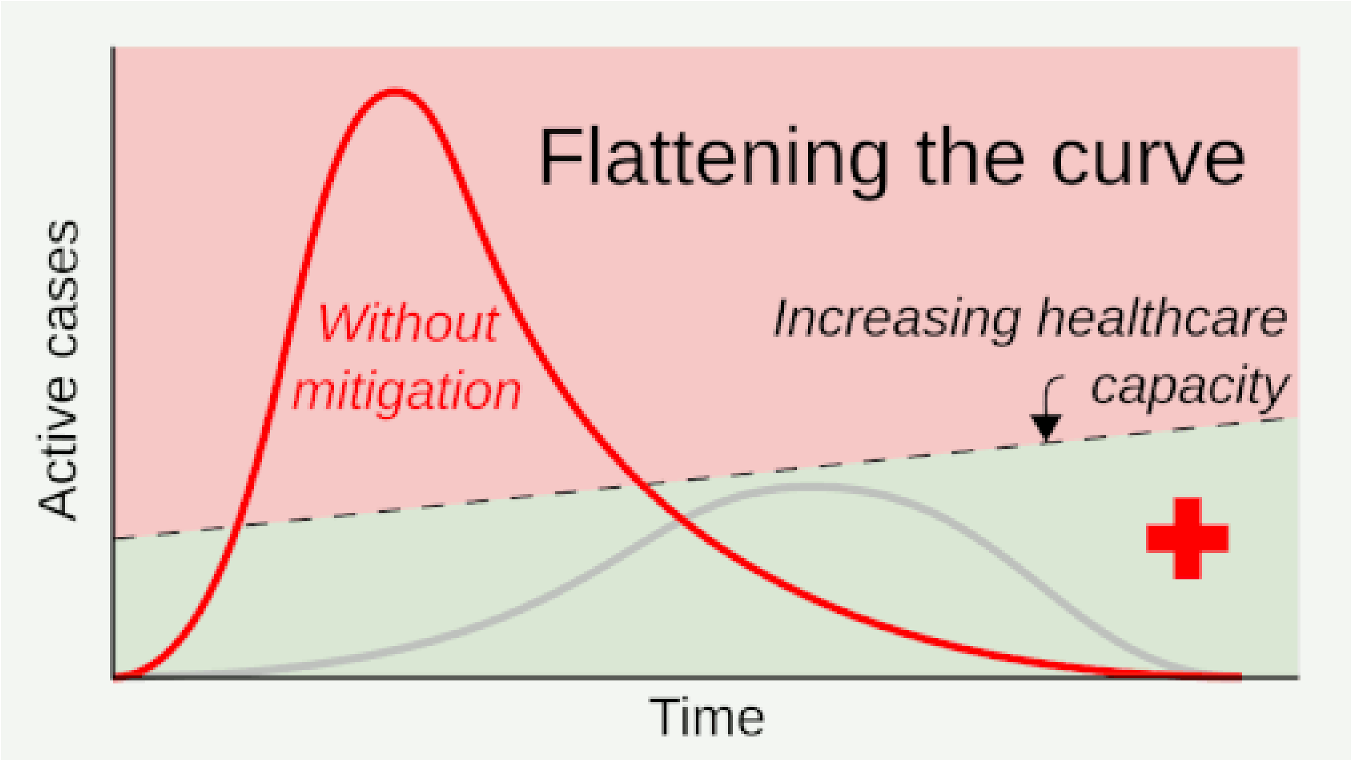
Smart electricity systems for facilitating the decarbonisation of islands:

