# Control of Distributed Energy Storage Systems for Energy Communities

**Dr. Shafi Khadem**

International Energy Research Centre, Tyndall National Institute, Ireland

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**Dr Shafi Khadem**, SMIEEE
Lead, Embedded and Distributed Generation Systems (EDGE) Group
International Energy Research Centre (IERC), Ireland

Senior Staff Researcher,
Tyndall National Institute (TNI), Ireland

E: shafi.Khadem@ierc.ie
O: +353-210234-6694
W: https://www.ierc.ie/people/dr-shafi-k-khadem/

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- ❑ Introduction
- ❑ Current Status
- ❑ Analysis/Approach
- ❑ Solution
- ❑ Summary Findings/Conclusion
- ❑ Questions remaining, Other challenges to address
- ❑ Conclusion

- Most widely used Energy Storage Technologies and their possible applications

- For the End-user Services, most of the technologies are not proven yet, but have some promising aspects

| | ELECTRICAL | | MECHANICAL | | | ELECTROMECHANICAL | | | CHEMICAL | THERMAL |
|---|---|---|---|---|---|---|---|---|---|---|
| | Superca-pacitors | SMES | PHS | CAES | Flywheels | Sodium Sulfur | Lithium Ion | Redox Flow | Hydrogen | Molten Salt |
| Possible applications by technologies | | | | | | | | | | |
| Power quality | ✓ | ✓ | | | ✓ | ✓ | ✓ | ☝ | | |
| Energy arbitrage | | | ✓ | ✓ | ☝ | ✓ | ✓ | ✓ | ☝ | ✓ |
| RES integration | | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Emergency back-up | | | | | ✓ | ✓ | ✓ | ✓ | ☝ | |
| Peak shaving | | | ✓ | ✓ | | ✓ | ✓ | ☝ | ☝ | ☝ |
| Time shifting | | | ✓ | ✓ | | ✓ | ✓ | ☝ | ☝ | ☝ |
| Load leveling | | | ✓ | ✓ | | ✓ | ✓ | ☝ | ☝ | ☝ |
| Black start | | | | | | ✓ | ✓ | ✓ | ☝ | ☝ |
| Seasonal storage | | | ☝ | ✧ | | | | | ☝ | ☝ |
| Spinning reserve | | ☝ | | | ☝ | ✓ | ✓ | ☝ | ☝ | |
| Network expansion | | | ✓ | ☝ | | ✓ | ✓ | ☝ | ☝ | ☝ |
| Network stabilisation | ☝ | ✓ | | | ☝ | ✓ | ✓ | ☝ | | |
| Voltage regultation | ☝ | ☝ | | | ☝ | ✓ | ✓ | ✓ | | |
| End-user services | ☝ | ☝ | | | ☝ | ✓ | ✓ | ☝ | | |

✓ for proven ☝ for promissing ✧ for possible

Ref: World Energy Council, 'Five steps to energy storage', Available: https://www.worldenergy.org/publications/entry/innovationinsights-brief-five-steps-to-energy-storage, 2020

# ❑ Introduction

- How ESS are integrated at the demand side?

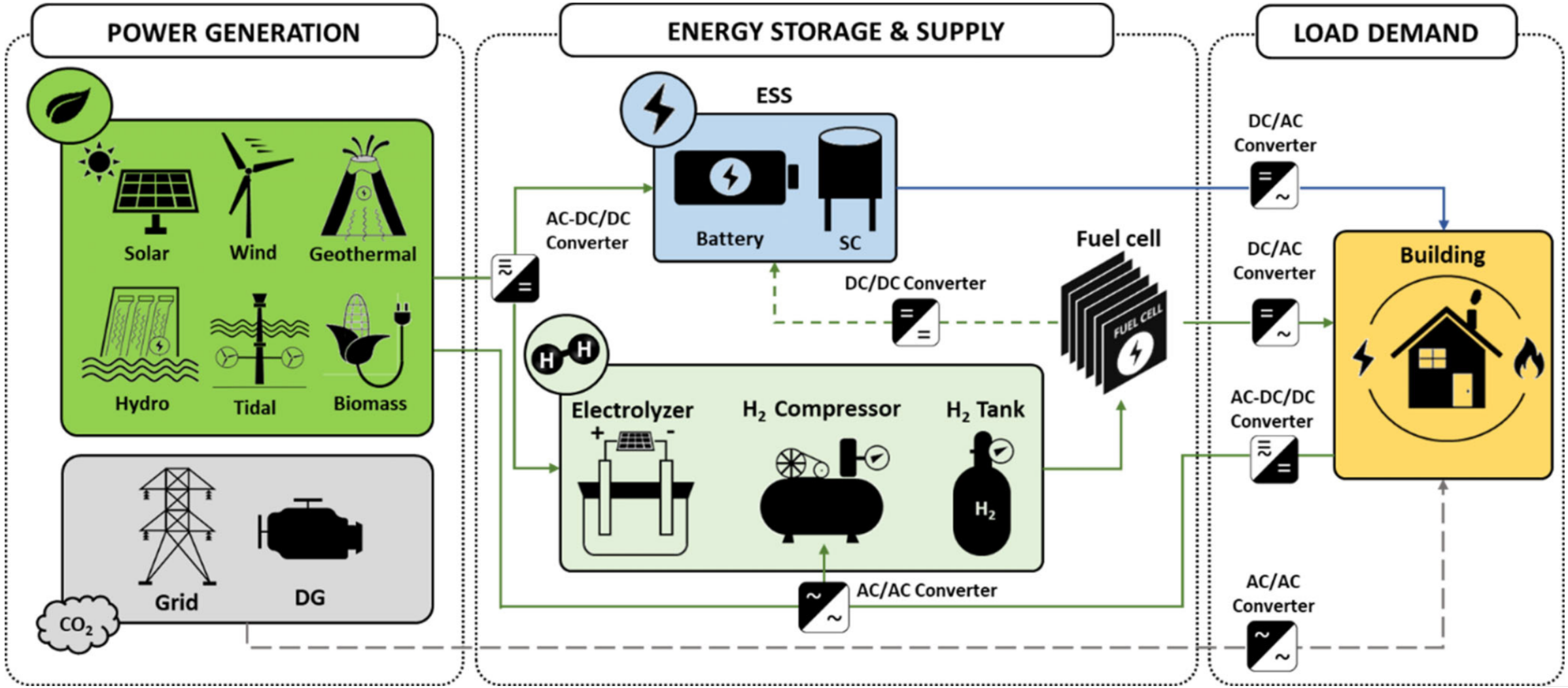



Fig: Integration of Energy Storage in Residential Sector and behind the meter

Ref: The role of hydrogen-based power systems in the energy transition of the residential sector, https://doi.org/10.1002/jctb.6938

