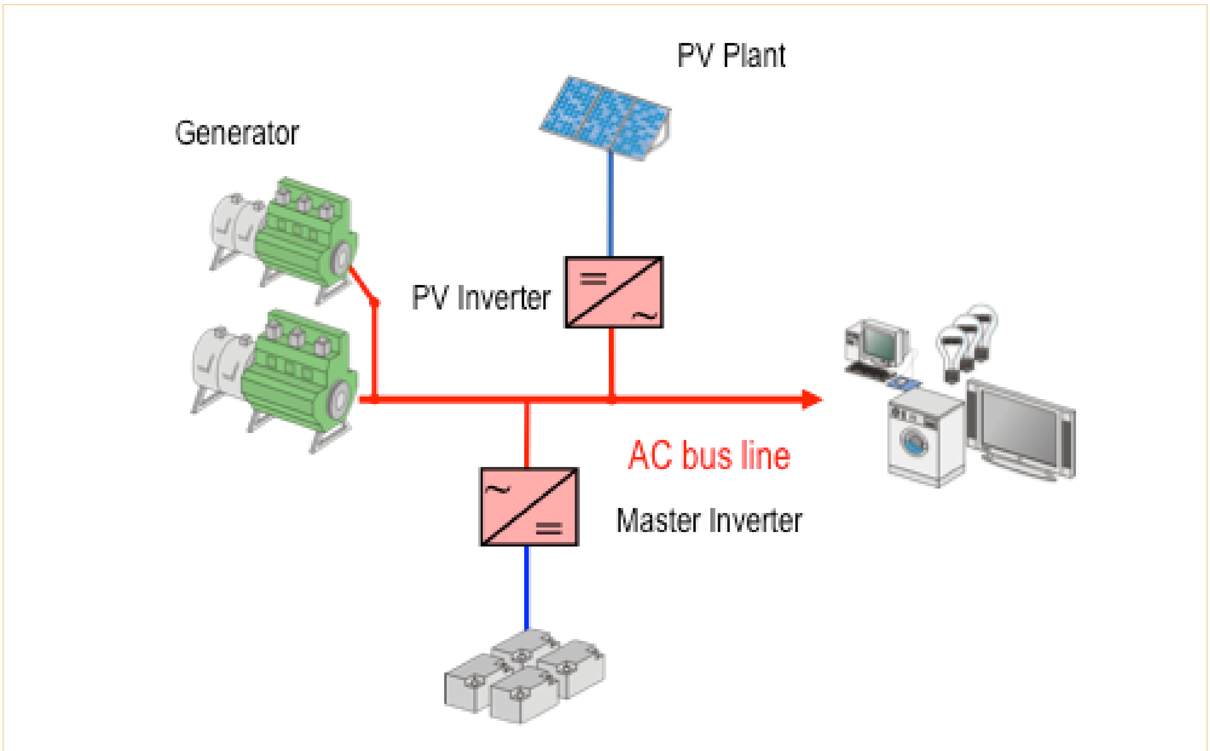


Figure 18. PV-diesel hybridization with storage and AC-coupled PV
Source: Wollny Consulting

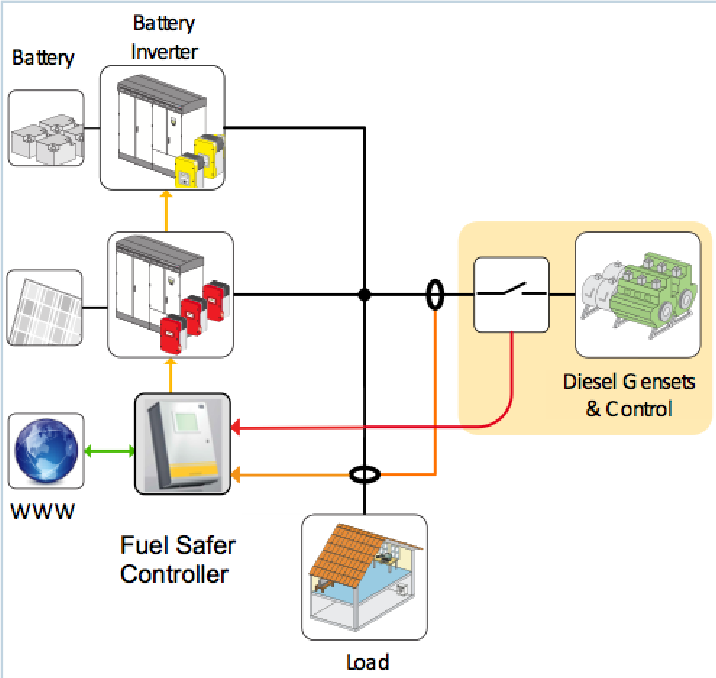


Figure 19. PV-diesel hybridization solution with storage
Source: SMA

The integration of a storage technology reduces the operating time of the diesel genset and the fuel consumption (instead of spinning reserve). The sizing of the storage is optimized – instead of using an additional genset. The use of weather forecast information reduces the need of spinning reserve (see Figure 19).

Figures 20 and 21 show industrial solutions based on control and management systems that integrate all generation components including battery storage. System solution in the MW range are commercially available.

For operating a hybrid plant, the operation strategy has to be adjusted to reducing diesel consumption to a minimum, and keeping frequency and voltage in range. This ensures a control of active and reactive power, and a stable grid.

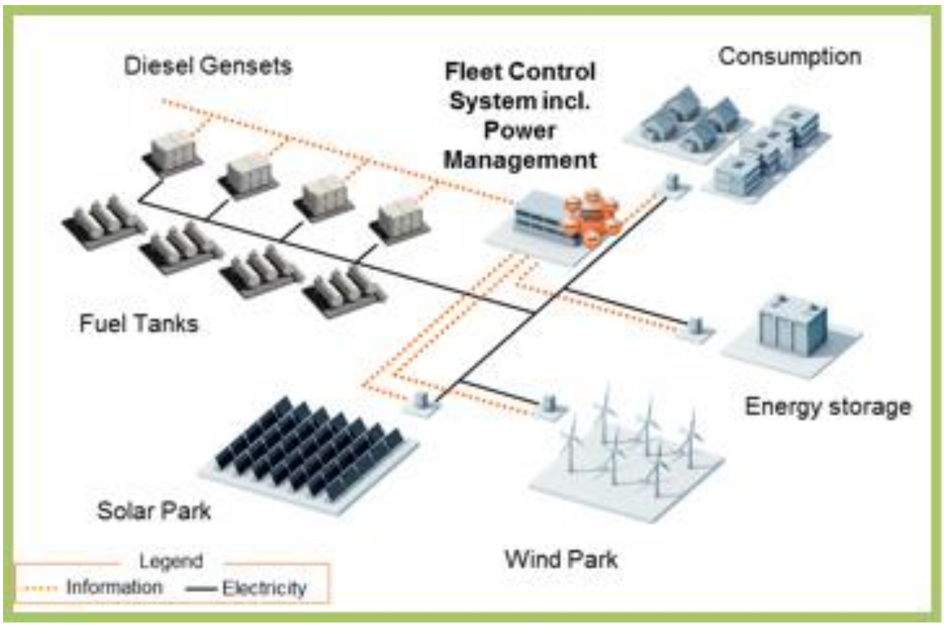


Figure 20. RE hybrid power solution with storage from SIEMENS

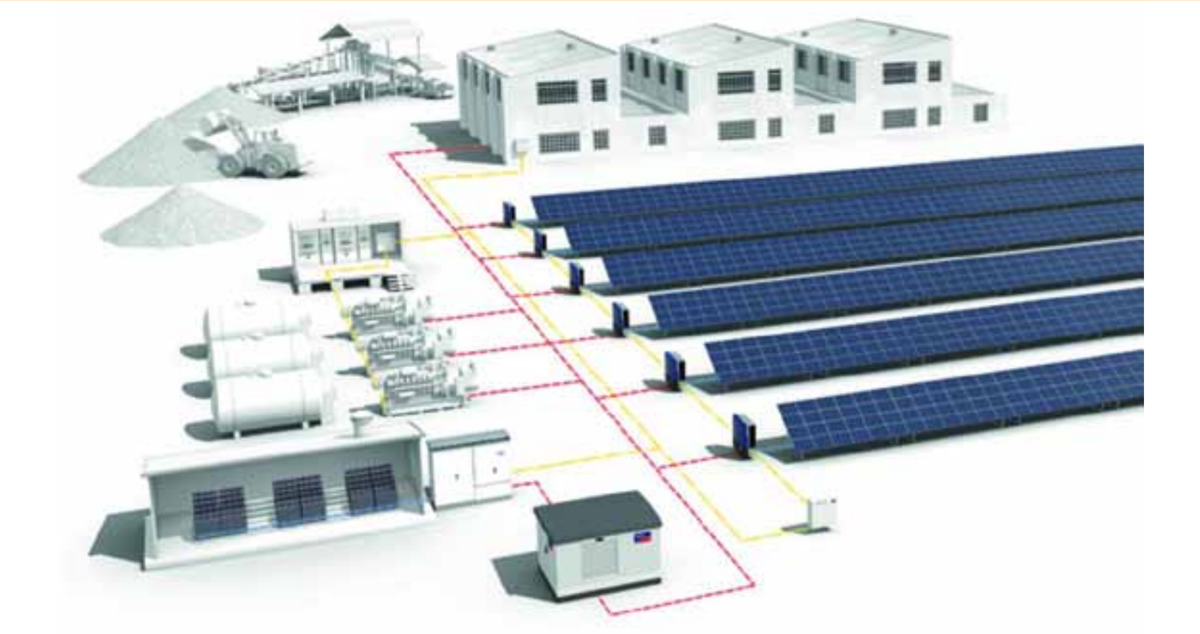


Figure 21. PV–diesel hybrid power plant with storage from SMA

To be taken into consideration for AC- or DC-coupled PV–diesel hybrid system solution with storage technology:

- ☐ SPV penetration and storage capacity can be extended to the economic optimum; diesel off-mode may be supported
- ☐ An additional control unit is needed
- ☐ Ensure power quality and grid stability (voltage, frequency, reactive power)
- ☐ Storage may substitute for spinning reserve and idle genset operation
- ☐ Power sharing among generation units may help to meet the load demand in the most economical way
- ☐ Diesel generators have to operate at least at 30% of installed capacity in order to avoid inefficient operation

IV.2.3 Operation conditions

The operational strategy of the system defines the system design. The operation mode should be directed toward efficiency of the diesel genset and battery operation, and target the prolongation of their operational life. Optimizing the load factor of the genset and the cycling of the battery is important as it has a strong impact on the sizing and the life cycle costs of the system.

IV.2.3.1 Diesel unit

The diesel unit can consist of one or more diesel generators. In particular, systems with more than 50 kW are usually built with multiple gensets of different sizes in order to allow for the optimization of the load factor of each of the different gensets during operation.