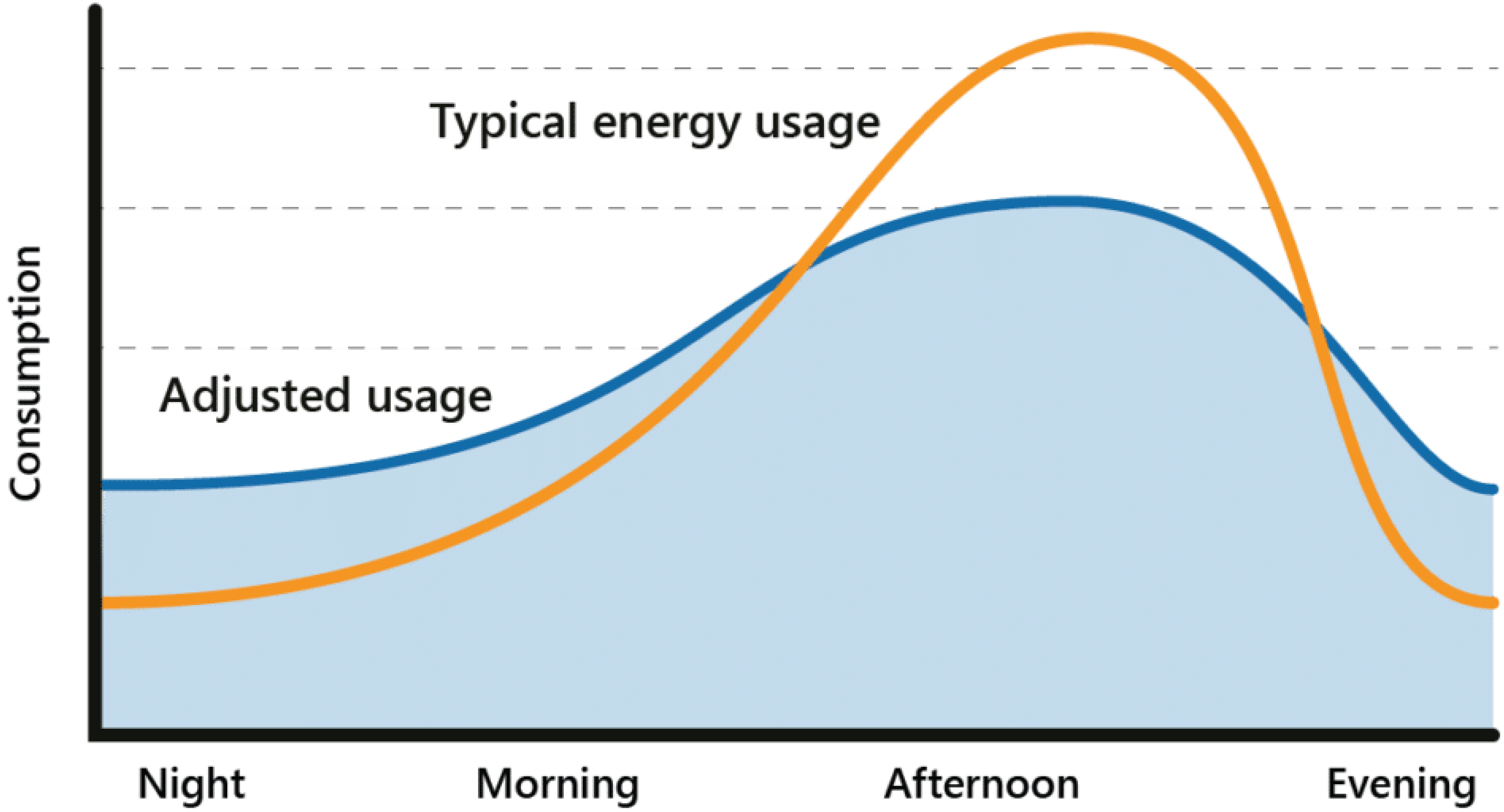
demand-side management and flexibility

European Commission | #CE4EUislands

Demand side management



Demand side management



Demand side management

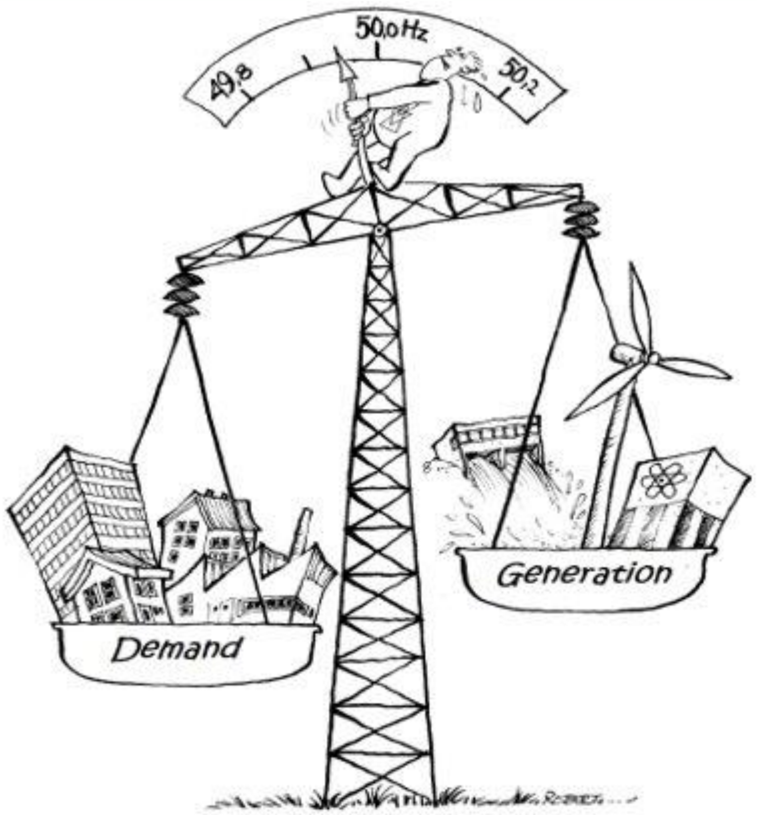
Demand-Side Management (DSM) refers to strategies and programs implemented to **influence consumer electricity usage patterns**, primarily

- through financial incentives,
- behavioral education,
- or technological upgrades.

DSM aims to optimize energy consumption by **reducing demand during peak hours or shifting it to off-peak times.** These measures:

- enhance grid reliability,
- defer the need for new power generation, and
- support the integration of renewable energy sources.

Flexibility



A 2017 article in *The Electricity Journal* defines flexibility as "the capability of the power system to maintain balance between generation and load under uncertainty."

Flexibility

Explicit Demand-Side Flexibility is committed, dispatchable flexibility that can be traded on the different energy markets (This is usually facilitated and managed by an aggregator that can be an independent service provider or a supplier)

Implicit Demand-Side Flexibility is the consumer's reaction to price signals. Where consumers have the possibility to choose hourly or shorter-term market pricing they can adapt their behaviour (through automation or personal choices) to save on energy expenses

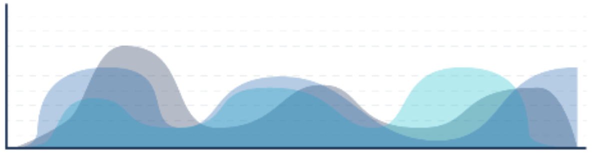
Demand side programs

Program Type	Customer Control	Utility Control	Nature	Participation	Target Customers
