How to increase renewable energy share in hybrid mini-grids ?

1. Diesel substitution market

1.1. Renewable energy can lower the average energy price

Several factors contribute to more renewable energy (RE) being integrated worldwide:

- Independence from fossils.
- Reduction of logistics challenges and losses/theft of fossil energy.
- Environment protection.

Besides, a new segment with very attractive profitability (unsubsidized) emerges: the diesel substitution market. According to EPIA, this potential could range from 60 to 250 GW by 2020[1]. Most islands worldwide depend on diesel to supply electricity, and look to reach higher shares of RE to lower their global energy price.[2]

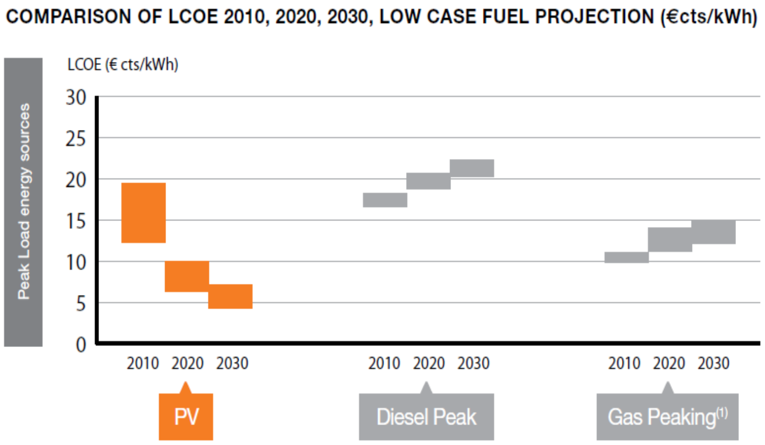


Figure 1: In a lot of countries, PV is cheaper than Diesel in 2010, than Gas in 2020

1.2. RE integration to overcome the fluctuation generation challenge

In these mini-grids, the amount of fluctuating RE that can be integrated is limited by the flexibility of the diesel generator. As a guideline, 30% of peak penetration can be achieved which results in an annual RE share of 7-10%. Dedicated PV-Diesel hybrid controllers can shift this limit to approxima-tely 20% RE share. Future energy solutions address this issue through three main ideas:

- **Storage integration**: batteries can “hide” RE vola-tility, but cost and integration are expensive.
- **Demand Side Management (DSM)**: this aims to adapt consumer demand through various methods. In PV environments the consumption can be adapted to match more sunshine at midday, for example.
- **Smart grid**: Intelligent grid management secures supply with volatile energy by coordinating DSM, storage and residual fossil generation.

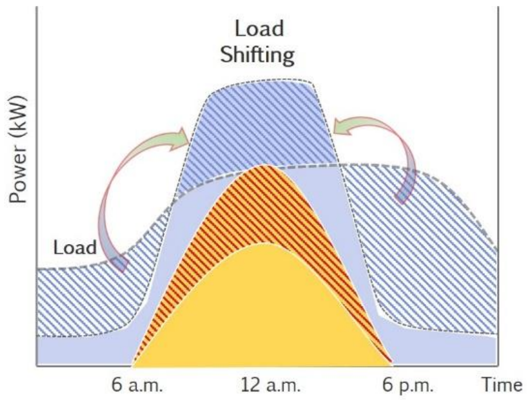


Figure 2 : Demand Side Management

[1] Global Market Outlook – For Photovoltaic 2013-2017 – EPIA
[2] Grafic: Unlocking the Sunbelt – Potential of Photovoltaics – March 2011 - EPIA

1.3. Different markets where ESG is relevant

Market 1: Diesel/Photovoltaic hybrid systems

RE Project developers and industry wish to extend the reach of diesel + Photovoltaic hybrids with an affordable solution. Demand Side Management and distributed flexibility is part of the solution they want to develop.

Market 2: Multisource integration

RE Project developers and industry wish to combine the advantages and constraints of different types of renewable energy and are looking for a relevant energy management control.

Market 3: Electrification program

Infrastructure Players (governments, development banks, communities) are developing "greenfield" and "brownfield" approaches to answer the growing energy demand. An attractive option is the "anchor" model with a main (private) prosumer delivering energy to local communities. ESG facilitates such business models by providing fair pricing of energy.