# ❑ Current Status

- Present status and future scenarios of residential ESS in Europe

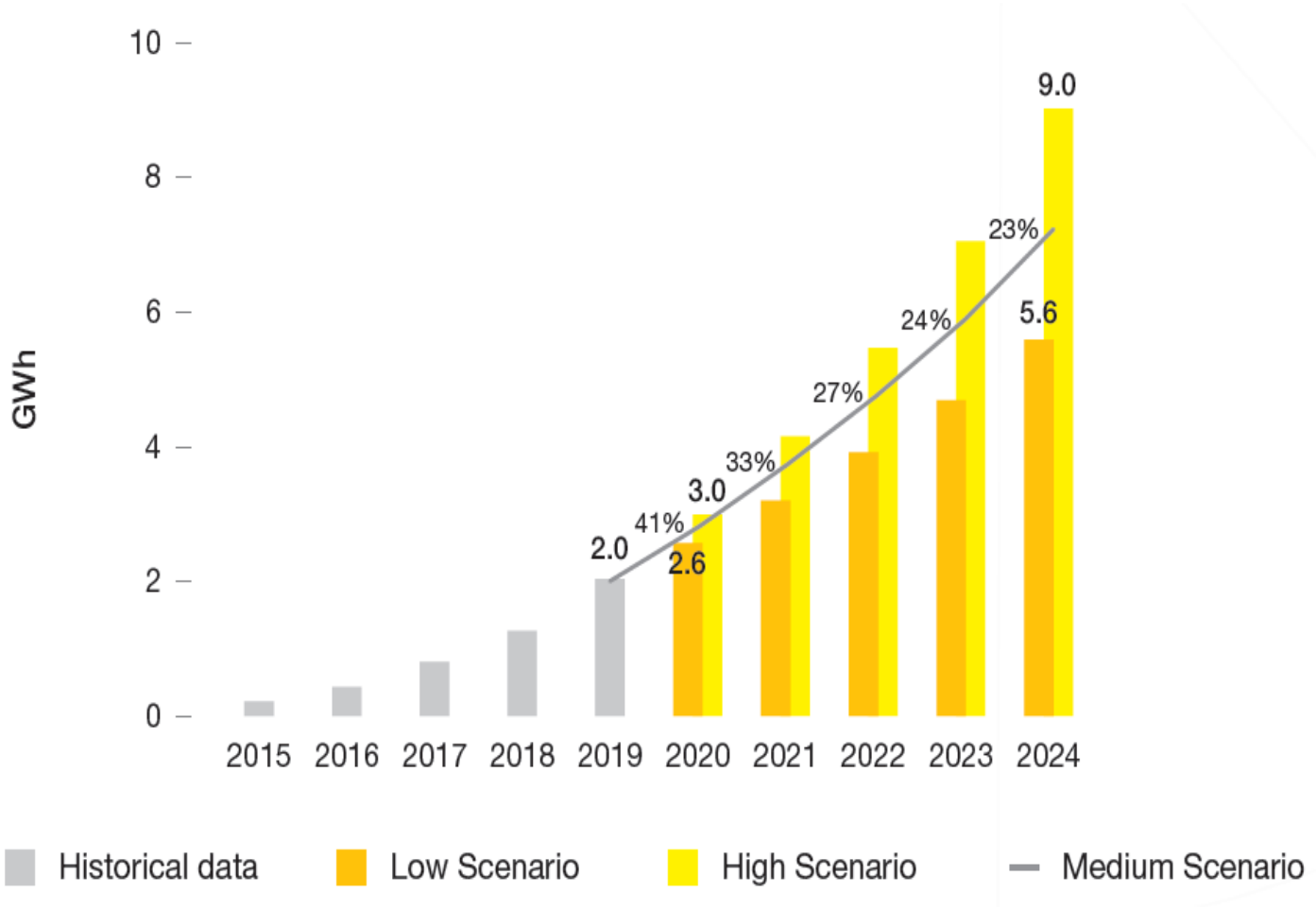



Fig: Residential BESS cumulative scenarios 2020 – 2024 in Europe

Ref: Solar Power Europe (2020): European Market Outlook for Residential Battery Storage 2020-2024.

# ❑ Current Status

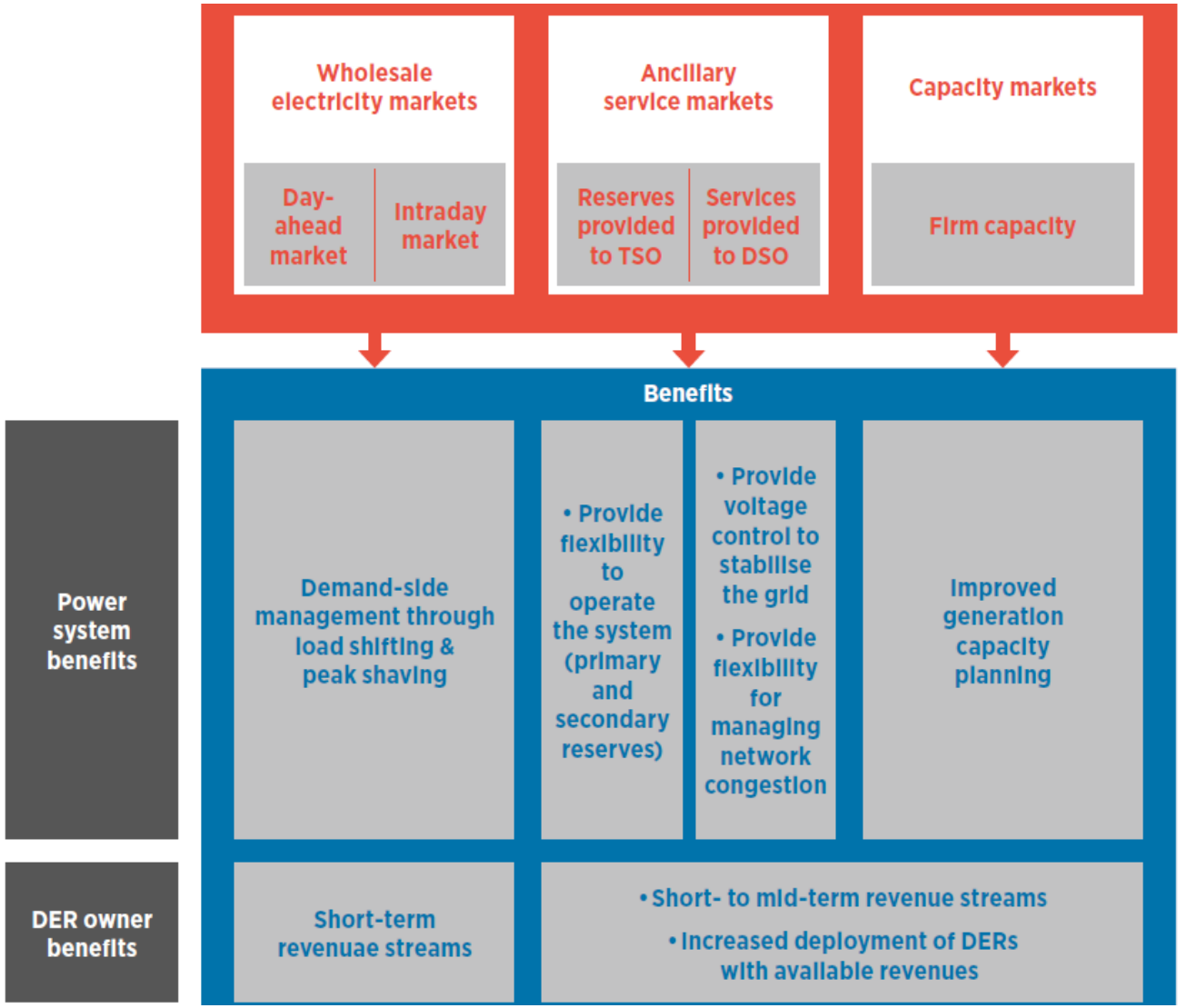
- Most advanced countries in Europe on ESS integration