Gensets, especially those below 250 kVA (200 kW), experience significant efficiency losses (increased fuel use per kWh generated) when used at low load factors (<30%), and all types of gensets suffer from degradation if repeatedly used for long time periods at low load factors.

It is recommended to ensure that diesel gensets run as much as possible at a load factor higher than 30%. Figure 22 shows the relation between fuel consumption and load factor.

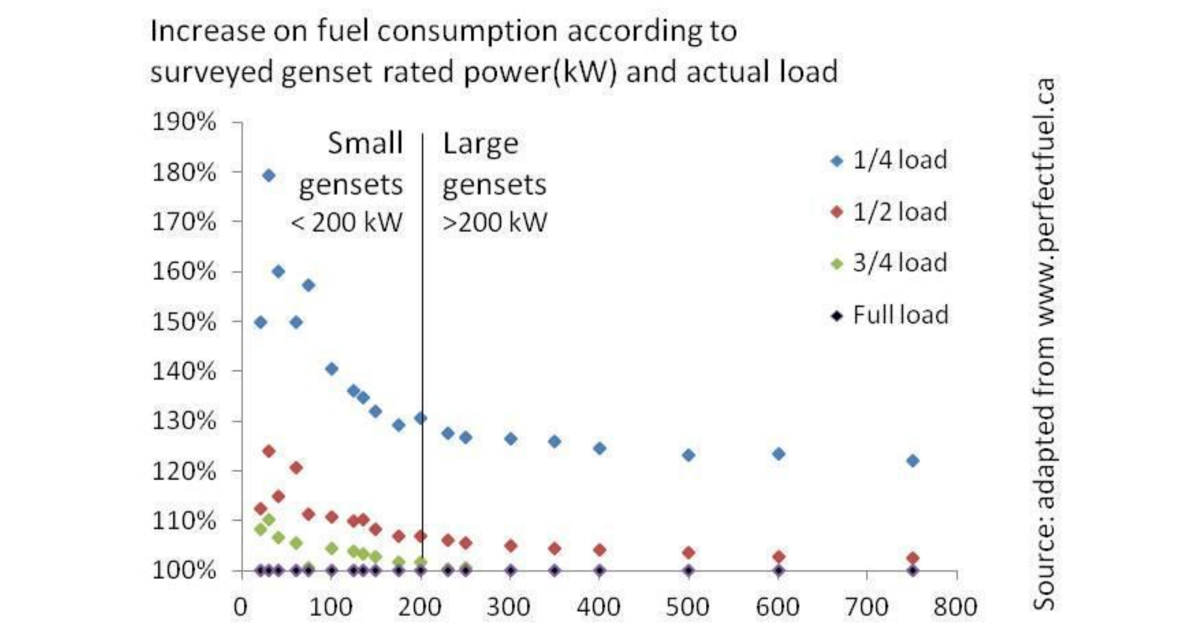


Figure 22. Increase in fuel consumption for gensets run at low load factor

IV.2.3.2 Battery storage

Today, the most suitable storage technology for hybrid systems in rural electrification is lead acid batteries with tubular plates, either vented lead acid (VLA: flooded batteries with liquid electrolyte to be regularly refilled) or valve-regulated lead acid (VRLA: maintenance-free batteries). The chosen battery should be specifically designed for deep cycling applications (not more than 50–60% discharge per cycle).

The battery capacity should be big enough to store the entire energy required for covering the load during the hours when the genset is not supposed to run and solar irradiation is not available (e.g. during night hours and early morning hours).

The battery discharge should be limited to 50–60% (deep discharge) of the actual battery capacity. The battery room should be designed to keep the batteries at low temperatures (at least below 30°C).

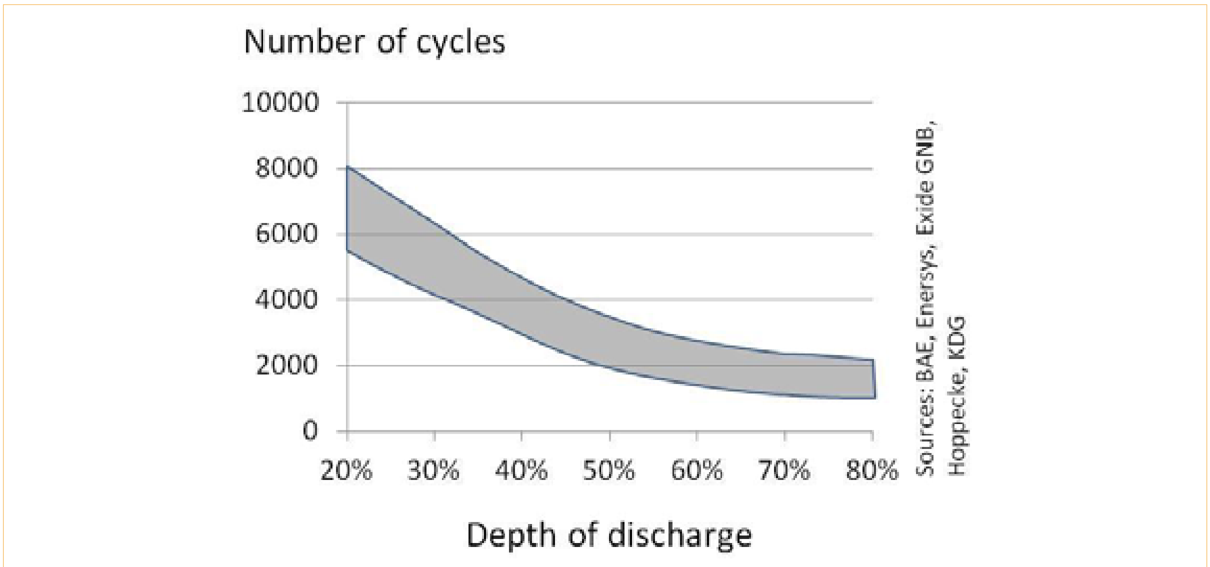


Figure 23. Life span according to depth of discharge (for 2 V cells OPzS and OPzV)

Figure 23 illustrates the relation between the amount of cycles and the discharge factor. The battery life span (measured in number of cycles) depends on the depth of discharge reached at every cycle: the deeper the battery is discharged at each cycle, the shorter is its life span, as shown for VRLA and VLA batteries.

Storage technologies are undergoing rapid enhancement. Advantages and constraints of commercially available battery types are summarized in Table 4.

IV.2.3.3 Multifunctional battery inverter

The inverter component should be designed in order to be able to supply the load when solar output is not available and the genset does not run at an efficient load factor. Seasonal variations of the load and its yearly growth should be taken into account when specifying its rated capacity.

The multifunctional battery inverter devices control the operations of the different energy sources of the system. A failure in one of its components significantly hampers the functioning of the entire system. Improper settings for the various thresholds that control the shift between sources affect the life span of the battery and the efficiency of solar energy use. Therefore, the system designer has to take into account the quality, robustness, simple operation and durability when specifying the multifunctional inverter and its operation.

To be taken into consideration:

- ☐ Load factor of the gensets should be optimized for efficient operation (min. 30%)
- ☐ Design of the storage cycle may influence the lifetime and the performance of the batteries
- ☐ Batteries (lead acid) must be protected against deep discharge and must not stay in low state of charge over longer periods
- ☐ Temperature restrictions for lead acid batteries must be taken into consideration
- ☐ Inverters or charge controllers must be able to manage the battery, including regular equalization and float charge to maximize storage life span

Table 4. Summary of commercially available storage technologies

	Lead-acid batteries	Li-Ion batteries	NaS batteries	Flow batteries	Fly-wheels	Pumped hydro	Large-scale CAES
Applicable grid system size [kW/MW]	≤10 MW	≤10 MW	≥100 MW	25 kW-10 MW	100 kW-200 MW	Mostly ≥200 MW	≥500 MW
Lifetime [years]	3-10	10-15	15	Cell stack: 5-15; Electro-lyte: 20+	20	25+	20+
Lifetime [cycles]	500-800	2,000-3,000	4,000-40,000	Cell stack: 1,500-15,000	>100,000	>50,000	>10,000
Roundtrip efficiency [%]	70%-90%	85%-95%	80%-90%	70%-85%	85%-95%	75%-85%	45%-60%
Capital cost per discharge power [$/kW]	$300-$800	$400-$1,000	$1,000-$2,000	$1,200-$2,000	$2,000-$4,000	$1,000-$4,000	$800-$1,000
Capital cost per capacity [$/kWh$_{cap}$]	$150-$500	$500-$1,500	$125-$250	$350-$800	$1,500-$3,000	$100-$250	$50-$150
Levelised cost of storage [$/kWh$_{life}$]	$0.25-$0.35	$0.30-$0.45	$0.05-$0.15	$0.15-$0.25	N/A	$0.05-$0.15	$0.10-$0.20
Annual operating costs [$/kW-yr]	$30	$25	$15	$30	$15	$5	$5

Source: IRENA

IV.3 Modeling of optimum system configuration

Guiding questions for the modeling process

Which is the optimum dimension for the SPV array in order to achieve least cost of electricity (LCOE)
… in the current situation?
… with a view to an expected future situation?
… over the life span of the SPV–diesel hybrid system?

What are the economic benefits of SPV hybridization compared to maintaining the diesel-only system?

What are the advantages of a battery storage, and …
… which is the optimum dimension of the battery?
… how will the battery influence the dimensioning of the SPV array?
… how will the use of the battery influence the overall COE?

What are the expected effects of SPV hybridization…
… on the security of local power supply?
… on the COE and the life cycle cost of the power generation system?
… on the use of fossil fuels?
… on the local CO2 emissions from power generation?

Prerequisite to start the simulation of a project

An approach with a chronological simulation and optimization of a project is recommended. The following steps are useful and will guide to the optimum PV hybrid system solution. Start with the current power situation and actual demand, the integration of a PV system and the benefits, sensitivity analyses of different scenarios and taking into account the expected future situation that leads to the optimum PV hybrid system solution.

1) Establish a model showing the current power generation system
- Simulation of actual load profile and demand
- Modeling of existing diesel generators in use
- Adjustment of specific cost figures to the actual TCGR
- Calculation of COE, NPC-SPUG fuel consumption, CO2 emission etc.