Market 4: weak grid and or grid willing to reach a higher RE penetration

The grid operators want to improve the grid stability with a better usage of limited generation capacity by adapting load behavior to energy availability.

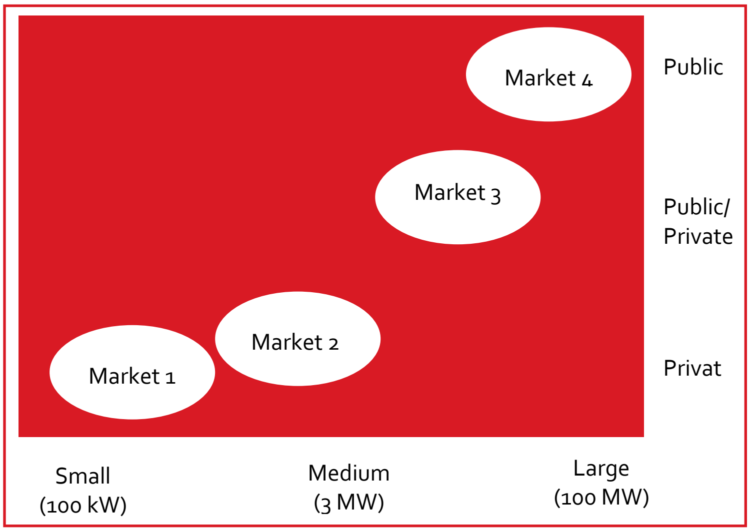


Figure 3 : Market description

2. Our solution

2.1. Our products

System solution

Patented technology to communicate a real time price signal to every grid participant.

Easy Smart Grid meter

The ESG meter allows the introduction of a variable tariff measuring the energy flow with the associated frequency in order to write down the energy bill to every producer, consumers (or prosumer).

SmaCo (Smart Controllers)

The SmaCo will control the consumption/production behavior of grid participants, taking its energy decisions based on economic criteria, price signal. As described above, this SmaCo will be adapted to different application with different economic constraints.

2.2. Different applications for energy consumers

The different appliances to be considered through ESG technology can belong to four different categories:

- SmaCo Cooling
- SmaCo Liquid Storage (Water processes)
- SmaCo Battery
- SmaCo Multigeneration

SmaCo solutions include a controller, sensors and algorithms to optimize energy prices for the equipment they are added to. As a result, the equipment is integrated as “virtual storage” into the grid, and the owner rewarded by commercial benefit. Note that some appliances might not be flexible (television, cooking devices…) and won’t participate in any flexibility market due to their function.

3. Migration Scenario

1st step: riskless integration with the adequate control for the grid operator

The solutions mainly promoted today to integrate RE in island grids are based on the “peak shaving” idea. For the photovoltaic sector, the inverters limit the photovoltaic supply to the grid to guarantee grid stability through the fossil generator controllers in case of low load. Basically, part of the energy at midday is cut away to avoid black out in case of instantaneous change of consumption and/or production. This allows to install more photovoltaic generation capacity and high contribution over the day. This initial situation is a great opportunity for Demand Side Management (DSM) measures since any shift of the energy consumption to midday reduces the amount of RE “shaved” away.

- ➔ To implement this 1st step, relevant consumers will be equipped with an ESG meter and a SmaCo device for each relevant shiftable load, reacting to the price signal, while the grid operator will ensure the variability of grid frequency.
- ➔ The participants integrated in the Easy Smart Grid solution will be big enough to measure an impact on the integration of Renewable Energy, but small enough to ensure the grid operator to guarantee the grid stability and the energy supply. Easy Smart Grid could be implemented in parallel to existing flexibility mechanisms to gather the small flexibilities that could not be addressed by an industry contractual relationship.

We are collaborating with different research institutes (Max Plank Institute for Dynamics and Self-Organization and Karlsruhe Institute for Technology) to ensure the grid stability and the balance system of energy supply in high penetration scenarios. The existing algorithm will be optimized to counter any negative impacts on the grid management. At the moment, these renowned R&D institutes don’t see any technical obstacles in the technical feasibility of our technology.