| COUNTRY | GERMANY | ITALY | UNITED KINGDOM | AUSTRIA |
|---|---|---|---|---|
| Authorisation to self-consume | ✓ | ✓ | ✓ | ✓ |
| Energy arbitrage possible | X | X | ✓ | X |
| Aggregation and grid services possible | Pilots ongoing | Pilots ongoing | ✓ | X |
| Financial support schemes | Several regional support mechanisms (about 2/3 of states). | 50% fiscal rebate; 110% depreciation alongside energy efficiency improvements; regional grants for storage in Lombardy and Friuli Venezia Giulia. | No | Federal investment grant; some regional support mechanisms. |
| Remaining barriers | Double charging for BESS connected to the grid, poor smart-metering infrastructure. | Political uncertainty on the various support schemes, net-metering. | Incomplete smart-metering infrastructure, lengthy DSO approval processes. | Poor smart-metering infrastructure. |

Ref: Solar Power Europe (2020): European Market Outlook for Residential Battery Storage 2020-2024.

# ❑ Current Status

- Market benefits of ESS



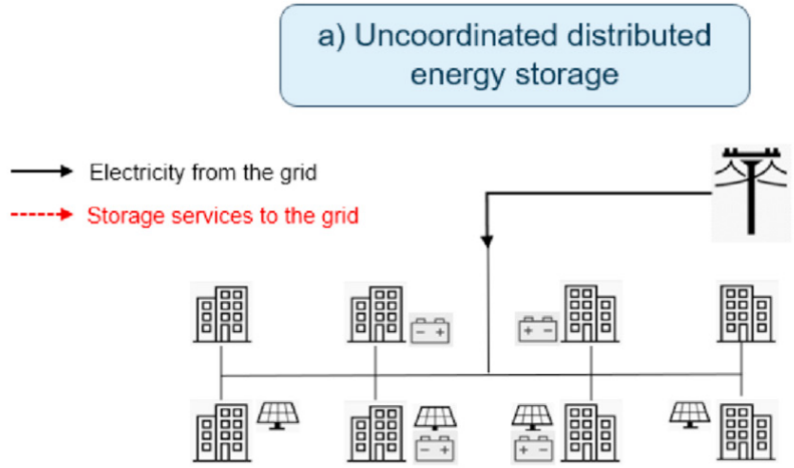
# ❑ Current Status

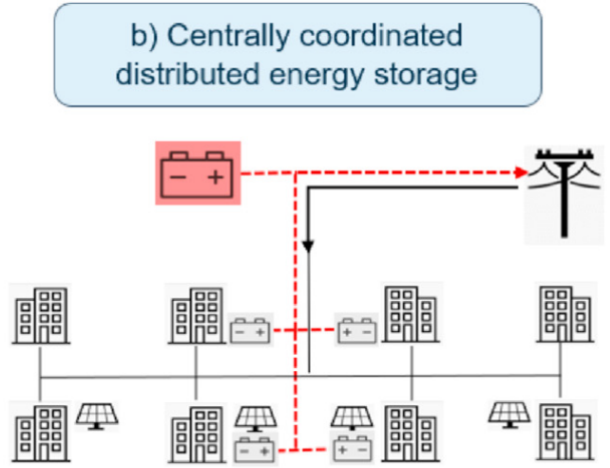
- Market barriers
  - ✓ Less favour compared to the dispatchable generators in some markets
  - ✓ lack of clear mechanism for participation in the wholesale market
  - ✓ Participation mechanism in local energy market framework is not defined yet--significant barriers to entry for small-scale
  - ✓ Lack of price signals presents and revenue compensation mechanisms
- ➢ Economic barriers
  - ✓ High capital cost-- uncertainty in investments
  - ✓ Lack of standards and experience in ESS development and deployment
- ➢ Technical barriers
  - ✓ There are very limited studies available on lifetime and degradation limitations, standardized control and interfaces, grid impacts and benefits
- ➢ Other regulatory barriers
  - ✓ No incentive to provide flexible generation power quality services
  - ✓ No obligation for renewable generations to install energy storages

Ref: M Bahloul, A Majumdar, M Daoud, S Khadem, Energy Storage System: A Potential "Flexibility Resource" to Accelerate the Decarbonisation of Smart Grid Network, MEDPOWER 2020

# ❑ Current Status

- How distributed ESS are generally controlled?