2) Simulate SPV hybridization of the current system
- Introduction and optimum dimensioning of the SPV array
- Introduction and optimum dimensioning of battery storage (optional)
- Calculation of COE, NPC-SPUG fuel consumption, CO2 emission ...
- Assessment of comparative benefits (cost, fuel consumption, emission…)

3) Establish a diesel-only design for an expected future situation
- Reference to consolidated load and demand forecasts
- Modeling of necessary diesel generators
- Simulation of COE and fuel consumption

4) Simulate SPV hybridization of the future system
- Introduction and optimum dimensioning…

5) Sensitivity analysis of different scenarios

6) Selection of the optimum system configuration recommended from the simulation tool

IV.3.1 Economic optimization and sensitivity analysis

The modeling of a technical solution under the different system configurations and components requires an adequate software tool. HOMER, a modeling system developed by the National Renewable Energy Laboratory (NREL) of the US-DOE, which is emerging as an international standard for modeling of distributed renewable electricity systems, can be used as a convenient tool in modeling a local solution. The model is available, in the initial version free of charge, through the following website:

- http://www.homerenergy.com/software.html

HOMER can be used for:

- Chronological simulation and optimization of a project
- Modeling technical and economic factors
- Comparing cost and feasibility of different configurations
- Sensitivity analysis with levelized cost simulation

Figure 24 shows the start-up window of the HOMER simulation tool.

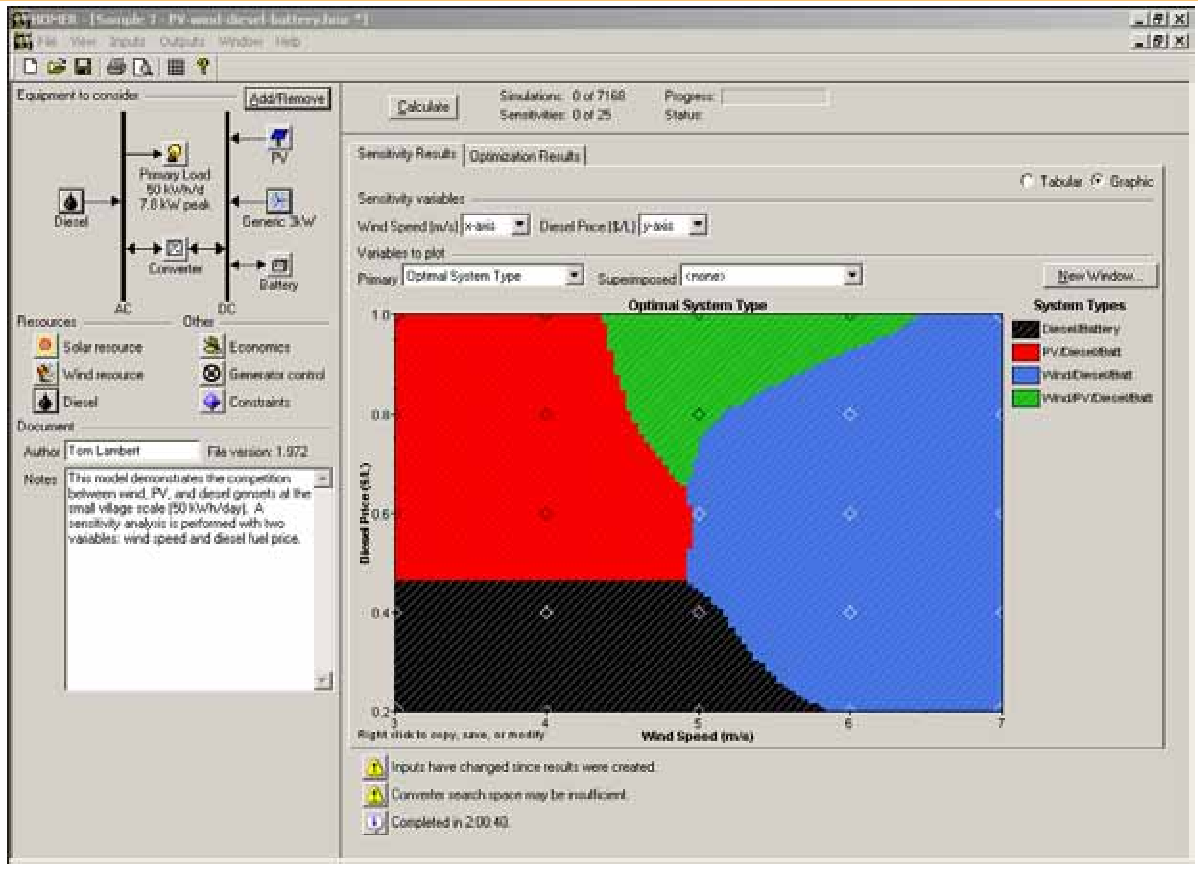
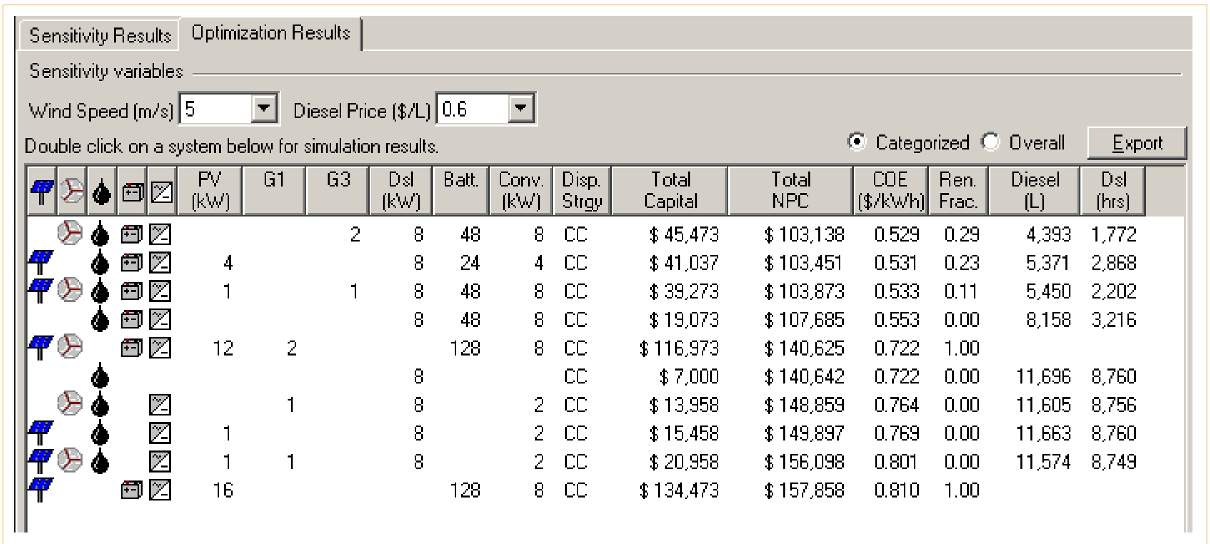


Figure 24. Start-up window of HOMER

Load, component and resource windows are available to enter, import or synthesize information on electric demand, component capacity, costs and resource availability. Optimization and sensitivity windows allow to enter and change values.

HOMER displays simulation, optimization, and sensitivity results in tables and graphs. The tables and graphs can be exported to other software or used in a spreadsheet, reports and presentations. Figure 25 shows a sample output of a sensitivity analysis performed with HOMER.



PV (kW)	G1	G3	Dsl (kW)	Batt.	Conv. (kW)	Disp. Strgy	Total Capital	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Dsl (hrs)
		2	8	48	8	CC	$ 45,473	$ 103,138	0.529	0.29	4,393	1,772
4			8	24	4	CC	$ 41,037	$ 103,451	0.531	0.23	5,371	2,868
1		1	8	48	8	CC	$ 39,273	$ 103,873	0.533	0.11	5,450	2,202
			8	48	8	CC	$ 19,073	$ 107,685	0.553	0.00	8,158	3,216
12	2			128	8	CC	$ 116,973	$ 140,625	0.722	1.00		
			8			CC	$ 7,000	$ 140,642	0.722	0.00	11,696	8,760
	1		8		2	CC	$ 13,958	$ 148,859	0.764	0.00	11,605	8,756
1			8		2	CC	$ 15,458	$ 149,897	0.769	0.00	11,663	8,760
1	1		8		2	CC	$ 20,958	$ 156,098	0.801	0.00	11,574	8,749
16				128	8	CC	$ 134,473	$ 157,858	0.810	1.00		

Figure 25. Sensitivity results from HOMER

If a household is located within a village, another software named ViPor can be used to determine which types of mini-grids can be constructed in the village. ViPor (developed by the NREL-USA, www.vipor.software.informer.com) determines which consumers should be connected to a mini-grid and which premises should better be supplied by stand-alone power systems to ensure the most efficient operation.

The following methods are recommended:

- ☐ Chronological simulation and optimization of a project over the entire project life cycle
- ☐ Modeling technical and economic options
- ☐ Comparison of cost and feasibility of different configurations
- ☐ Sensitivity analysis of levelized cost of electricity (LCOE)
- ☐ Sensitivity analysis of uncertain factors such as fuel prices, life span of components, O&M costs, interest rates

IV.3.2 Performance modeling

A useful web-based PV hybrid design tool to model the technical performance of a hybrid solution is provided by the inverter manufacturer SMA Solar Technology AG. Without downloading the software, plant planners and installers can take advantage of the complete and improved functions of the proven design software.

For a more concrete technical performance-based simulation, the PV hybrid web tool generates and proposes marketable solutions as an alternative for pure diesel-operated grids. A simulation with storage technology is possible with the software tool SMA Off-Grid Configurator.[4]

The software tool shows the integration of a higher level of PV without a storage unit, while maintaining system reliability and keeping costs down. It shows how a higher portion of PV penetration, reliability and cost interact. The modeling of an electricity system starts with a fossil-fueled system, to which a PV system is adapted. Key model outputs are reliability, costs and the return of investment. Furthermore, it is displayed how increased use of PV can affect the overall costs. The tool can be accessed at http://www.sunnydesignweb.com (see Figure 26).

