Smart Renewable Hubs: Multi-Hybridization to Achieve High RE Penetration in Island Grids

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Introduction: Smart Renewable Hubs

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GRIDSOL is a H2020 project aimed at increasing the **penetration of renewable energies** in the grid while ensuring grid **stability** and **security of supply**, reducing the necessity of fossil backup in an **efficient** manner

The consortium is coordinated by **Cobra**, with IDIe leading WP2: Modelling of non-dispatchable RES and Synchronous Generation in Smart Renewable Hubs

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Introduction: Smart Renewable Hubs

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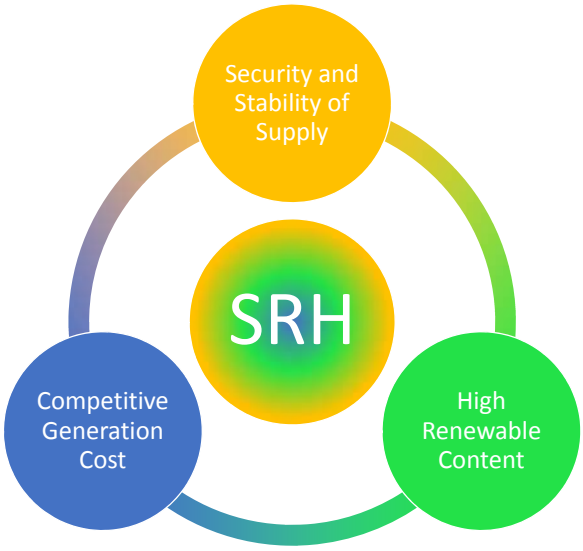
Smart Renewable Hubs (SRH) manage the operation of several **renewable** and **non-renewable** technologies to provide a **single** coordinated **output** to the grid

Storage (TES, BESS, pump-hydro) and **backup** (GT + HYSOL, coal, biomass) technologies are **tailored** to maximize renewable content at a **competitive price**, while ensuring **grid stability**



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The Relevance of Storage

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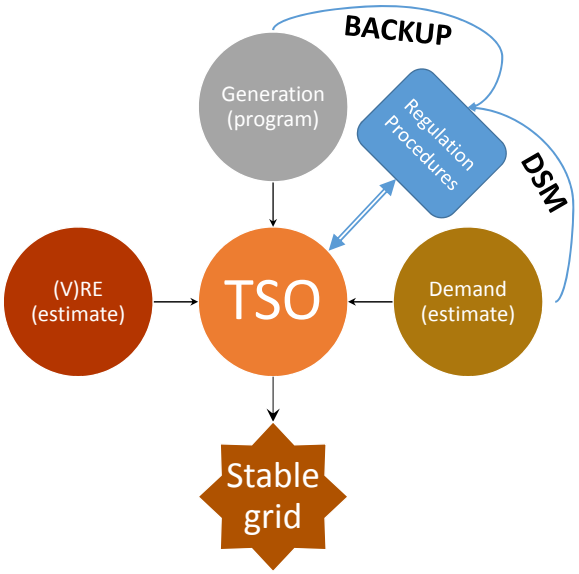
Grid stability is a **dynamic equilibrium**

Thermal generation provides **stability** (e.g. regulating voltage and frequency, inertia)

VRE (**non-synchronous** and/or **non-dispatchable** renewables such as Wind and PV) might disrupt the balance, especially in **islands and poorly interconnected areas**

Significant periods of synchronous generators idle just for stability, which is **inefficient and costly**



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The Relevance of Storage

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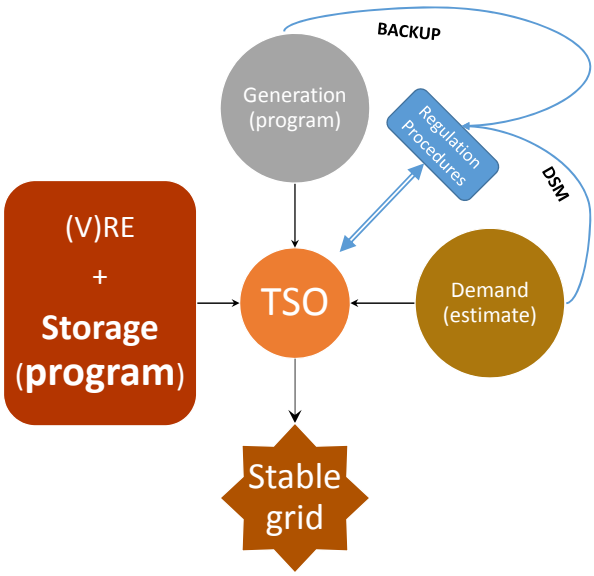
The main challenge in the use renewable energy as the basis of an electric system is **timing** → security of supply must necessarily include energy storage: thermal (TES), electro-mechanical, electro-chemical (BES)…