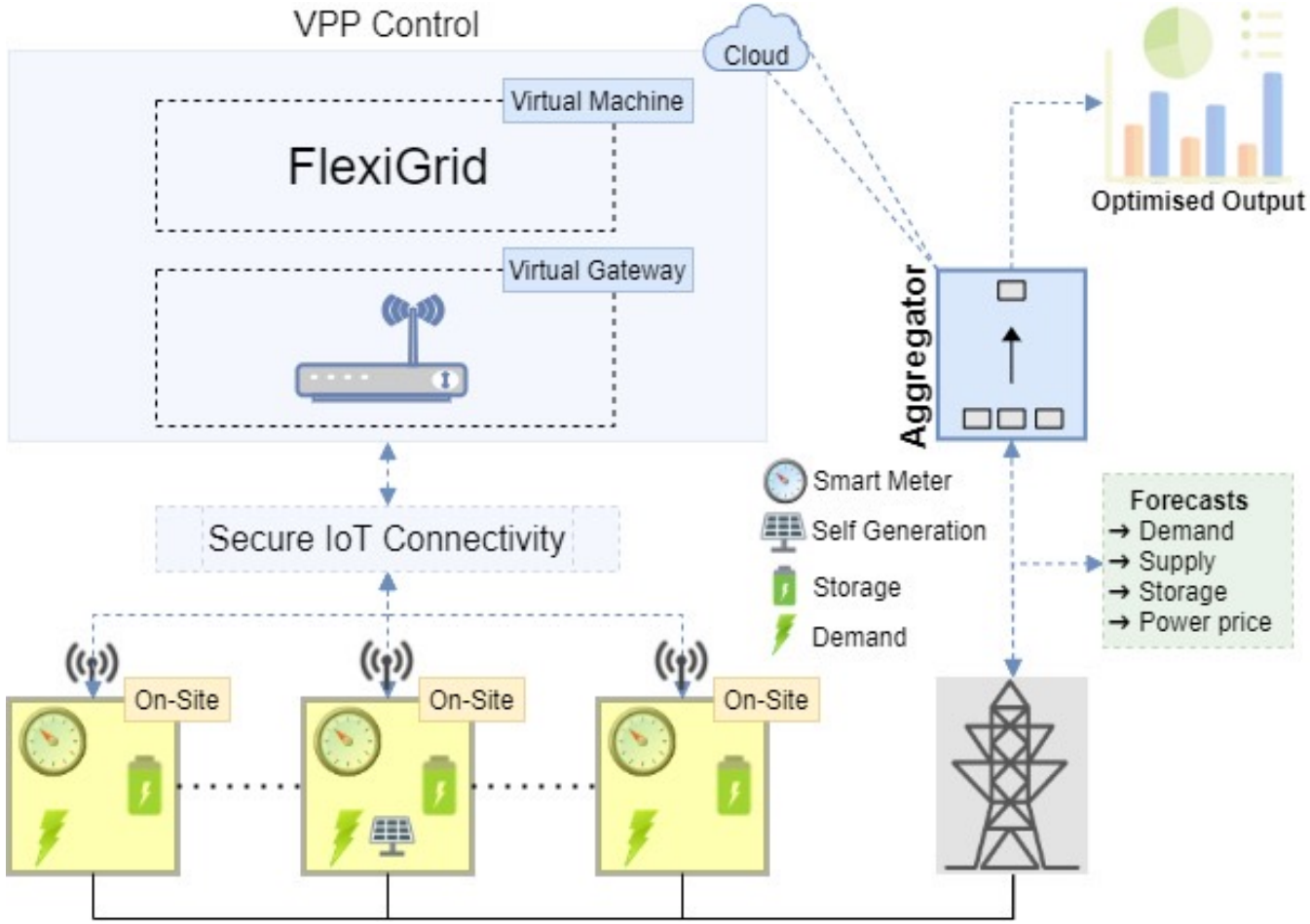



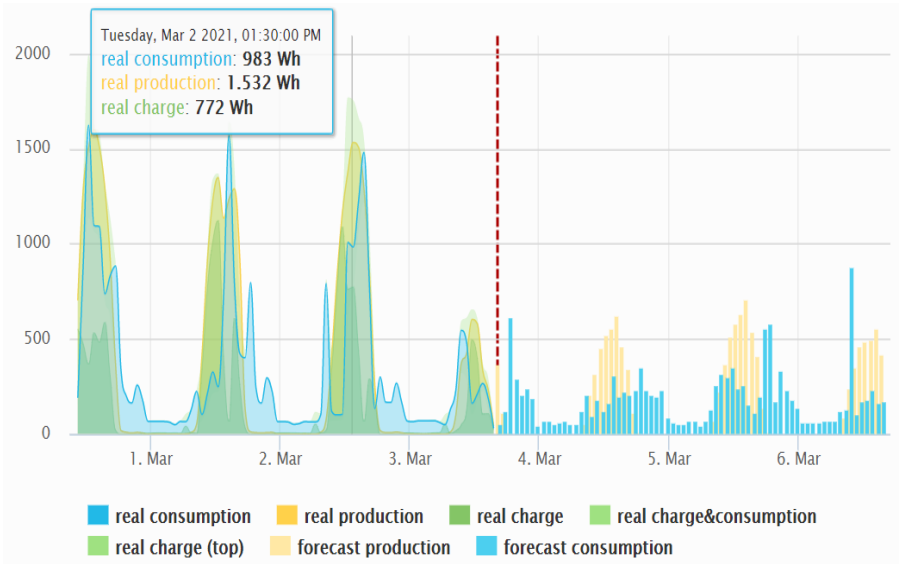

| | | | | |
|---|---|---|---|---|
| **System-level benefits of distributed storage:** | Possible peak shaving or load leveling (indirect, uncoordinated) | | Peak shaving, load leveling, ancillary services, reserve capacity, T&D deferral | |
| **Private consumer:** | *Without storage* | *With storage* | *Without storage* | *With storage* |
| **Additional cost:** | - | Investment on storage | - | Investment on storage |
| **Storage strategy:** | - | Optimization of own consumption | - | Provision of storage to the grid |
| **Leverage to reduce electricity bill:** | Not available | Reduced cost by use of storage onsite | Reduced cost grid-level | Reduced cost grid-level |
| **Revenues from storage aggregation:** | - | - | - | Yes |

Ref: Behnam Zakeri, Giorgio Cas, Centralized vs. distributed energy storage – Benefits for residential users, Energy, Volume 236, 2021

# ❑ Analysis Approach

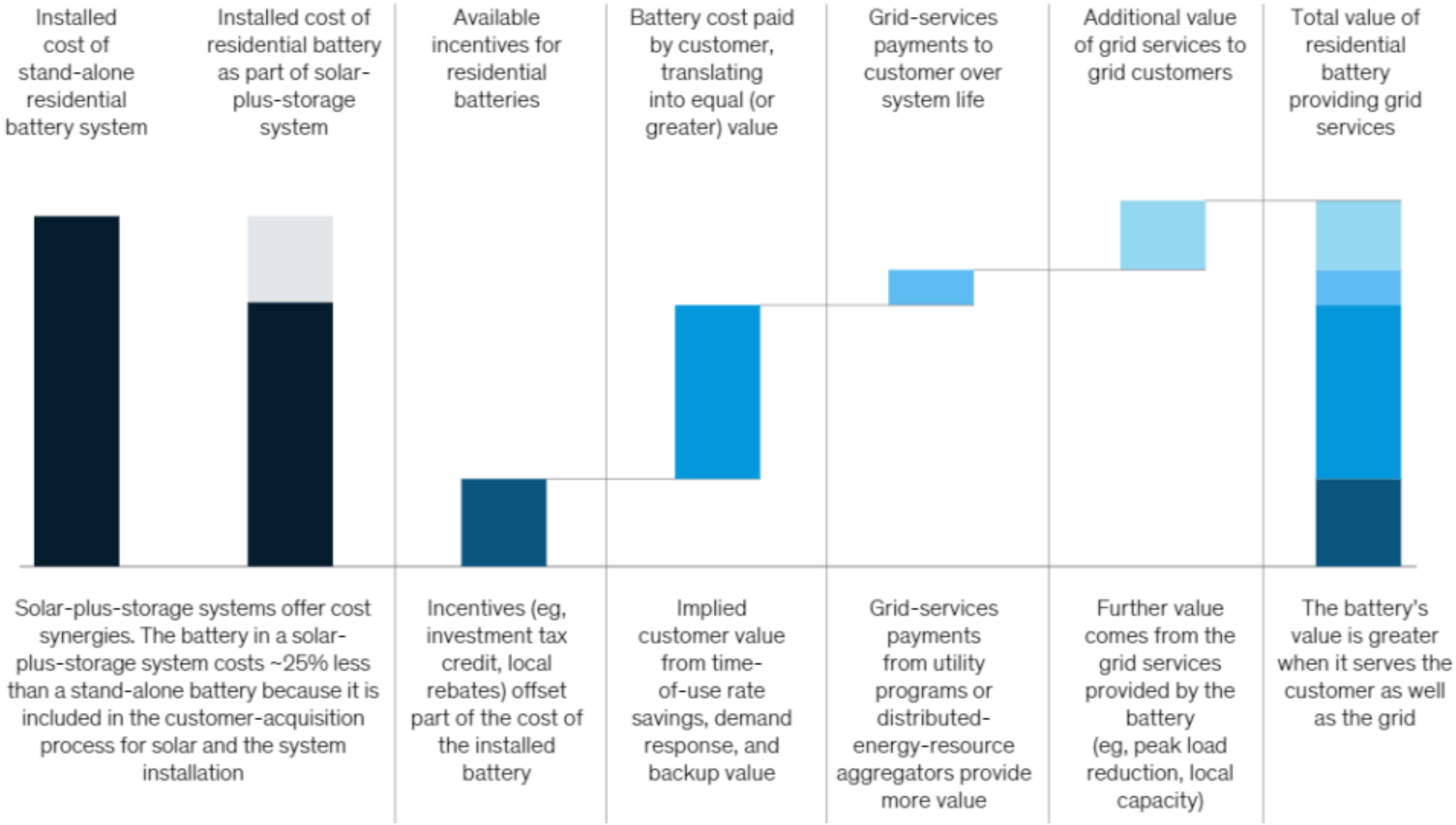
- How distributed ESS can form a VPP?