Direct Load Control	Minimal	High	Automated	Residential/Commercial	Home appliances
Load Curtailment	Moderate	Low	Voluntary	Large Commercial/Industrial	Flexible load reductions
Demand Bidding	High	None	Market-Driven	Large Commercial/Industrial	Price-driven participation
Interruptible Load	Low	High	Mandatory	Large Commercial/Industrial	Contract-based interruptions

Why smartening islands' electrical systems matters?

Great variety of electrical systems
Islands of different size, population, distance from the mainland

Big variations of demand both daily and yearly basis
Great increase of demand during summer months due to tourism



Seasonality of demand

Great variety of electrical systems

Use of thermal stations

Isolated systems with no or small interconnections

High production cost

Voltage and frequency **regulation problems**

Why smartening islands' electrical systems matters?

RES (especially Wind farms) are subject to output power limitations:

1) **technical minima** of thermal units

- ✓ Sufficient number of generators should be in operation to meet reserve requirements
- ✓ The cumulative technical minimum production levels cover a significant amount of load

2) **penetration level limit**, applied for stability purposes (e.g. 20-35% of the total demand). Different limits are imposed according to the island and the demand levels.

Sector coupling and Demand Side Management (DSM) can facilitate higher RES penetration levels, while also offering services like frequency regulation.