However, storage's **economic viability** is hard to measure, and **sizing** the system is doubly difficult: generation mix and demand profile, **both actual and expected**, must be taken into account to minimize overall system costs



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Modeling of Generation Technologies: SRH-M

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Within the GRIDSOL consortium, IDIe has developed the software tool "SRH-M" → **Smart Renewable Hub Modeler**

Using a combination of first-principles equations and empirical correlations, each generation and storage technology is modelled and **optimized** through a **numerical multi-variate** method using full-year hourly simulations

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Modeling of Generation Technologies: SRH-M

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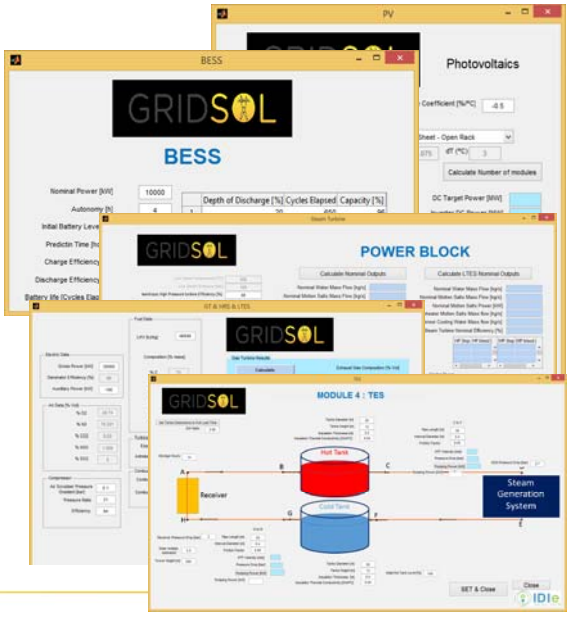
SRH-M can design a whole multi-technology plant, or determine a small **system's optimal generation/storage mix**

It can also calculate, for an existing system, the optimal **additions required for future needs**: replacement of outdated units, expected demand growth, etc.

The solutions are tailored to the location's **available resources** and **market conditions**



DOME'S Core: Reasonably Prudent Operator

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Labelling a certain energy mix as "optimal" would not make sense unless a proper **energy management system** is in place: **DOME** (Dynamic Output Manager of Energy) is an industry-grade plant control suite under development in GRIDSOL, with a core set of regulation rules already implemented in SRH-M

The regulation system emulates the actions of a Reasonably Prudent Operator (RPO), determining the **set point for each generator & storage** based on the information available at any given time

The operational rules followed by the RPO are defined along these **overarching objectives**:

- Maximizing renewable content
- Minimizing curtailment / dumping of primary energy
- Ensuring **firmness**, i.e. reaching at least 95% of the target production, 95% of the time
- Maximizing efficiency

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Islands and Non-Interconnected Systems

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Poorly interconnected systems struggle to maintain the stability of the grid, as they have **fewer degrees of freedom** to manage any event: excessive or insufficient production, transient conditions, plant incidents, etc.

Typical solutions are large amounts of highly flexible, **fossil-fuelled backup** power, sometimes with a non-interruptible minimum ("must-run" units)

Adding renewables, especially VRE, to the mix **increases the need** for flexible capacity while **reducing the overall use** of the backup systems, thus increasing the unit cost of backup

Well-dimensioned and **properly-managed** storage is a promising solution for a decarbonized future

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Case Study: the Fuerteventura-Lanzarote System

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Current situation:

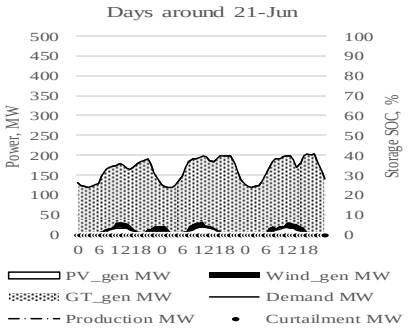
Lanzarote and Fuerteventura share a submarine connection, so they have been considered as a single, isolated system

Relevant figures (2015):

- Total installed power: 464,1 MW
  - Of which renewables: 9,7 %
- Peak demand: 246,5 MW
- Electricity consumed: 1,56 TWh
  - Of which renewables: 4,5 %

The system's current mix was implemented in SRH-M (installed power of each technology, demand profile, TMY)

Technology	Current mix, real		Current mix, SRH-M	
	Installed power (%)	Production (%)	Installed power (%)	Production (%)
PV	5	1.5	5	3
Wind	5	3	5	4
ST-CSP	-	-	-	-
GT	90	95.5	90	93
BES	-	-	-	-
Total	100	100	100	100



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Case Study: the Fuerteventura-Lanzarote System

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SRH solution w/o CSP:

The SRH-M was used to determine a renewable-based solution that could address the Fuerteventura-Lanzarote system's necessities (peak power, demand profile, total consumption, etc.)