# ❑ Analysis Approach

- How it can provide more benefit?

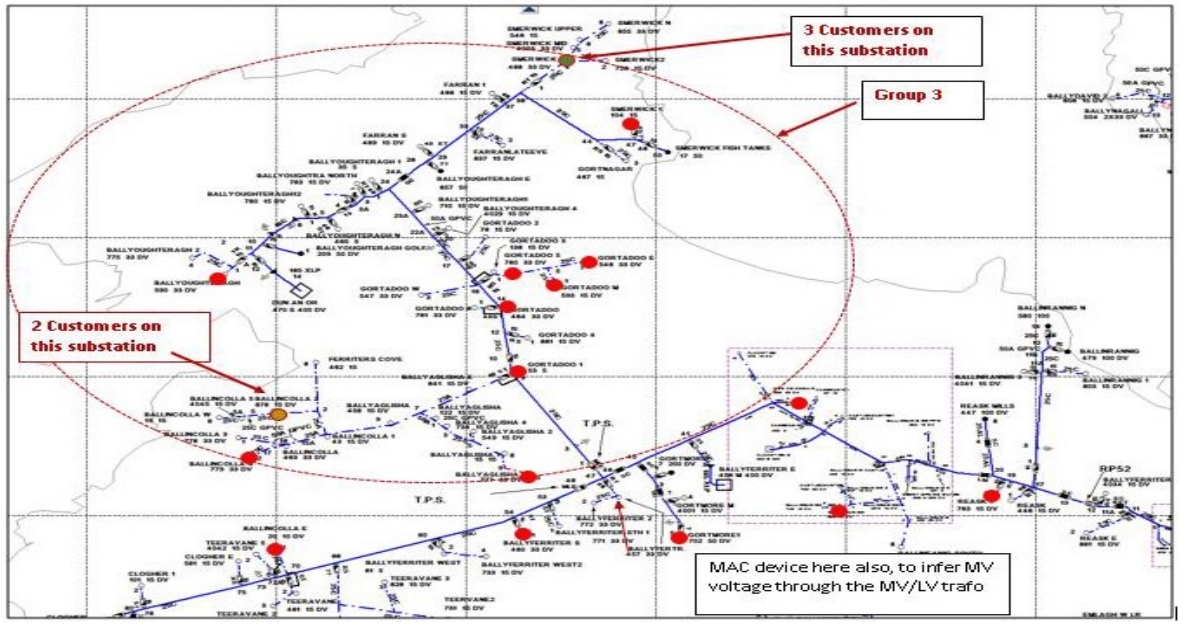


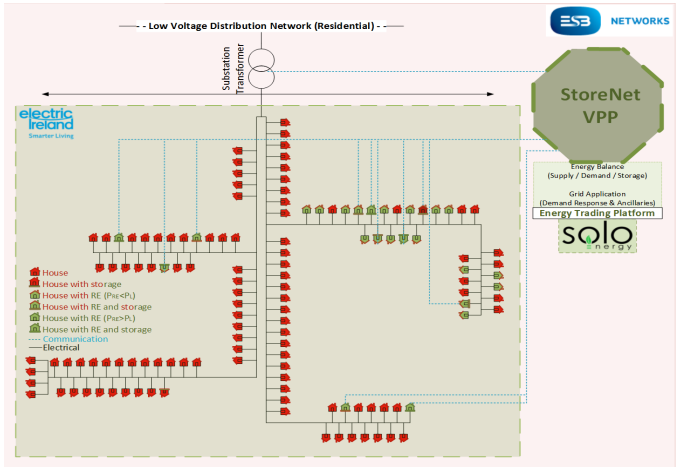

Ref: J Finkelstein, S Kane, M Rogers, How residential energy storage could help support the power grid, 2019

# ❑ Analysis Approach

## StoreNet

- A distributed ESS based residential VPP
- A real-life demonstration project
- First of its kind in Ireland
- Demonstrating the value proposition of consumers/prosumers, aggregator, network operator