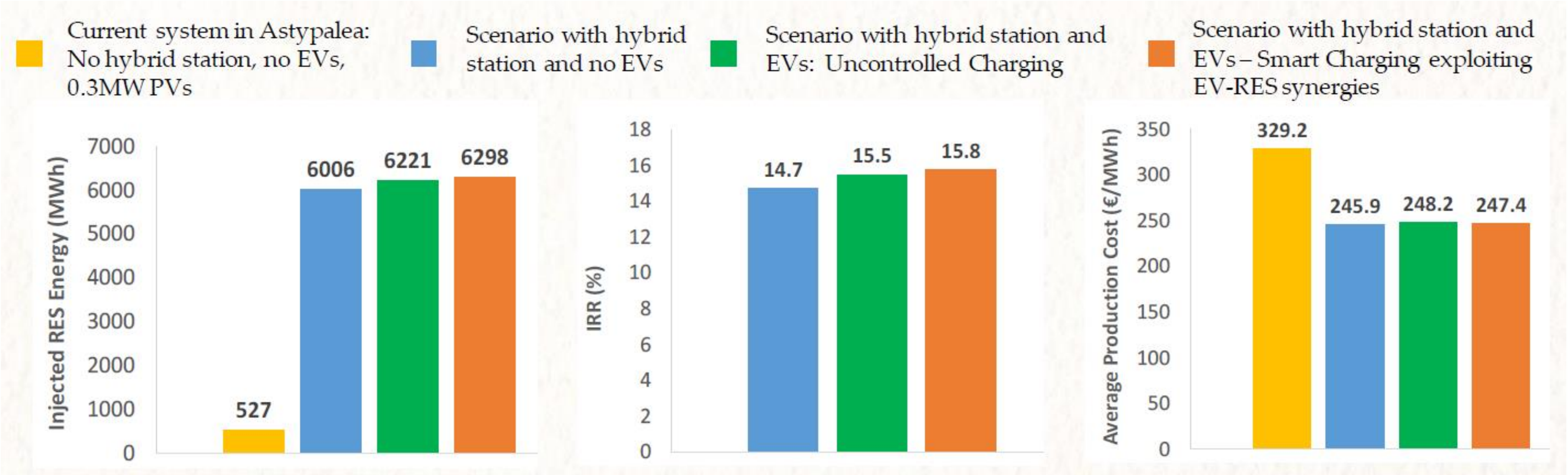
Different applications in islands:

- ✓ E-Mobility
- ✓ HVAC, Appliances
- ✓ Large Loads (e.g. Desalination Plants)

Source: Prof. Nikos Hatziargyriou, NTUA, SmartRue

Astypalea: EVs and High RES penetration

- A hybrid station with 2.3MW PVs, 2MW Wind and a Battery capacity of 9.6MWh (bluebars) significantly increases the RES penetration levels and reduces the system's production cost
- The higher EV demand in the case of uncontrolled charging (green bars) can increase the RES energy supplied to the grid, while also increasing the IRR related to the Hybrid station investment
- A smart charging scheme that exploits EV-RES synergies (orange bars) can further increase the RES penetration and the IRR of the Hybrid station investment and decrease the system's production cost compared to uncontrolled charging.