2nd step: higher RE penetration and potential storage

Due to activated Demand Side Management and with all the collected information, additional renewable energy plants can be integrated and strengthen the existing variable tariff market design.

- ➔ Most of the energy producers, renewable or fossils, will be equipped with an ESG meter and a SmaCo so that the multisource energy system can better be coordinated: as price for energy varies over time, also producers of energy will have incentives to produce when demand is highest. Negative prices could be implemented to limit the output of photovoltaic or wind energy if required, without any need for regulatory intervention. At that stage, power back-up storage might be integrated in this market and benefit from this variable tariff as well, charging when the energy is cheap and unloading when the energy is expensive.

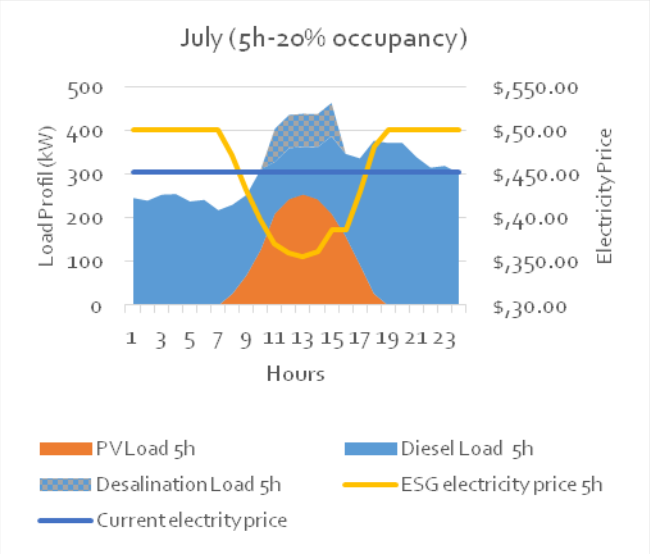
3rd step: full ESG implementation

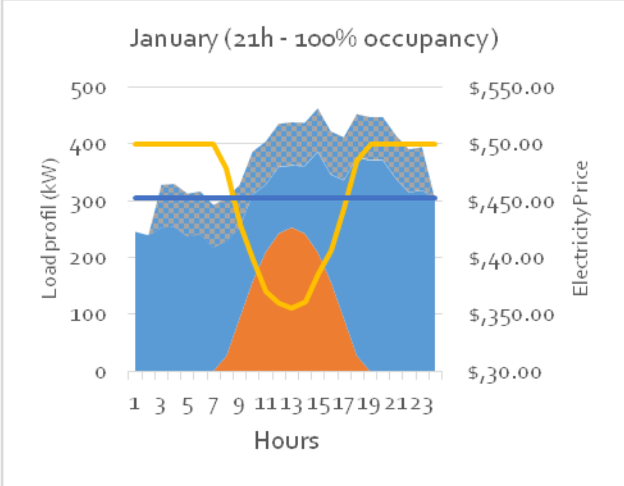
The final step is to enable the integration of all relevant participants of the island system and the generalization of the variable tariff design.

- ➔ Every grid participant willing to offer their flexibility to the grid will benefit from a better energy price. Some manufacturers will integrate ESG functions directly in their equipment. At this stage, energy storage can be installed and integrated within the variable tariff market.
- ➔ Once the whole Demand Side Management potential will be enhanced, potential for additional RE plants will be analyzed and allow additional installations.

<u>Simulation on a desalination plant in a touristic resort on the Maldives:</u>

With 70% occupancy over the year, the desalination plant can reduce its operating hours while the resort is not fully occupied. With the same PV penetration, shifting the load can have great economic benefits for the grid operators, reducing its PV energy lost.





To motivate the desalination plant to shift its load whenever it is grid supportive, the grid operator offers him a variable tariff coded through the frequency. In July, the desalination plant is saving 19% on its monthly energy bill and is saving 4% (more than 7000 USD) on the yearly energy cost. For the grid operators and/or the independent power producer, this load shift guarantees the optimization of the RE used. For example, in July, should the 5 hours operations run during the night, the RE shares will be only 16.8% while it could be 21.4% with a load shift to daytime.