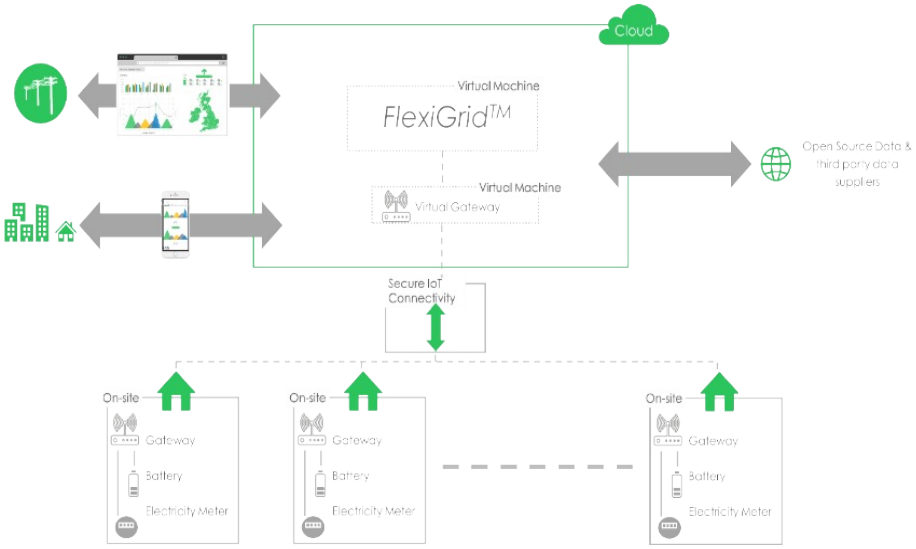



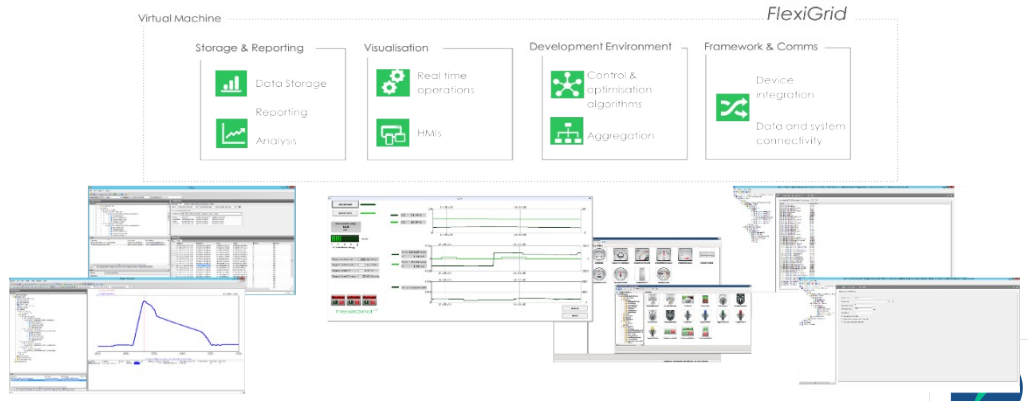



# StoreNet

- Recommend the technical specifications of the required integrated infrastructure

VPP architecture – a cloud based platform, *FlexiGrid*, incorporates a Supervisory Control and Data Acquisition (SCADA) control system which communicates in real-time across a private IoT network to energy storage assets across the grid.

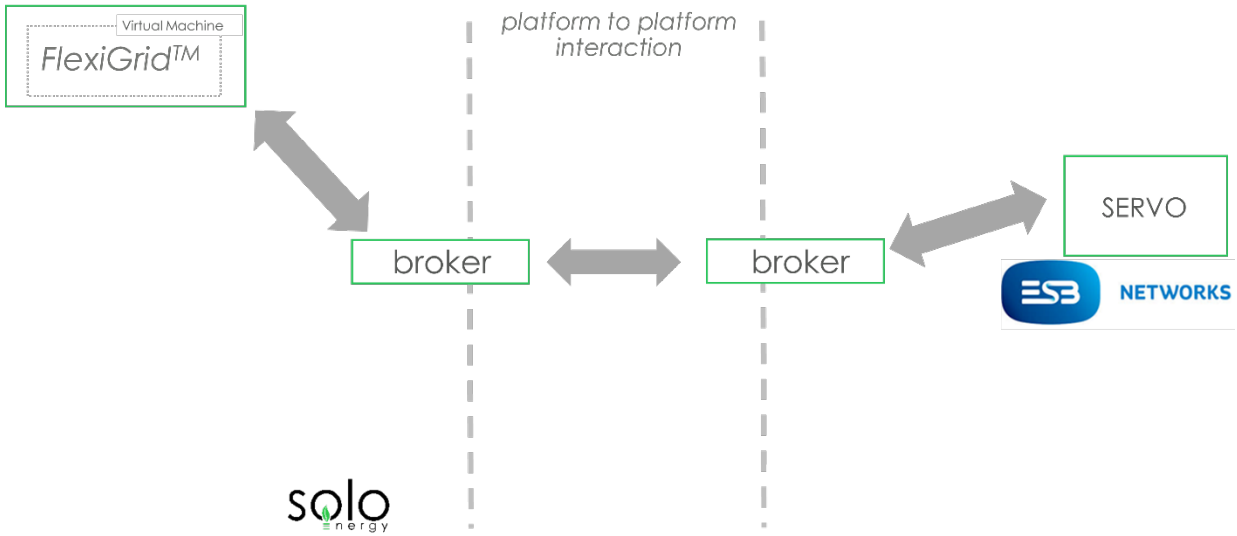


# StoreNet

- Identifying the ICT mechanism for the stakeholders

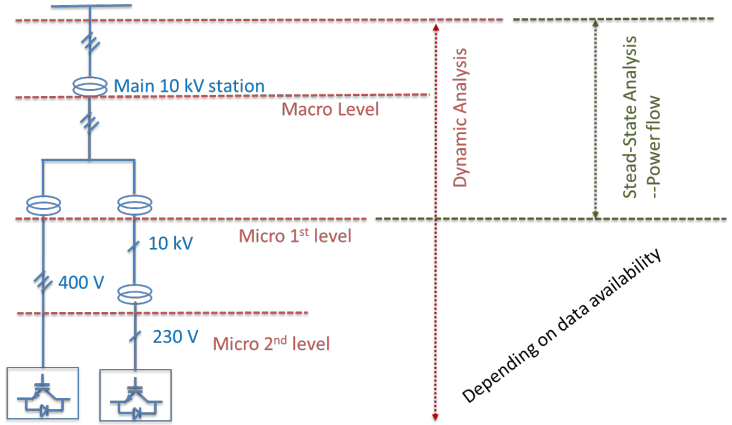
Solo and ESBN have already fully tested the interaction between the FlexiGrid platform and ESBNs' *SERVO* platform via an MQTT broker. For example, performance data such as active power output, grid voltage, frequency, battery state of charge, and power factor has been successfully published to, and received by, ESBN.