4 http://www.sma-america.com/en_US/products/software/sma-off-grid-configurator.html

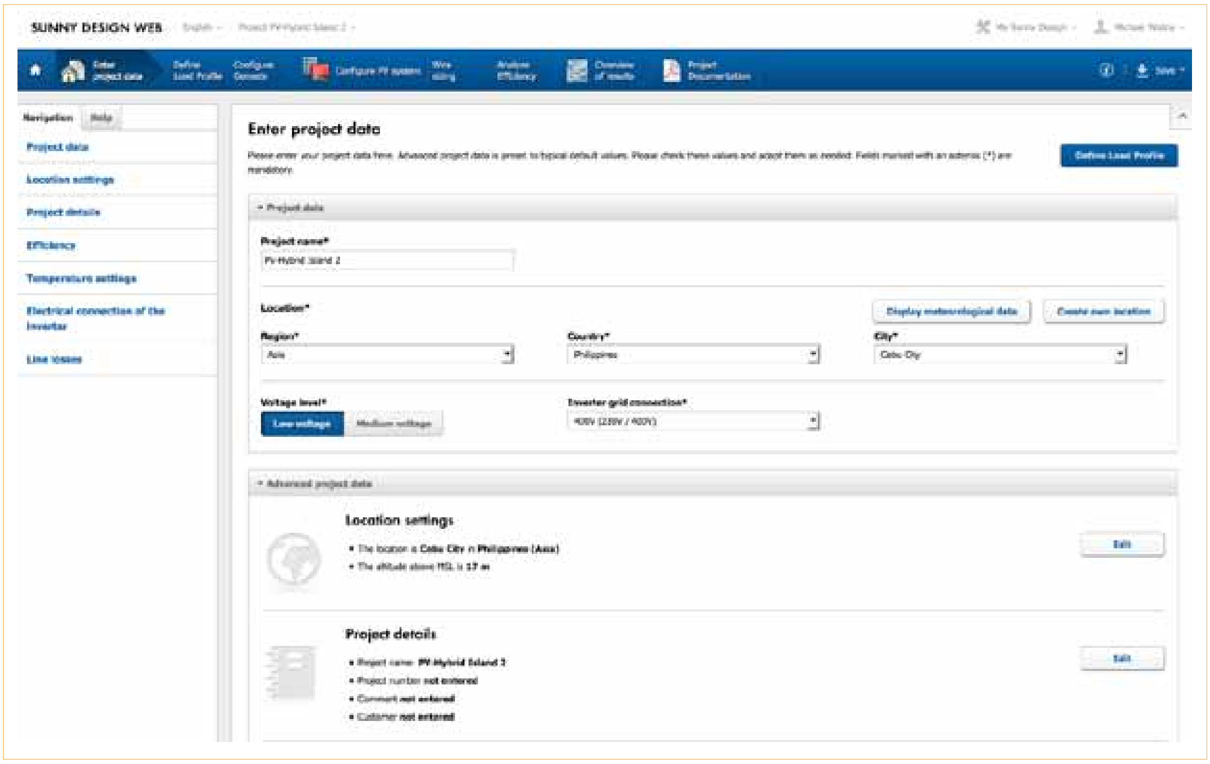


Figure 26. Start-up window of a PV hybrid web design tool
Source: SMA

Beside the data on project location, temperature, voltage level (low or medium voltage grid), type of grid connection, line losses, wiring size and electrical connection of the PV inverter, the economical input data, load profile, genset and PV plant configuration are of importance:

Key economical input data:

- OpEx PV as a percentage of CapEx/year
- True fuel costs
- Annual increase in fuel costs
- Analysis period of economic viability
- Specific investment costs of the PV system
- Inverter's share of the PV system investment cost
- Equity ratio
- Debt ratio
- Interest rate
- Credit period
- Cash flow discount rate

Key load profile data input:

- Industry loads
- Commercial load
- Create or load own load profile
- Average annual energy consumption
- Average displacement power factor cos φ of the loads
- Average daily profile of energy consumption by season

Key generator input data:

- Apparent power
- Fuel consumption at nominal power
- Efficiency at nominal power
- Minimum utilization of the genset, load factor
- Expected PV minimum power with no clouds

Useful information about the different load characteristics can either be chosen as default value from the tool or be created and loaded using own definitions. The configuration of the genset or of the units is of relevance for the simulation. The minimum power of the gensets, adjusted for the load, takes into account an additional power reserve that can be provided by the gensets. A load-related minimum power of 110% means a power reserve of 10%. The minimum load factor of 40% ensures the efficient operation of the generator and avoids increased maintenance efforts and reduction of generator lifetime.

The following methods are recommended:

- ☐ Collection and evaluation of meteorological input data for the project location, or for another location close by
- ☐ Modeling technical and economic options
- ☐ Sensitivity analysis of uncertain factors such as fuel prices, PV investment, O&M costs, interest rates, debt ratio
- ☐ Assessment of the return of investment
- ☐ Determination of levelized cost of electricity (LCOE) with sensitivity analysis

IV.3.3 Levelized costs of electricity (LCOE)

Levelized costs of electricity (LCOE) are the total average cost per unit of the total electricity generated by a specific system its lifetime. It is a systematic economic cost assessment including all costs occurring over the lifetime of the system: initial investment, operations and maintenance, cost of fuel, cost of capital and replacement cost of components (NREL 2013). Table 5 shows the LCOE for different system configurations for conventional and renewable sources, and Figure 27 shows the LCOE comparison of various electrification options.

Table 5. Sensitivity analysis for different hybrid configurations

	Genset Capacity	RET Capacity	RE Share	LCOE* (US$/kWh)	Break-even point
100% diesel	30 KVA	-	0%	0.538	-
Hybrid PV	20 KVA	60 kW	93%	0.456	12.7 years
Hybrid Small Wind	20 KVA	60 kW	83%	0.451	11.2 years
Hybrid PV-Small Wind	10 KVA	PV - 35 kW SW - 20 kW	91%	0.420	8.7 years
Hybrid Small Hydro	10 KVA	26.8 kW	97%	0.219	1.5 years

Source: ARE, Brussels

Nowadays, for most sites, renewable energy solutions have a lower levelized cost of electricity than diesel generators (for current LCOE cost data of renewable energy; see: REN21 2014).

The following method is recommended:

- ☐ Estimation of true cost of generation rate per kWh for the entire hybrid system

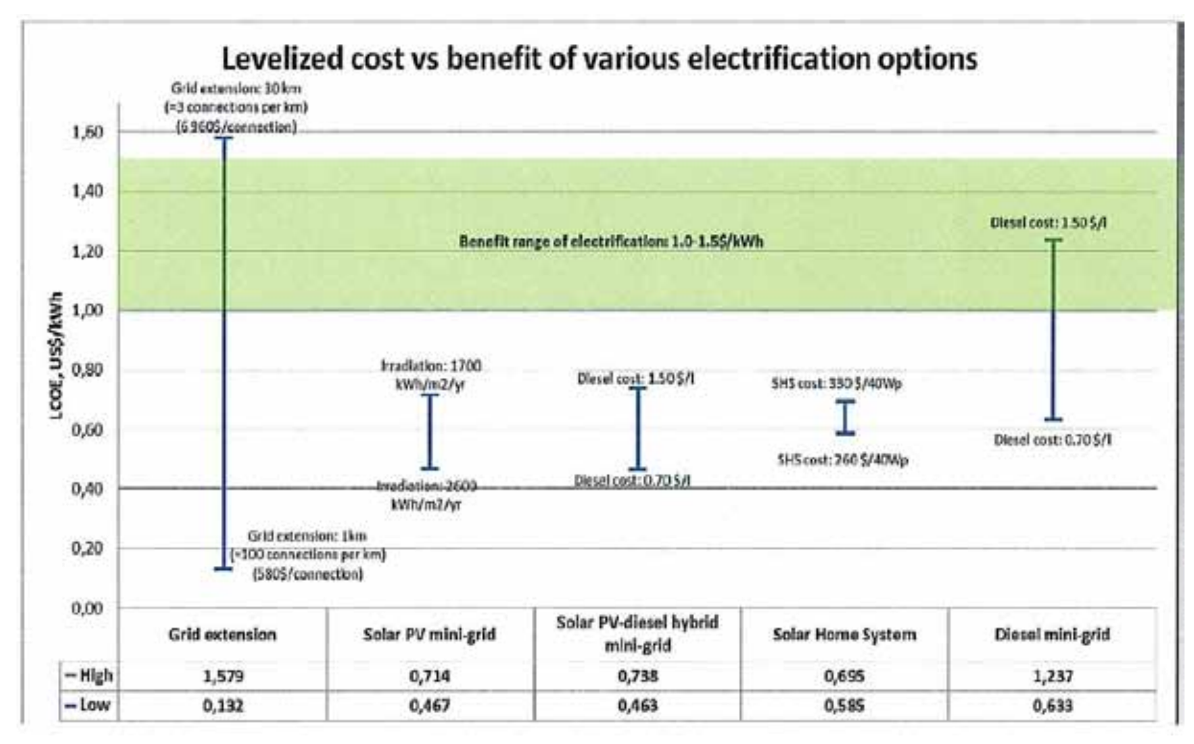


Figure 27. Comparing the levelized cost of various electrification options
Source: Norplan (2012)

IV.4 Bankable project documentation

Key aspects of bankable PV-diesel hybrid projects

Already today, there is a significant cost advantage of PV-diesel hybrid systems compared to conventional diesel gensets. There are two macroeconomic trends to be considered: first, prices for PV system technology have dropped by more than 50% within the last 3 years. Second, the fuel cost for diesel gensets are steadily rising (see Figure 28). In numerous countries in the sunbelt regions of the earth, levelized costs for photovoltaic energy are already significantly lower than energy from diesel engines. The integration of storage technologies are well proven, and new storage technologies with advantages in energy density and life span are expected to become commercially available in the future. The storage increases the security of power supply and reduces the overall cost of energy of SPV–diesel hybrid systems.

The integration of a photovoltaic plant could be beneficial for an investor if there is a significant amount of base load gensets to leverage high fuel-saving potential.

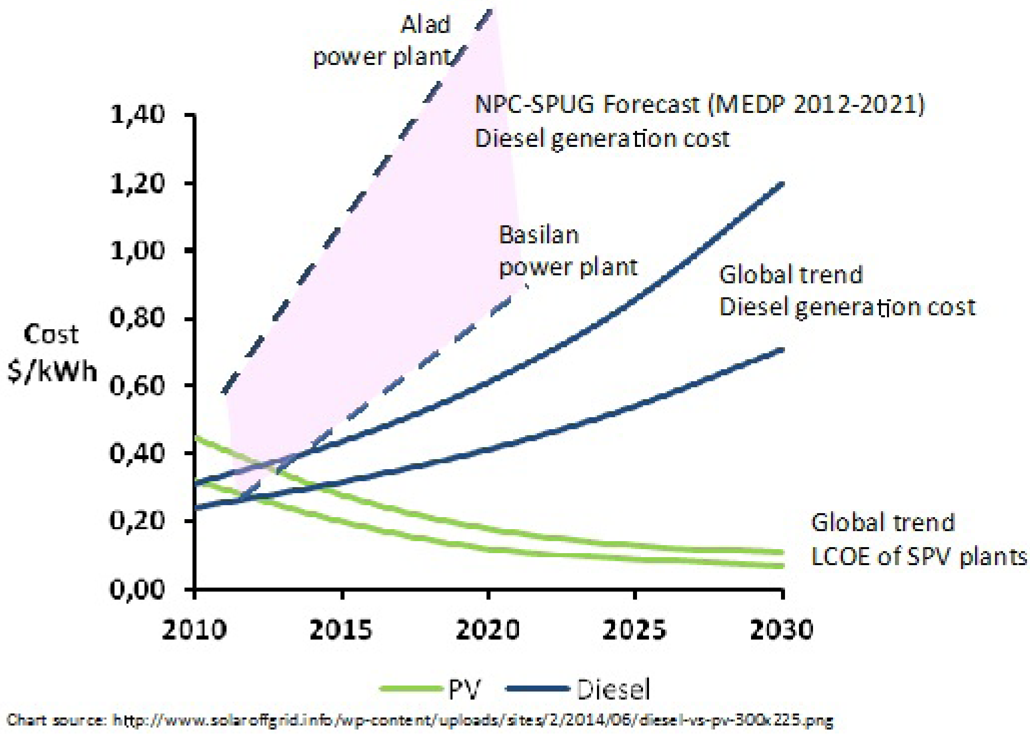


Figure 28. PV generation cost today and trends in diesel generation costs
Source: Integration

The combination of diesel and photovoltaic ensures consumers an attractive and reliable energy supply with low maintenance and operating costs. They have a modular design, are scalable and can be adjusted according to current energy demands. This means that despite high, initial up-front costs for a PV system and an optional storage, PV systems can reduce the local TCGR and FCRR as well as dependence from imports of fossil fuels, while minimizing the impact of the local market on energy prices in the Philippines within the next years. This results in savings for UCME subsidies and is beneficial for all energy consumers.