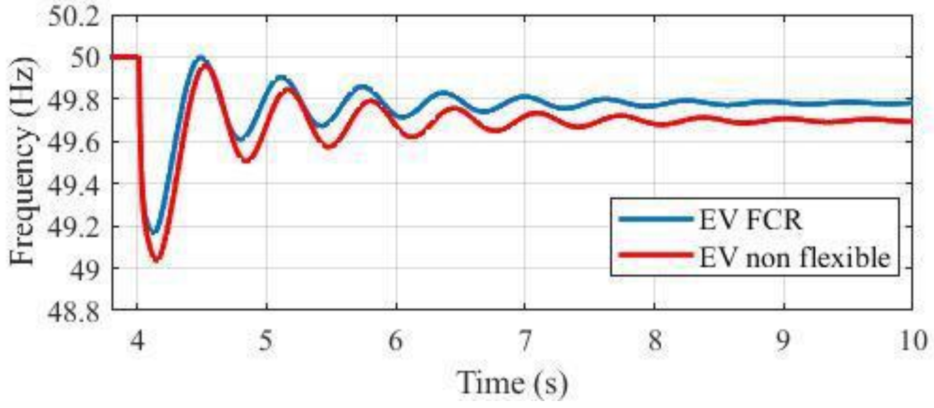


Source: Prof. Nikos Hatziargyriou, NTUA, SmartRue

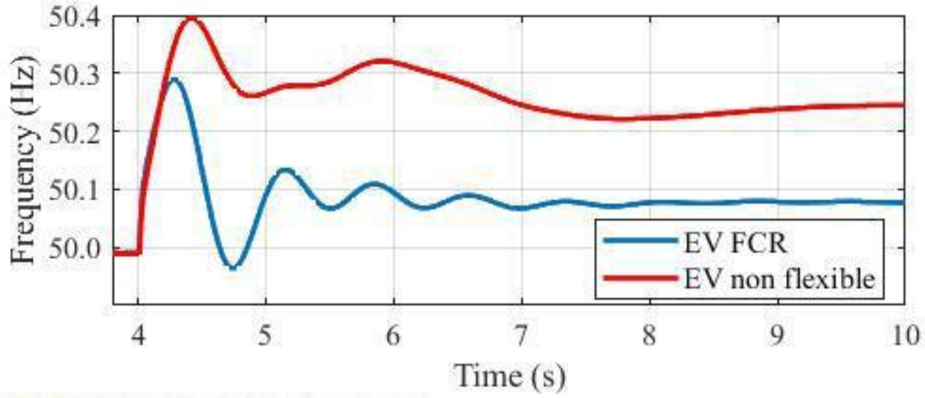
EVs for Meeting Technical Challenges

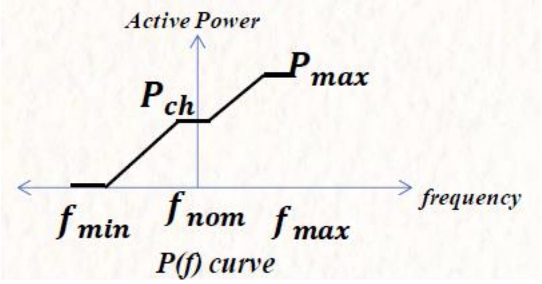
- EVs can alter their charging power to provide frequency containment reserves (FCR).
- In underfrequency reserves the charging power can be reduced and in overfrequency can be increased dynamically according to the frequency to provide FCR.
- Study in Astypalea network. Operating scenario:
  - Island demand:1,6MW and EVs charging:0,6MW
  - WT: 2MW, BES=-0.4MW, Diesel=0,6MW

- Contigencies
  - ✓ Disconnection of WT (underfrequency event)
  - ✓ Disconnection of central BES (overfrequency event)



Impact of EVs in underfrequency transients





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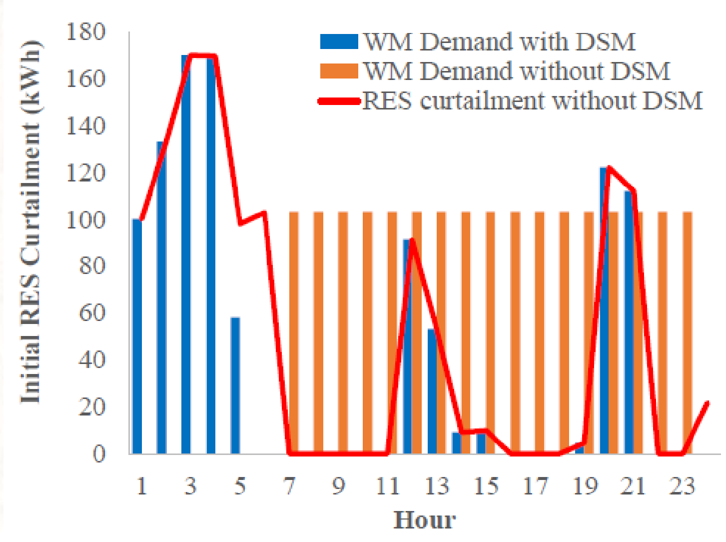
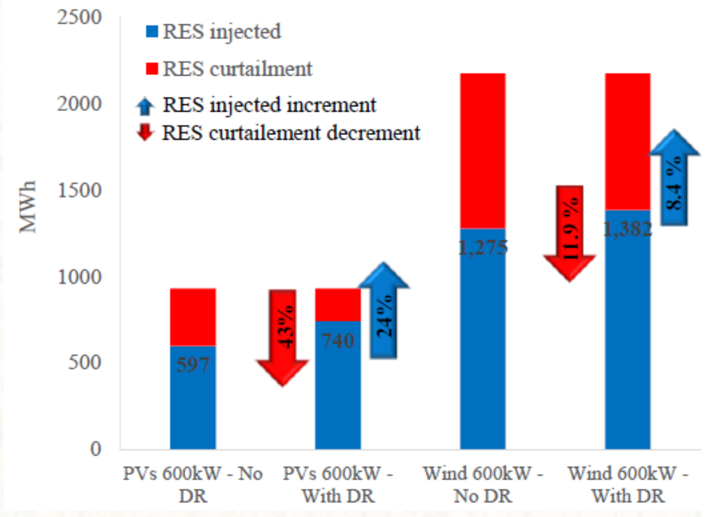
Appliances