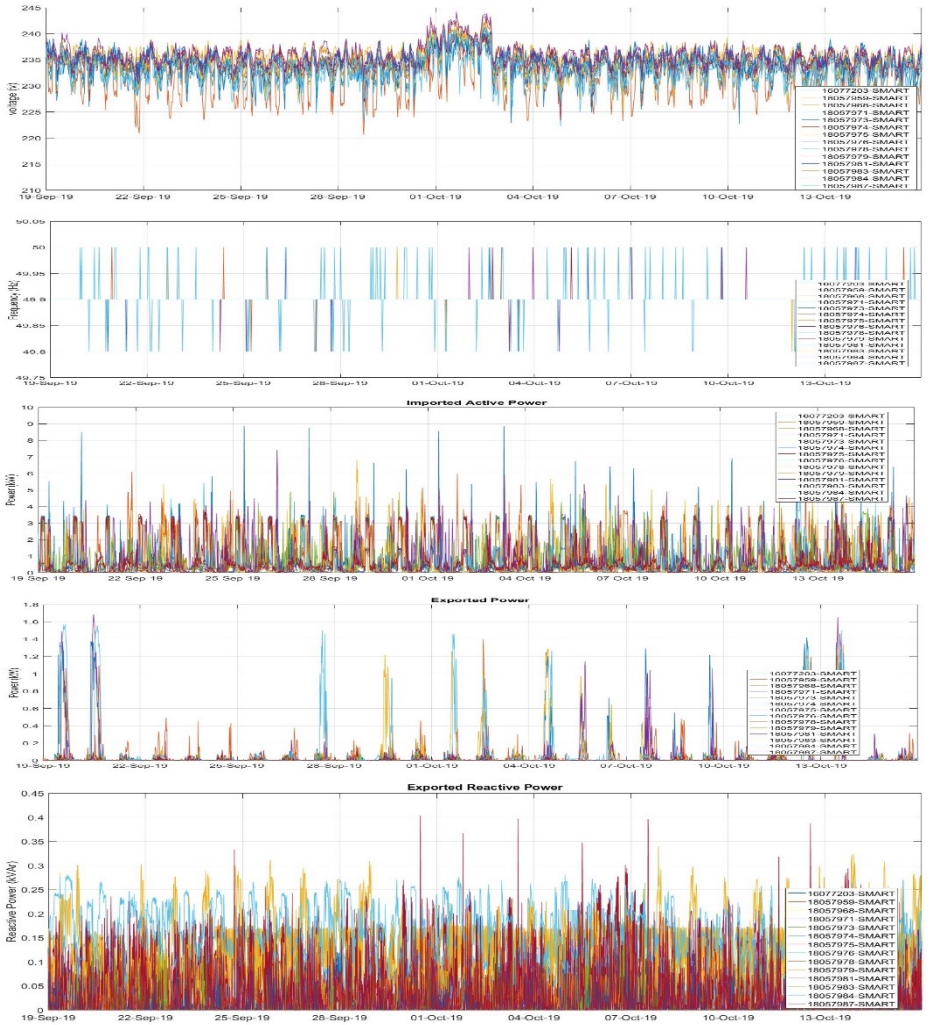



Platform to platform API interaction using MQTT

# StoreNet

- LV Network Analysis (how the solution provides grid services / stability improvement / high penetration of clean energy…)

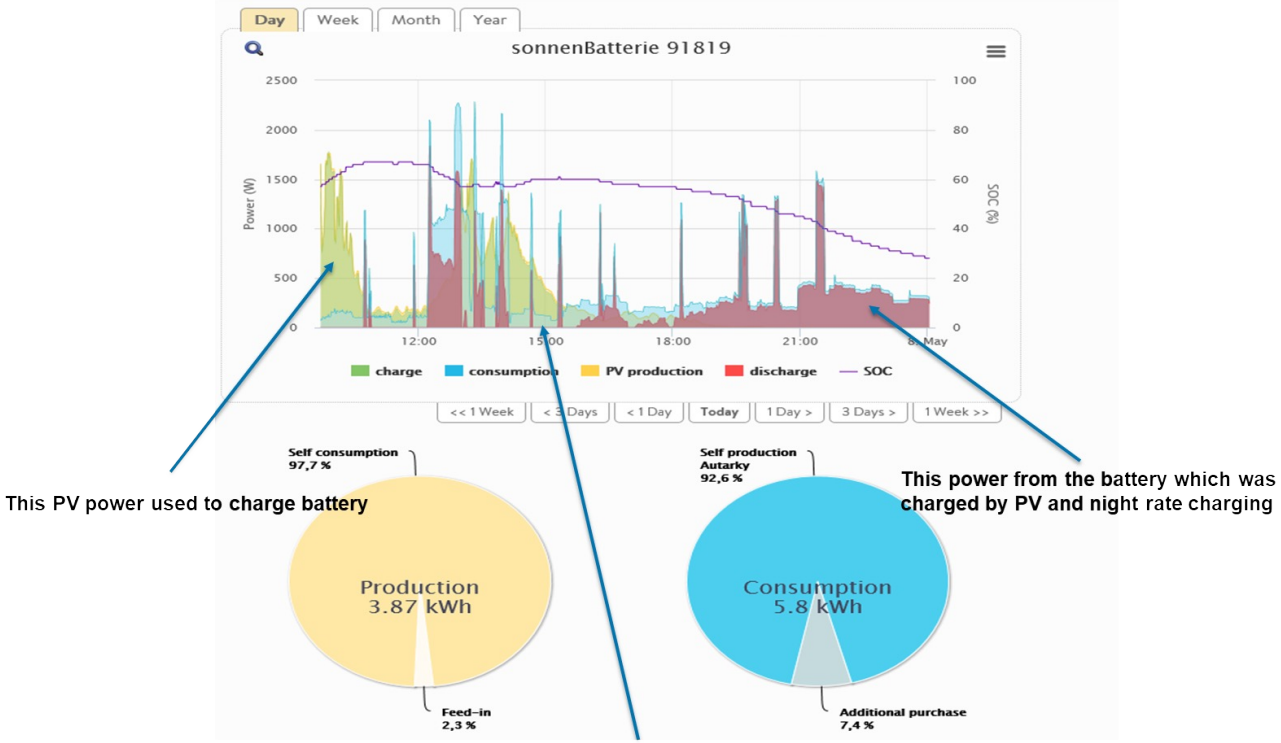


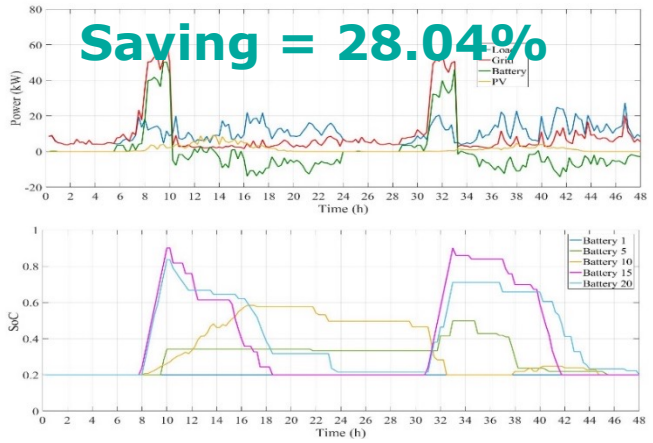
# StoreNet

- VPP optimisation

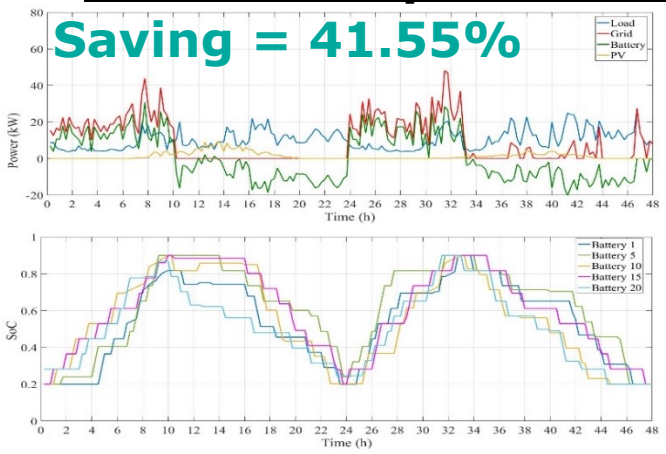
PV production consumed in-house, also used to charge battery plus battery discharged to house