The analysis in Figure 29 shows when the effective diesel costs exceed 1 USD/per liter for the operator and the local solar irradiation conditions allow the use of PV (especially economically viable with PV yields above 1,500 kWh/kWp).

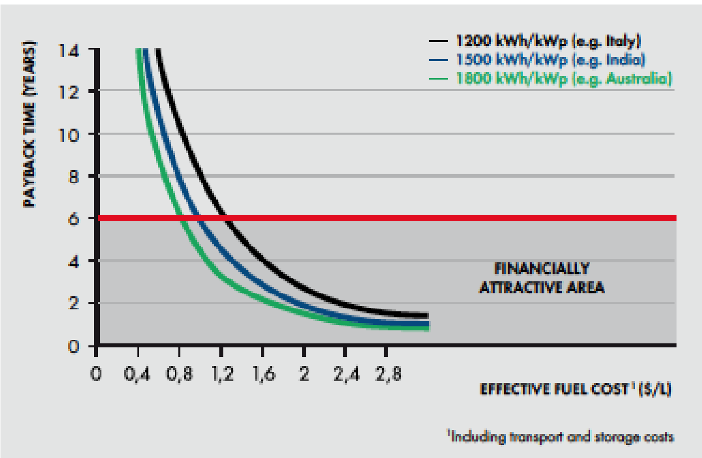


Figure 29. Financially attractive area for PV-diesel operation in remote areas
Source: SMA

IV.4.1 Investment costs

Rural electrification agencies as well as many operators of small diesel mini-grids are aware that hybridization can help provide better service and reduce production costs. The costs of solar modules have been steadily decreasing, and this trend favors a broad deployment of PV hybrid systems. A project developer may consider, as a rule of thumb, that in case a storage is integrated, one-third of the budget for the capital cost will be dedicated to the PV array itself.

However, one also has to consider that a hybrid system can have many other components, besides the PV array. The cost of the storage component is significant (see Figure 30). The replacement of a used battery storage after 6–9 years, with a cost roughly equivalent to 20% of the available budget, should be included in the cumulated expenses.

In addition, the battery charge control feature of the battery inverters for hybrid systems makes them more expensive than grid-connected inverters. This makes a significant cost difference compared to simple PV power plants connected to the grid. Data collected on recent systems installed in Africa and Asia show that the typical real installed cost of a complete PV/battery diesel hybrid system is in the range of 5,500 to 9,000 EUR/kWp with variations according to system size and location. Diesel gensets are widespread in developing countries, and products and services are readily available. On the contrary, solar PV distributors and installers with a significant market base and experience are far fewer, implying generally higher costs with some variations according to the country.

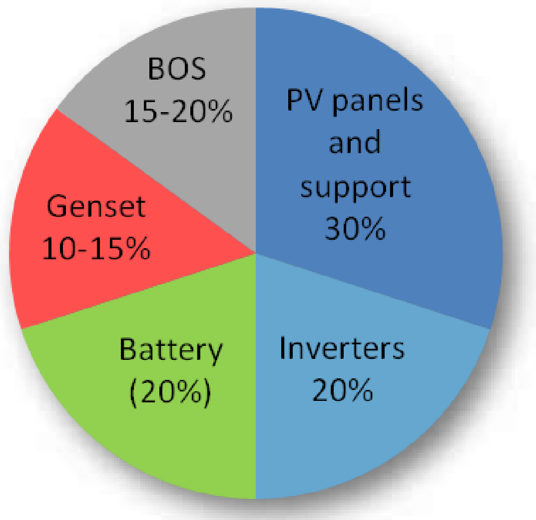


Figure 30. Typical cost structure of a PV–diesel hybrid system
Source: IEA PVPS Task 9

Despite variations due to system size and location, the cost structure of a PV-diesel hybrid system typically follows the breakdown shown in Figure 30. The private investors can contribute to the optimization of the investment cost.

To be taken into consideration:

- ☐ Include storage replacement during project lifetime in the calculations
- ☐ Due to small project volume and uncertain framework conditions, transaction costs may be relatively high
- ☐ Fiscal incentives should be taken into consideration for the assessment of economic feasibility; probable delays in availing these incentives should be taken into consideration as well
- ☐ Deviations from the optimum technical systems design may be reasonable if they help in reducing the investment cost and the resulting LCOE substantially
- ☐ Establishing SPV installations on commercial land or on existing roofs may help in avoiding delays in project development due to land use or IP issues

IV.4.2 Operation and maintenance costs

As a basic minimum, the project should generate a cash flow sufficient to cover O&M costs and be built around existing local businesses or public institutions in order to increase critical mass, revenue, and local involvement. Because it is sometimes difficult and costly to retain skilled personnel in a remote village, an operator should consider operating valuably on a bundle of hybrid systems in a given area to reduce operations and maintenance costs.

O&M expenses, such as those associated with maintenance activities, are less predictable and can be influenced by: system size and location (e.g. water availability, weather conditions, travel distances), plant architecture and ease of site access (e.g. ground mount vs. roof mount), as well as the extent that meters and inverters are deployed at a site. As a result, estimated and actual O&M expenses can markedly differ. Table 6 gives an indication for O&M costs for solar PV without storage technology.

Table 6. O&M costs of solar PV without storage technology

Table 5 – Solar PV O&M Costs

System Size	$/kW	% of O&M Relative to "All In" Cost
1 MW and Less	$6/kW - $27/kW	<1% to 5%

Notes:
Figures represent a range of anecdotal data and comprise costs for handling O&M of distributed PV assets via utility in-house and outsourced approaches. Data largely indicates direct O&M costs and doesn't include variables such as roof leases and utility management oversight of labor.
Sources: EPRI O&M interview sample, 2010

Source: EPRC (2010)

Access to service and spare parts is very critical in the case of electronic components. In the case of failure of one component, the necessary diagnosis and replacement is often an issue. In addition to initial training sessions, it is required that RE developers and manufacturers and/or local distributors provide an adequate after-sales service for the components. The long-term continuity of the after-sales service is important.

To be taken into consideration:

- ☐ Ensure sufficient cash flow over the entire project life cycle
- ☐ Involve local capacities in O&M
- ☐ Employ and train local staff for the operation of all components of the SPV hybrid plant
- ☐ Establish lean and efficient billing and collection system
- ☐ Ensure a realistic assessment of O&M cost for SPV arrays, inverters, converters and storage, and avoid overestimations of the relevant costs
- ☐ Implement an adapted planned maintenance concept in order to avoid system outages and to reduce unplanned repair costs

IV.4.3 Cash flow

Hybrid mini-grids are still perceived as a high-risk and low-return investment. Local financial institutions are a natural debt provider due to their ability to understand market dynamics and perform due diligence. However, these institutions have limited experience in cash flow analysis and rely on collateral for corporate lending. For developers' and lender's credits, analysis must be based on projected cash flows.

The following methods are recommended:

- ☐ Comprehensive cash flow analysis has to include all foreseeable cash in- and out-flows over the project lifetime
- ☐ Economic risk assessment and risk mitigation strategy is requested in order to be able to avoid illiquidity and other disturbance of the cash flow

IV.4.4 Internal rate of return

The internal rate of return is a rate of return used in capital budgeting to measure and compare the profitability of the investment. It is recommended to provide a sufficient internal rate of return in the financial concept in order to cover the risks accordingly and to elaborate a comprehensive risk analysis and risk mitigation strategy. This prevents illiquidity and all potential disturbances of the cash flow.

From the point of view of a private investor, providing capital for an investment in a PV option must be attractive. The savings in generation cost (versus the diesel option) should pay back the initial investment in a reasonable time frame and provide a suitable rate of return. To be viable from an economic and financial point of view, and to attract investment, a hybrid system has to be efficient. Environments with low fuel costs or with limited solar resources would make it difficult for such a system to compete with diesel-based power plants.

The following methods are recommended:
- ☐ Preparation of financial concept with sufficient high internal rate of return
- ☐ Elaborate a comprehensive risk analysis and risk mitigation strategy, to avoid illiquidity and all potential disturbances of the cash flow

IV.5 Selection of appropriate market option

Based on the legal background for rural and missionary electrification in the Philippines, two fundamental avenues with further options can be identified for RE developers to provide electricity in rural areas. An overview of the market options for the private sector with RE projects in off-grid areas is given in Figure 31. The NPC-SPUG is the lead agency overseeing and implementing the missionary electrification program. DUs, particularly the ECs, complement the SPUG activities.

Private investors, in the form of NPPs for the SPUG areas or as QTPs for the waived/declared unviable areas, act as market delivery partners of the government in achieving the goal of facilitating access to electricity even in the remotest areas of the country.

Private sector participation (PSP) can be done under two general schemes:
- The **new power producer** (NPP) for NPC-SPUG areas
- The **qualified third party** (QTP) for the unviable remote areas

Figure 31. Options for RE projects in rural and missionary areas
Source: GIZ (2014)

IV.5.1 New power provider (NPP)

A NPP provides the same service as NPC-SPUG. It generates electricity and sells it to a DU for distribution within its franchise area. The NPP is an entity that is financially and technically capable to take over the generation capacity of SPUG in the off-grid areas either by building a new plant or buying the SPUG assets.

A NPP is in general selected through a competitive selection process (CSP) and is qualified to avail of subsidies from the Missionary Electrification Subsidy Fund collected through the UCME. A private investor has either to submit the economically most favorable tender in a CSP, to submit an unsolicited proposal to an EC or to enter into a joint venture with an EC.

Options for NPP to take over the power function of SPUG:

- Competitive selection process (CSP)
- Unsolicited proposal
- Joint venture agreement

IV.5.1.1 The competitive selection process

The competitive selection process is imperative if the NPP wants to claim subsidy, i.e. UCME and probably also the cash incentive for RE projects. This rule can be relaxed if the tariff offered by the NPP under the Power Supply Agreement (PSA) is lower than the existing SAGR and if the NPP would not avail of the subsidy (see Section IV.5.1.2 The unsolicited proposal).