- ➢ DSM by home appliances, like HVAC or Washing Machines.
- ➢ DSM schemes have been evaluated in Kythnos by shifting Washing Machine (WM) demand to hours with increased RES production
  - ✓ Day Ahead Scheduling to identify hours with increased RES curtailment
  - ✓ WM demand is transferred towards these hours.





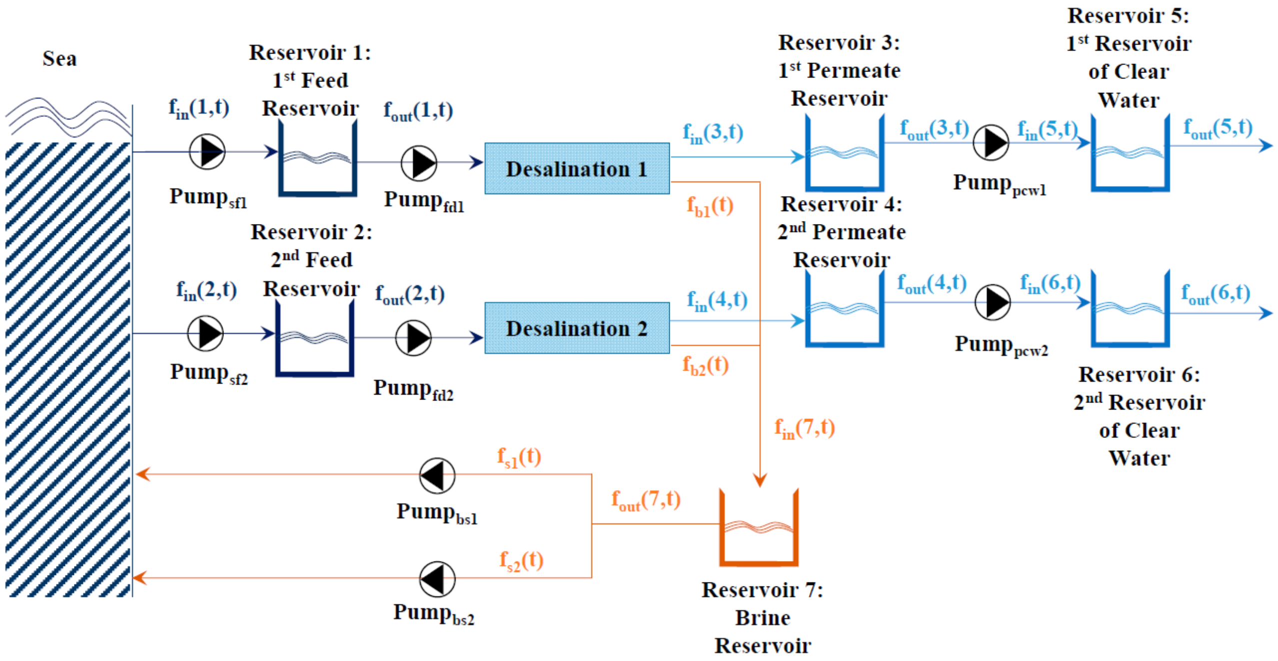
- ➢ The application of DR assuming that all the residential WMs participate in DSM has been evaluated for 2 scenarios:
  - ✓ Installation of 600kW PV
  - ✓ Installation of 600kW Wind Generator
  - ✓ In both cases, DSM can effectively achieve increase in RES penetration

Source: Prof. Nikos Hatziargyriou, NTUA, SmartRue

Large Loads

- Significant opportunities for DSM by larger loads, e.g. loads of a desalination plants or demand of hotels.
- Specific constraints should be considered in this case linked to the operation of each load.
- DSM capabilities of the desalination system in Kythnos have been evaluated
- In this case, the complex operation of a desalination system (comprising an increased number of pumps, water reservoirs, etc.), requests a careful design of the management scheme [1]
  - ✓ The constraints linked with the desalination system have been identified
  - ✓ An optimisation problem is defined to solve the optimal Day Ahead Scheduling of the desalination system.