The first solution is based on PV and batteries (BES)

A technically feasible solution is found, heavily based on PV and BES with a relevant Wind portion and over 85% renewable content, but curtailment is significant (28%)

SRH solution with CSP:

A second solution, allowing the inclusion of CSP w/ TES, was found with SRH-M

It is still including a large amount of PV, but the inclusion of CSP reduces the need for batteries' peak power (although the energy traded is similar)

The cost of storage (BES + TES) in this solution is 11% lower than the previous option (BES-only), BES is 76% and TES is 13% compared with (BES-ony), despite having twice the equivalent capacity.

With CSP, the RE content is even higher (88%) and curtailment is reduced to more manageable levels (8%)

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Case Study: the Fuerteventura-Lanzarote System

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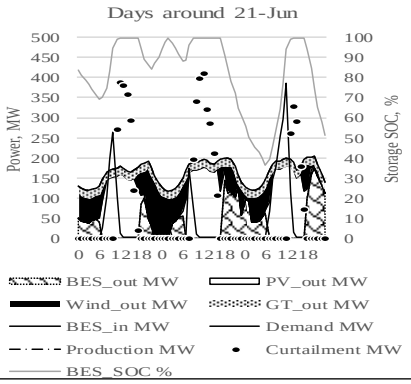

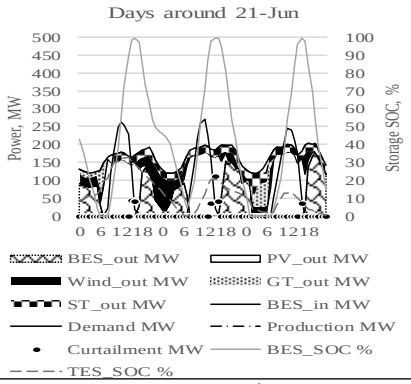

	Current mix, SRH-M		Non-CSP solution, SRH-M		CSP solution, SRH-M	
Technology	Installed power (%)	Production (%)	Installed power (%)	Production (%)	Installed power (%)	Production (%)
PV	5	3	65	56	67	56
Wind	5	4	24	30	13	16
ST-CSP	-	-	-	-	11	16
TES	-	-	-	-	(16 h, 1160 MWh)	
GT	90	93	11	14	9	12
BES	-	-	+78 (2.5 h, 905 MWh)	+18	+37 (4 h, 688 MWh)	+18
Total	100	100	+70/+148	+28	+42/+79	+8

Economic Analysis

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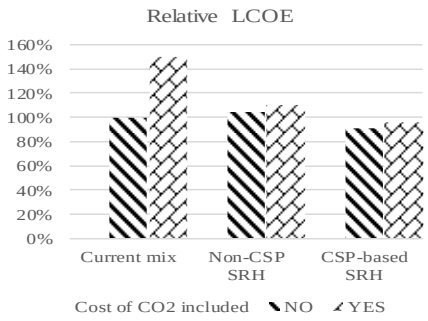
Even though the full economic impact of switching the generation mix towards renewables is much deeper (externalities), a comparison in terms of LCOE has been carried out as a preliminary indicator

- Lifetime: 25 years
- Discount rate (real): 5,5%
- Inflation/cost escalation: no



Technology	Investment cost k€/MW	Investment cost k€/MWh-e	O&M cost k€/MW
PV	750		9.5
Wind	1050		27
ST-CSP	6200		70
TES		70	
GT	850		560
BES		350	28

A variant considering a cost for CO2 emissions of 83,4 €/t* is included as a likely future situation

A decided bet for renewables can reduce the price of electricity even at current costs, and tailoring the energy mix can guarantee grid stability with minimum backup

*source: ENTSO-E

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Conclusions

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Isolated grids do not tap into their potential for renewable energy, usually due to stability and/or security of supply concerns

Storage technologies are key in mitigating the variability of both renewable generation and consumer demand

Sizing the storage capacity is key for the economic viability of the system, and it is a problem that cannot be solved independently from the generation

The software SRH-M, developed in GRIDSOL, is implementing the tools for this task, simultaneously sizing generation and storage for an optimum final cost

The concept of Smart Renewable Hubs can help cutting down emissions in islands, while reducing the generation cost and maintaining security of supply

A SRH can be developed from scratch, or integrating existing plants to form a coordinated unit

A comprehensive regulatory framework and support for pioneering projects can make SRHs a reality before the end of the decade

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THANK YOU FOR YOUR ATTENTION

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