Within the CSP bidding, the NPP has to also submit a time frame when the NPP is expected to phase in its plant operation. The winning NPP will be selected based on the ability to achieve the lowest long-term cost of power and services, environmental compatibility with the local area and most advantageous implementation schedule.

The PSA to be signed by the EC and the NPP can be for a period of up to 15 years. The NPPs are allowed for full cost recovery, and they are also entitled to collect subsidy from UCME.

Essential for the CSP:

- Full cost recovery
- Tendering process
- Contract approval by the Energy Regulatory Commission (ERC)
- Contract period up to 15 years

The cost recovery is based on the TCGR, which is calculated on a per plant basis and again has to be approved by the ERC. Meanwhile, the ECs will collect from its consumers a rate based on the SAGR. If the TCGR is higher than the SAGR, the difference (subsidy) shall be collected from the NPC-SPUG through the UCME. If the NPP puts up a RE project, it is still entitled to get the cash incentive for RE projects in missionary areas.

IV.5.1.2 The unsolicited proposal

The unsolicited proposals are considered a form of competitive bidding if they are properly subjected to a Swiss challenge. The Swiss challenge approach means that following an unsolicited approach, an open bidding process is conducted. If unsuccessful, the original proponent has the option to match the winning bid and win the contract (see Public Private Infrastructure Advisory Facility, Note 6, May 2012).

In this case, the successful NPP also qualifies for availing subsidies from UCME. Otherwise, NPPs concluding a PSA with a DU on the basis of unsolicited proposal would be excluded from availing subsidies from the UCME.

Important steps:

- ☐ Selection of local partner for foreign companies (the partnership will be 60% owned by the Philippine partner)
- ☐ Determination of an appropriate range of NPP services
- ☐ Negotiate an appropriate contractual setting with the DU and NPC-SPUG
- ☐ Develop an appropriate investment strategy

IV.5.2 Qualified third party (QTP)

The QTP is an entity that is financially and technically capable to provide generation and distribution facilities in the unviable or remote areas of the DUs – especially the electric cooperatives.

There is still a big number of unviable areas that can be targeted for QTP operation. After getting the accreditation, the RE developer can select the area it wants to develop, propose it to the DOE and start working on getting the permits and developing the project.

In case that a foreign company wants to be a QTP, it has the option of forming a company together with a local partner that will take a majority control. The RE developer also needs to make sure that it has a good and reliable partner on the ground that can perform the above-mentioned operational steps and has the capability to build the generation facility, the distribution system and the collection from the end users.

The following methods are recommended:

- ☐ Selection of local partner (has to be 60% Philippine-owned company)
- ☐ Develop an integrated business model for both power generation and distribution, including establishment of the grid
- ☐ Determine an appropriate investment strategy

IV.5.3 Joint venture (JV)

A joint venture with ECs is a possible option for the private sector to enter the power market with RE technologies. For this reason, private investors can establish JVs with ECs in the missionary areas. The ECs in general can also enter into a joint venture agreement with private companies and other ECs to jointly develop power projects, invest in auxiliary services and develop projects. The ECs that has entered into joint ventures can apply for technical and financial assistance from NEA – usually to help defray the equity required from the EC.

To be taken into consideration:

- ☐ Willingness of EC to enter into JV with the private sector is the critical issue

IV.5.4 Incentives

The promotion of RE in power generation is enhanced by the RE Act that aims to accelerate the exploration and development of the country's RE resources by providing fiscal and non-fiscal incentives to private sector investors and equipment manufacturers/ suppliers.

Regardless whether the option taken by the developer is NPP, JV or QTP, to avail of the incentives and privileges (please see below) provided under the RE Act, RE developers have to first register with the DOE and apply for a RE service contract (RESC).

Incentives in the Philippines:

- Income tax holiday (ITH) for the first 7 years of commercial operations
- Duty-free importation
- Reduced (1.5%) realty tax rates on equipment and machinery
- Net operating loss carry-over (NOLCO) for the first 3 years of commercial operations
- Reduced (10%) corporate tax rate after the expiration of the ITH
- Accelerated depreciation
- No (0%) value-added tax
- Tax exemption on sale of carbon credits
- Tax credit on domestic capital equipment and services related to the installation of equipment and machinery
- Exemption from paying universal charge for power generated for own use
- RE generation-based cash incentive
- Can avail of UCME subsidy

With regard to the non-fiscal incentives (especially FIT and RPS), the guidelines, rules and regulations for their implementation in rural electrification (off-grid and unviable areas) are being deliberated by the technical working group chaired by the NPC. Due to the differences in conditions between the off-grid/unviable areas and the on-grid areas, different rules and procedures for the non-fiscal incentives will be applied.

Cash generation-based incentive per kilowatt hour generated from RE[5]	**= (TCGR[6] – SAGR[7]) * 50%**

Note: For QTPs, FCRR[8] and SARR[9] shall replace the TCGR and SAGR in the formula.[10]

Formula 1. Formula for cash generation-based incentive
Source: GIZ

In the Philippines, the average retail electricity price for consumers is approximately 10.19 PHP/kWh. However, diesel generation costs in remote areas are much higher. Most of these areas receive their power from diesel generation that needs to be heavily subsidized due to high true power generation cost. The average true cost generation rate in 14 NPC-SPUG first wave areas (8.42 PHP/kWh) is almost 50% higher compared to the subsidized generation rate (5.645 PHP/kWh).

There are two different types of subsidies to be taken into consideration. The subsidy from UCME covers the difference between TCGR and SAGR in off-grid power generation, and the difference between the FCRR and the SARR in the unviable or QTP areas. The cash generation-based incentive provided on the basis of the RE Act amounts to 50% of the difference between TCGR and SAGR for each kWh produced from RE sources. The cash incentive will also be sourced from the UCME.

The operators of solar PV–diesel hybrid who want to avail of subsidies through the UCME and/or the cash generation-based incentive have to ensure that the electricity generated and supplied from different components of their hybrid system is separately metered and verified. This is a requirement for determining the applicable cash generation-based incentive as only generation from the RE source would be entitled to this incentive.

The ERC recognizes the difficulty and expense of locating RE generation projects in missionary areas. Hence, the "ERC Amended Guidelines for the Setting of Generation Rates and Subsidies for Missionary Areas" (ERC Resolution 21, s. 2011), Article II, Section 3, states that in cases where the NPP utilizes renewable energy or where the NPP is a RE developer, the ERC may use the approved FIT rate for power generation from the same source in on-grid areas as a benchmark for the reasonability of the price for power generated from RE sources in missionary areas.

In a declared remote or unviable area, a QTP charges ERC-approved rates that allow for the full cost recovery of both the costs of generation facilities and the costs of the associated delivery systems built to serve these remote or unviable areas.
The QTP framework provides the FCRR and SARR to be recoverable from the end users and/or the UCME. If the SARR is lower than the FCRR, the QTP is entitled to recover the difference from the UCME.

Important:

- ☐ Registration with the DOE and enter into a RE service contract (RESC) with the DOE in order to qualify for the availing of fiscal and other incentives.

5 Equivalent to 50% of the universal charge for power needed to service missionary areas where it operates the same.
6 TCGR refers to the reasonable cost of generation for the particular SPUG area where the RE developer operates.
7 SAGR refers to the generation rates, expressed in peso per kilowatt hour, that the ERC has approved for an EC to charge its customers for electricity generation services.
8 FCRR refers to the rate, expressed in peso per kilowatt hour, that recovers the full efficient costs of providing electricity service sufficient to enable the QTP to operate viably.
9 Subsidized/approved retail rate (SARR) refers to the rate, expressed in peso per kilowatt hour, that the ERC has determined to be the maximum that an end user in a declared unviable area shall pay for the electricity service provided by a QTP.
10 ERC Resolution 7, s. 2014.

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Appendices

Appendix 1. Fact Sheet - Carabao Island

GEOGRAPHIC INFORMATION

	
Geographic Location	Carabao island is located between Tablas Island and the resort island of Boracay. Coordinates: between 12.0^{0} and 12.10^{0} latitude and between 121.50^{0} and 122.0^{0} longitude.
Distances	4.31 nautical miles southwest of Sta. Fe, Romblon; 5.39 nautical miles from the northeastern tip of Panay Island; and 35.05 nautical miles from the Provincial Capital in Romblon, Romblon.
Land Area	28.90 square kilometers
Topography	The terrain is characterized by lowlands in the northern and eastern sections and by rolling hills in the central and the south central portion. 67% of the land area generally hilly.
Accessibility	Carabao Island can be reached by boats from Tablas Island, Caticlan and Boracay Island. Regular trips are available from the Caticlan (30-40 minutes ride) and Boracay Island (20-30 minutes ride). These trips are scheduled only during daytime.
Climate	No pronounced season. Relatively wet from May to October, dry for the rest of the year. Based on PAGASA's climate classification the island is under the Type III.

ADMINISTRATIVE INFORMATION

Political Classification	Island municipality
Name of Municipality	San Jose, Romblon, Region IV-B MIMAROPA
Barangays	5 namely Busay, Combot, Lanas, Pinamihagan and Poblacion.
Population	10,294 (based on 2010 Census)
Number of Households	1,752
Annual population growth rate	1.9%
Population density	378 persons per square kilometer
Average household size	6 (2010 Census)

TRANSPORTATION, COMMUNICATION & OTHER INFRASTRUCTURES

Road network	Primarily made of single lane concrete roads and dirt roads. Of the islands' 51.33 kilometres road network, only about 30% paved to a limited extent. Two-lane concrete roads are found in the poblacion while two-lane dirt roads are spread along the coastline
Mode of transportation	Public transportation is provided by mostly by motorcycles (see picture at the right) which act as the island taxis. Fare cost will vary on the distance.
Communication facilities	Cell phone signals are weak because the primary cell sites are located in the island of Boracay
Water and Sanitation	Sixty-One percent (61%) of the island's water supply is mostly shared community water system primarily composed of a common water source (usually a spring) and water piped to the houses (8.5%). No centralized sewerage treatment, only septic tanks per household.
Educational Facilities	One (1) secondary school and eight (8) elementary schools with a total of 66 classrooms in 36 buildings.
Health facilities	One municipal hospital with 25 beds, 5 barangay health centers