Desalination system in Merichas (Kythnos)

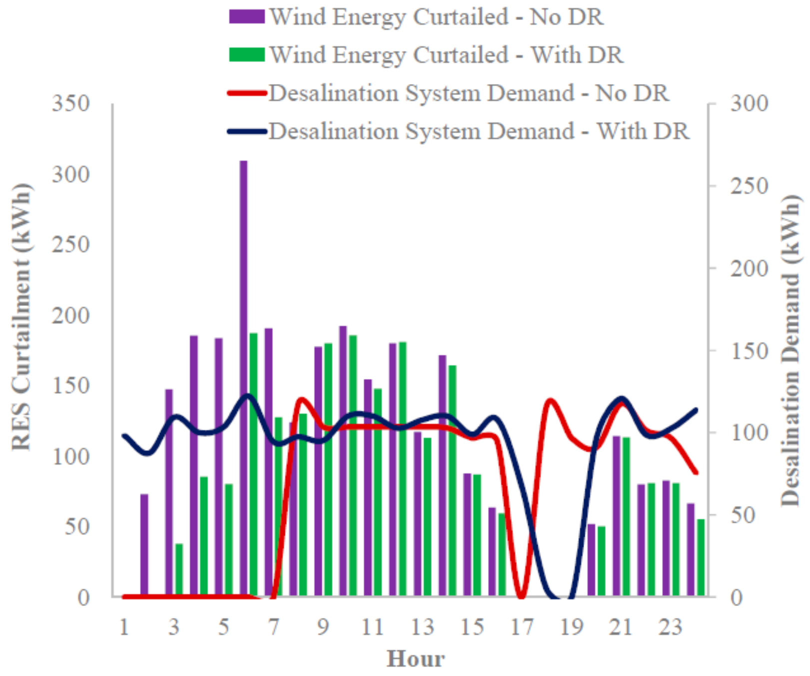


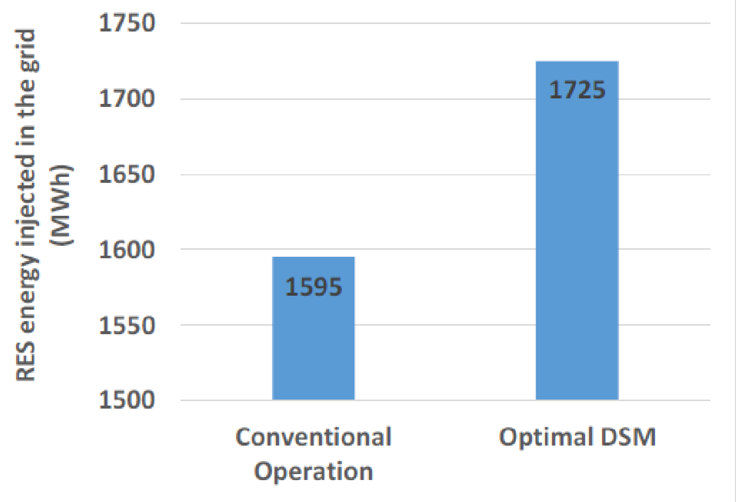
[1] Karakitsios, I.; Dimeas, A.; Hatziargyriou, N. Optimal Management of the Desalination System Demand in Non-Interconnected Islands.Energies2020,13, 4021. https://doi.org/10.3390/en13154021

Source: Prof. Nikos Hatziargyriou, NTUA, SmartRue

Large Loads

- The desalination system in Kythnos operates according to the level of water in each reservoir: when the water is lower than a specific level the relevant pump or desalination system is activated to increase the reservoir level.
- An optimal management of the desalination system has been applied to exploit RES:
  - ✓ The available volume capacity in all reservoirs is effectively exploited to schedule the system's energy consumption during the day and offer demand response services to the system operator
  - ✓ The desalination demand is effectively shifted towards hours with increased RES curtailment allowing a significant increase in RES energy inje





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Thank you!

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