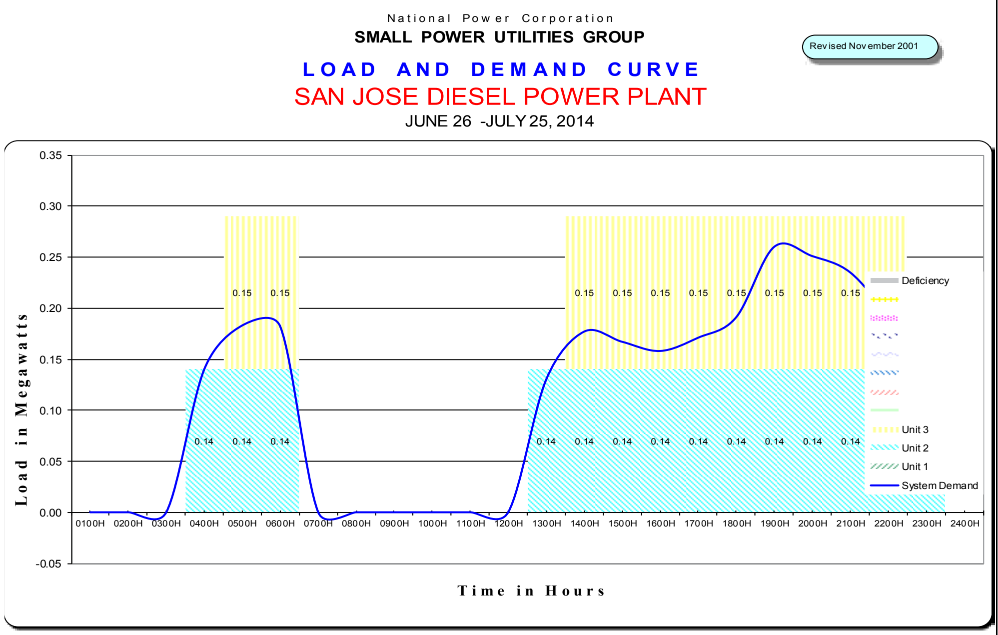
ECONOMIC INFORMATION

Primary economic activities	Agriculture, fishing, forestry and tourism
Main agricultural product	Coconut
Ave. Annual Household Income	P121,060.00 (2009 data for the province)
Ave. Annual Household Expenses	P96,117.00 (2009 data for the province)

ENERGY SUPPLY & UTLIZATION

Distribution Utility	Tablas Island Electric Cooperative (TIELCO)
Power Generation Entity	National Power Corporation – Small Power Utilities Group (NPC-SPUG)
Power Plant Capacity	two (2) operating generating sets – 228kW and 163kW
Year Plant Operation Started	May 1997
Power Plant operation	14 hours: 4am to 6am and 3:30pm to 11pm
Load Demand	Peak load is 260kw, minimum is 110kw

Load and Demand Curve (Source: NPC)



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TOTAL CAPABILITY																							
0.000	0.000	0.000	0.140	0.290	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.140	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.290	0.140	0.000
SYSTEM DEMAND																							
0.000	0.000	0.000	0.140	0.183	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.177	0.167	0.158	0.171	0.191	0.260	0.251	0.235	0.192	0.140	
RESERVED / (DEFICIENCY)																							
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Fuel Consumption	SPUG Diesel consumption is 3.2 liters/kWh which translate into PhP21,000.00 per month.
True Cost Generation Rate	PHP 14-16/kWhr
Power Supply Service Quality	Due to old age of the units, particularly the 163kw, breakdowns are normal occurrences and lack of replacement parts worsened the situations. Furthermore, fuel supply problem affects the plant operation especially during poor weather conditions. Power failures become the norm rather than the exception. Poor power quality (i.e., low voltages and unstable frequencies) can be deduced from users who complaint of damaged appliances or

	equipment. All those interviewed during the field mission by the team claimed that they have damaged appliances (usually televisions and refrigerators) due to power instability
Power Plant Upgrading Plans	NPC-SPUG plans to replace the units with three (3) brand new 250kw generating sets in 2015. With these new units, the plan is to increase operating hours up to 16 hours.
Present Total Customers	1,457 (50% of households plus commercial loads)
Average monthly energy sales	64,570 kWh
Electricity Rate (Subsidized/approved Generation Rate [SAGR] + Distribution Charges + VAT)	PHP 13.018/ kWh (SAGR: PHP 6.84)
Collection System	The cooperative directly bills and collects form big customers such as the local government offices, schools, resorts, etc. On the other hand, the BAPAs or Barangay Power Associations (organized by the electric cooperative) bills and collects smaller consumers, mostly residences. There are 28 BAPAs in the island.
Collection Efficiency	90%.
Local cost of diesel	PHP 50/liter
Electricity Demand Forecast	a. Increasing population. With a growth of 1.97%, the island's population is estimated at 11,500 by year 2018. b. On-going construction of new buildings/facilities. There are at least three development projects in the island: the Boracay View Resorts (500kW load); the Sky City Leisure Resort; and Cucuman Integrated Farm (13kW). c. An existing supressed demand for household electricity as manifested by the use of alternative electricity/lighting-producing equipment/devices such generating sets, PV systems and kerosene lamps; d. A supressed demand as expressed by businessmen (i.e., stores owners and resort operators) who wish to improve their services and products; and e. An expressed desire by the locals for better and continuous electrical supply

Appendix 2. Fact Sheet - Isla Gigantes Norte

GEOGRAPHIC INFORMATION

Geographic Location	Located in the Visayans Sea at 11.60°N 123.34°E.
Distances	Roughly 14 nautical miles north of Panay Island
Land Area	Approximately 9.7 square kilometers
Topography	Hilly with flat and narrow coastal areas. The highest point in the island is 213 metres (699 ft.).
Accessibility	The island can only be reached by boats. Boats can be chartered from either the municipality of Estancia (2 hours travel) or Carles (1 hour travel). Public ferries leave daily from Estancia Port to Isla Gigantes Norte (P100/person). Private boats can also be chartered to reach the islands at a cost of P3,000.00.
Climate	The climate in Gigantes Islands can be categorized as type III, according to the Philippine Atmospheric Geophysical and Astronomical Services (PAGASA) with seasons not very pronounced; relatively dry from November to April and wet during the rest of the year.

ADMINISTRATIVE INFORMATION

Political Classification	Island barangays
Name of Municipality	Carles, Ilolio, Region VI - Western Visayas
Barangays	Asluman and Granada
Population	5,894 (Bgy. Asluman - 2,849 and Bgy. Granada - 3,045)
Number of Households	1,155
Annual population growth rate	1.51%
Population density	602 per square kilometre (based on provincial average)
Main population center	There are two main population centers in the island - Poblacion Asluman and Poblacion Asluman. Roughly 55% of the population of the island are located in these two centers. These are also the center of the political, economic, health and educational activities.
Average household size	5

TRANSPORTATION, COMMUNICATION & OTHER INFRASTRUCTURES

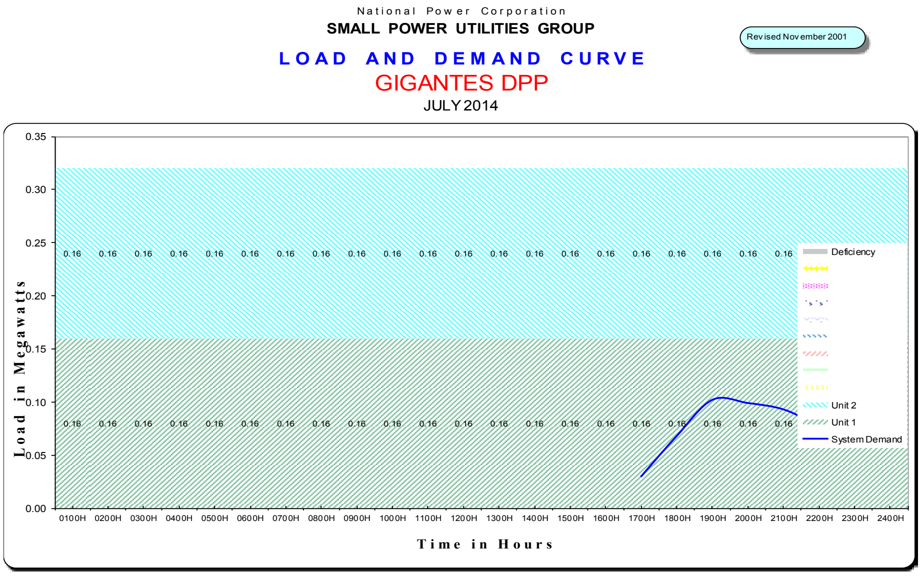
Road network	The road system is composed of barangay roads that are all earth-filled and unpaved.
Mode of transportation	Motorcycle is the main form of transportation. There are no 4-wheeled vehicles in the island. The minimum fare is P10/person and will increase depending on the distance.
Communication facilities	Mobile network signal in the island is quite weak. Mobile signals originate at cell sites located at main island of Panay.
Water and Sanitation	Water supply comes from springs that are piped by gravity to the houses. Some enterprising local residents built small water reservoir (e.g. tanks) located near the water source and piped down the water to the houses for a fee. Fresh water is abundant providing a 24-hour supply to the communities. The island does not have a sewerage system, houses usually have their own septic tanks.
Educational Facilities	1 Elementary School, 1 High School
Health facilities	1 Barangay Health Center

ECONOMIC INFORMATION

Primary economic activities	Fishing (95% of the households are engaged in fishing) and tourism
Main agri/aqua cultural product	Scallops, crab and dried fish (as seen in the picture at the right).There are two ice plants in the island that also acts as buying stations of fish and other marine products. These ice plants are owned by out-of-town based companies.
Ave. Annual Household Income	P187,023.00 (2009 Municipal data for all barangays)
Ave. Annual Household Expenses	P139,086.00 (2009 Municipal data for all barangays)

ENERGY SUPPLY & UTLIZATION

Distribution Utility	Iloilo Electric Cooperative III (ILECO III)
Power Generation Entity	NPC-SPUG
Power Plant Capacity	SPUG has three (3) generating sets – two (2) 163kW and one (1) 140kW.

<table>
<tr><td>Year Plant Operation Started</td><td>1997</td></tr>
<tr><td>Power Plant operating hours</td><td>8 hours (3:30pm and ends at 11pm)</td></tr>
<tr><td>Load Demand</td><td>Before Typhoon Haiyan (November 2014), the normal maximum peak load is 120kw up to 140kW. Present maximum peak load is only 100kW.</td></tr>
<tr><td>Load and Demand Curve (Source NPC)</td><td>


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<tr><td colspan="24">TOTAL CAPABILITY</td></tr>
<tr><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td></tr>
<tr><td colspan="24">SYSTEM DEMAND</td></tr>
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<tr><td colspan="24">RESERVED / (DEFICIENCY)</td></tr>
<tr><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.320</td><td>0.290</td><td>0.252</td><td>0.218</td><td>0.221</td><td>0.227</td><td>0.242</td><td>0.255</td><td>0.320</td></tr>
</table>
</td></tr>
<tr><td>Fuel Consumption</td><td>The diesel consumption before Typhoon Haiyan is 230 litres for every 8 hours of operation. After the typhoon, the diesel consumption went down to 170 litres for the same period of operation which translate into PhP21,000.00 per month.</td></tr>
<tr><td>True Cost Generation Rate</td><td></td></tr>
<tr><td>Power Supply Service Quality</td><td>ILECO III does not maintain an office or service center in the island. ILECO III staff would travel from the mainland to perform the necessary works such as billing and collection, maintenance and repair of the distribution lines. For minor problems with the distribution lines, the NPC-SPUG staff would normally work on it. However, for major problems, NPC has to call ILECO III who, in turn, will send a team to do the repair. Since most of the power failures experienced in the island are due to distribution line faults, power interruptions are normally long since it will take time for the repair team to go to the island.

Based on observations most of distribution lines are new since the old lines damaged by Typhoon Haiyan in November 2013 were recently replaced.</td></tr>
<tr><td>Power Plant Upgrading Plans</td><td>NPC plans to replace one of the units with a new 160kW generating set by 2015.</td></tr>
<tr><td>Present Total Customers</td><td>346 households (30% of total households)</td></tr>
</table>

Average monthly energy sales	-
Electricity Rate (Subsidized/approved Generation Rate [SAGR] + Distribution charges + VAT)	PHP 11.44616/kWhr (SAGR: PHP 6.59)
Collection System	ILECO III directly bills and collects its consumer. The electric cooperative tried to establish BAPAs (Barangay Power Association) but it failed.
Collection Efficiency	100%
Local cost of diesel	PHP 50/liter
Electricity Demand Forecast	a. Increasing population. With a growth of 1.51%, the island's population is estimated at 6,850 by year 2020; b. Recovery from Typhoon Haiyan. The daily normal peak loads before and after the typhoon was 120kW and 100kW, respectively. As the island continue to recovery, the demand for electricity will increase; c. An existing supressed demand for electricity as manifested by the use of alternative electricity/lighting-producing equipment/devices such generating sets, PV systems and kerosene lamps; d. A supressed demand expressed by businessmen (i.e., stores owners, water distributor, welding shops operators and resort operators) who wish to improve their services and products; and e. An expressed desire by the locals for better and continuous electrical supply.

Appendix 3. Fact Sheet - San Vicente, Palawan

GEOGRAPHIC INFORMATION

Geographic Location	San Vicente is located in the northwest of Palawan's mainland, bounded by the West Philippine Sea in the West, the municipality of Taytay in the north, municipality of Roxas in the East and City of Puerto Princesa in the Southwest.
Distances	The town is 186 kilometers north from Puerto Princesa City, the capital of the Province of Palawan
Land Area	It occupies a total land area of 165,797.6525 hectares with a forest area of 82,080.09 hectares and 22 identified islands and islets within its municipal boundaries.
Topography	The terrain is characterized by narrow coastal plains and coves along the western part of the town. On the eastern sections are rolling hills and mountains.
Accessibility	The town can be reached by land from Puerto Princesa City which has an operating international airport. Travel time is approximately 3-1/2 hours. In the future, direct flights to San Vicente from Manila will be possible once the airport being built in the town starts operating.
Climate	San Vicente's dry season begins in December, lasting until the month of May while the onset of the wet or rainy season is in June, usually drying up again in November. North-eastern winds, the "amihan", prevail from November to May. Rough coastal waters characterize the season of "habagat", or the south-western winds.

ADMINISTRATIVE INFORMATION

Political Classification	Classified as a first class municipality
Name of Municipality	San Jose, Palawan, Region IV-B MIMAROPA
Barangays	The municipality has jurisdiction over ten (10) barangays: Alimanguan, Binga, Caruray, Kemdeng, New Agutaya, New Canipo, Poblacion, Port Barton, San Isidro, and Sto. Nino..
Population	30,919 (2010 Census)
Number of Households	6,460 (2010 Census)
Annual population growth rate	6.0% (2010 Census)
Population density	21 persons per square kilometer (2010 Census)
Average household size	5 (2010 Census)

TRANSPORTATION, COMMUNICATION & OTHER INFRASTRUCTURES

Road network	Roads (two-lane concrete roads) and other infrastructure support facilities are now on its implementation process funded by the National Government. However, most of these road improvements are located on the Poblacion and its nearby barangays and the access roads from the main provincial highway to Port Barton and the Poblacion. A provincial road that runs along the coast, connects all the barangays of San Vicente, however, this road is in a dilapidated condition.
Mode of transportation	San Vicente is accessible by bus & shuttle vans, from several points such as directly from Puerto Princesa City, or via the municipality of Roxas. Within San Vicente, tricycles, motorcycles, and outrigger boats are the usual mode of transportation.
Communication facilities	Cell phone signals are relatively good since major telecomunication companies has installed cell sites in several barangays in the town(i.e., Poblacion, Alimanguan, Binga, Port Barton and Caruray). Cable TV and Internet services are also available in the barangays of Poblacion, Alimanguan and Port Barton.
Water and Sanitation	The Municipality's water supply is mostly shared community water system primarily composed of a common water source (usually a spring) and water piped to the houses. No centralized sewerage treatment, only septic tanks per household or establishment are used.

Educational Facilities	Aside from the elementary schools at each of the barangay, the municipality has the San Vicente National High School. It also host branches of Palawan State University and Palawan Poly-technical College Inc. which offer tertiary education.
Health facilities	The municipality has no major hospital, instead it has a Rural Health Unit and several barangay health centers.

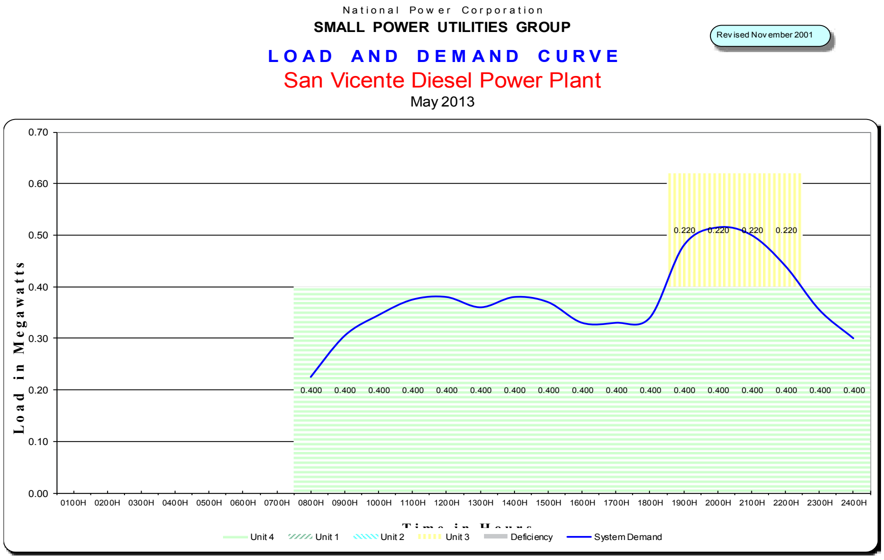
ECONOMIC INFORMATION

Primary economic activities	Fishing and farming are the major economic activities in San Vicente wherein 29.50% and 25.77%, respectively are engaged in it. Tourism is a growing industry. The municipality has several white sand beaches including a 14km beachfront, waterfalls, islets, coral reef sites, vast forest cover, mangroves, and varied endemic flora and fauna are also some of the attractions.
Main agricultural product	Rice, coconut and marine products
Ave. Annual Household Income	P132,640.00 (2009 data for the province)
Ave. Annual Household Expenses	P112,822.00 (2009 data for the province)

ENERGY SUPPLY & UTLIZATION

Distribution Utility	Palawan Electric Cooperative (PALECO)
Power Generation Entity	National Power Corporation – Small Power Utilities Group (NPC-SPUG)
Power Plant Capacity	The NPC-SPUG plant consists of three diesel generating sets: 1 – 500kW (with only 400 kW dependable); 1 - 260 kW; and 1-160 kW. The first unit is used for the base load and the last two are for peaking/reserve purposes. All generators are old and need replacement.
Year Plant Operation Started	1995
Power Plant operation	16 hours: 8am to 12am
Load Demand	Peak load is 0.50MW, with a load factor of 51.54%

Load and Demand Curve (Source NPC)



	0100H	0200H	0300H	0400H	0500H	0600H	0700H	0800H	0900H	1000H	1100H	1200H
TOTAL CAPABILITY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.400	0.400	0.400	0.400	0.400
SYSTEM DEMAND								0.225	0.305	0.345	0.375	0.380
RESERVED / (DEFICIENCY)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.175	0.095	0.055	0.025	0.020

	1300H	1400H	1500H	1600H	1700H	1800H	1900H	2000H	2100H	2200H	2300H	2400H
TOTAL CAPABILITY	0.400	0.400	0.400	0.400	0.400	0.400	0.620	0.620	0.620	0.620	0.400	0.400
SYSTEM DEMAND	0.360	0.380	0.370	0.330	0.330	0.340	0.480	0.515	0.500	0.440	0.355	0.300
RESERVED / (DEFICIENCY)	0.040	0.020	0.030	0.070	0.070	0.060	0.140	0.105	0.120	0.180	0.045	0.100

Fuel Consumption	Diesel consumption is 3.2 liters/kWhr which translate into PhP21,000.00 per month.
True Cost Generation Rate	PhP31.0995/kWh (based on a 2012 NPC audit)
Power Supply Service Quality	Due to old age of the diesel generators, breakdowns are normal occurrences and lack of replacement parts worsened the situations. Power failures are frequent. Poor power quality (i.e., low voltages and unstable frequencies) can be deduced from users who complaint of damaged appliances or equipment.
Power Plant Upgrading Plans	NPC-SPUG plans to replace the units with two (2) brand new 450kw generating sets in 2015. However, It is not clear to date when this plan will be realized.
Total Customers	2,144 (mostly residential users and a few commercial establishments)
Average monthly energy sales	125,416 MWh (2012 data)
Electricity Rate (Subsidized/approved Generation Rate [SAGR] + Distribution Charges + VAT)	PHP 8.90/kWhr (SAGR: PHP 6.4812)
Collection System	The cooperative directly bills and collects from customers.
Collection Efficiency	90%.
Local cost of diesel	P50/liter
Electricity Demand Forecast	The demand for electricity in San Vicente is expected to grow due to the following: a. Increasing population. With a growth rate of 6.0%, the San Vicente's figure is higher than the national average of 2%;

	b. An increasing tourist arrival. In the early 2000s, the annual tourists arrivals numbered only in the hundreds. But starting 2009, the visitors are arriving in the thousands; c. On-going construction of new buildings/facilities (e.g. airport, resorts, golf course, etc.); d. An existing supressed demand for electricity as manifested by the use of alternative electricity/lighting-producing equipment/devices such generating sets, PV systems and kerosene lamps; e. A supressed demand as expressed by businessmen (i.e., stores owners and resort operators) who wish to improve their services and products; and f. An expressed desire by the locals for better and continuous electrical supply.

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