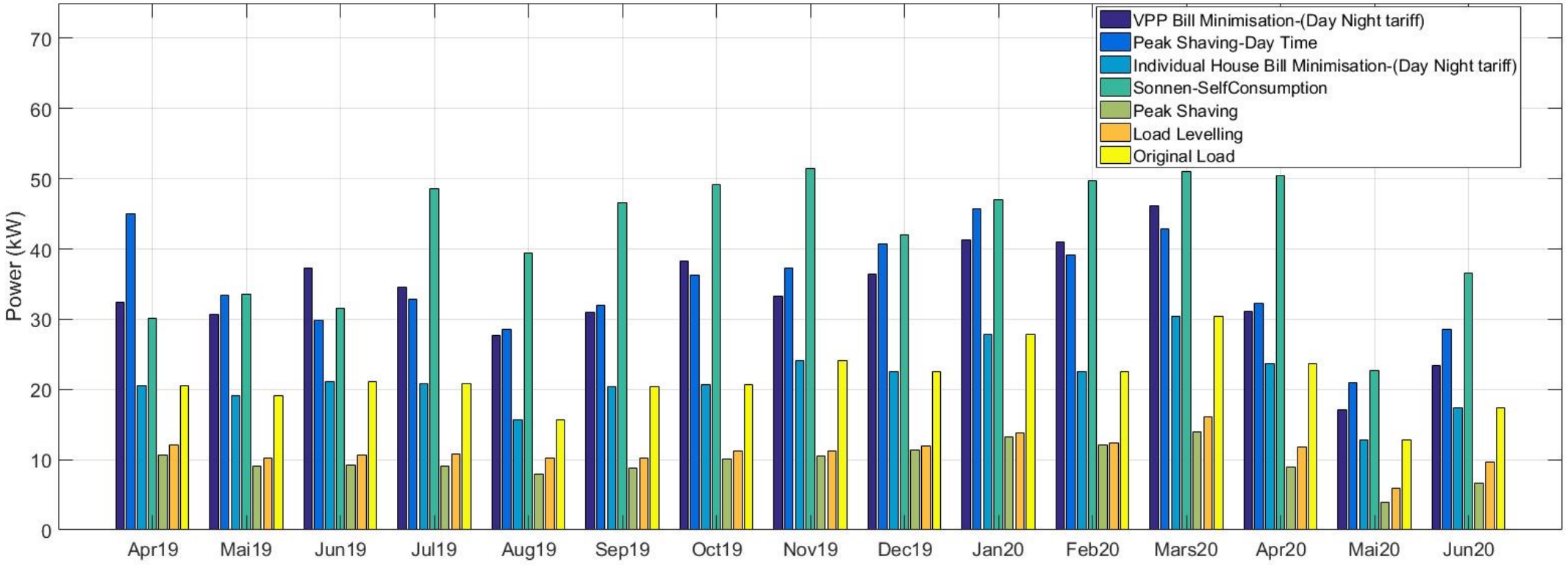

## Individual house optimization



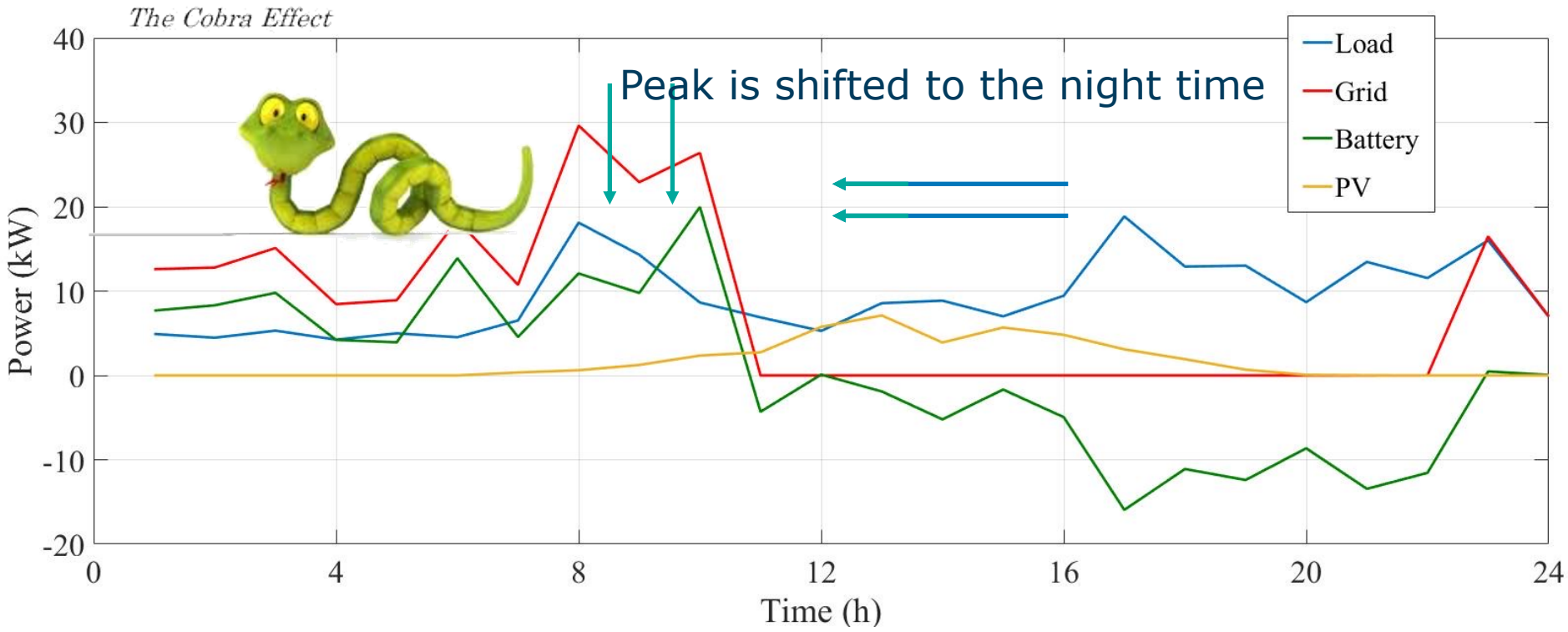

## Combined optimization



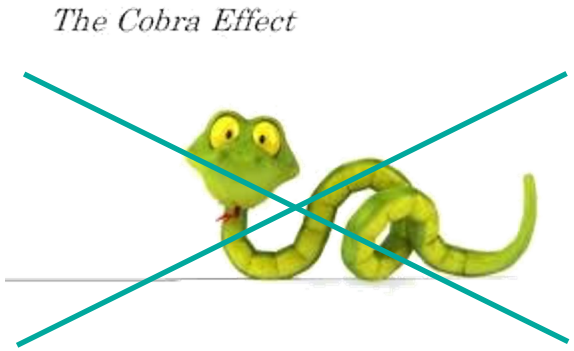
StoreNet


VPP Bill Minimisation-(Day Night tariff)
Peak Shaving-Day Time
Individual House Bill Minimisation-(Day Night tariff)
Sonnen-SelfConsumption
Peak Shaving
Load Levelling
Original Load
Power (kW)
0
10
20
30
40
50
60
70
Apr19
Mai19
Jun19
Jul19
Aug19
Sep19
Oct19
Nov19
Dec19
Jan20
Feb20
Mars20
Apr20
Mai20
Jun20

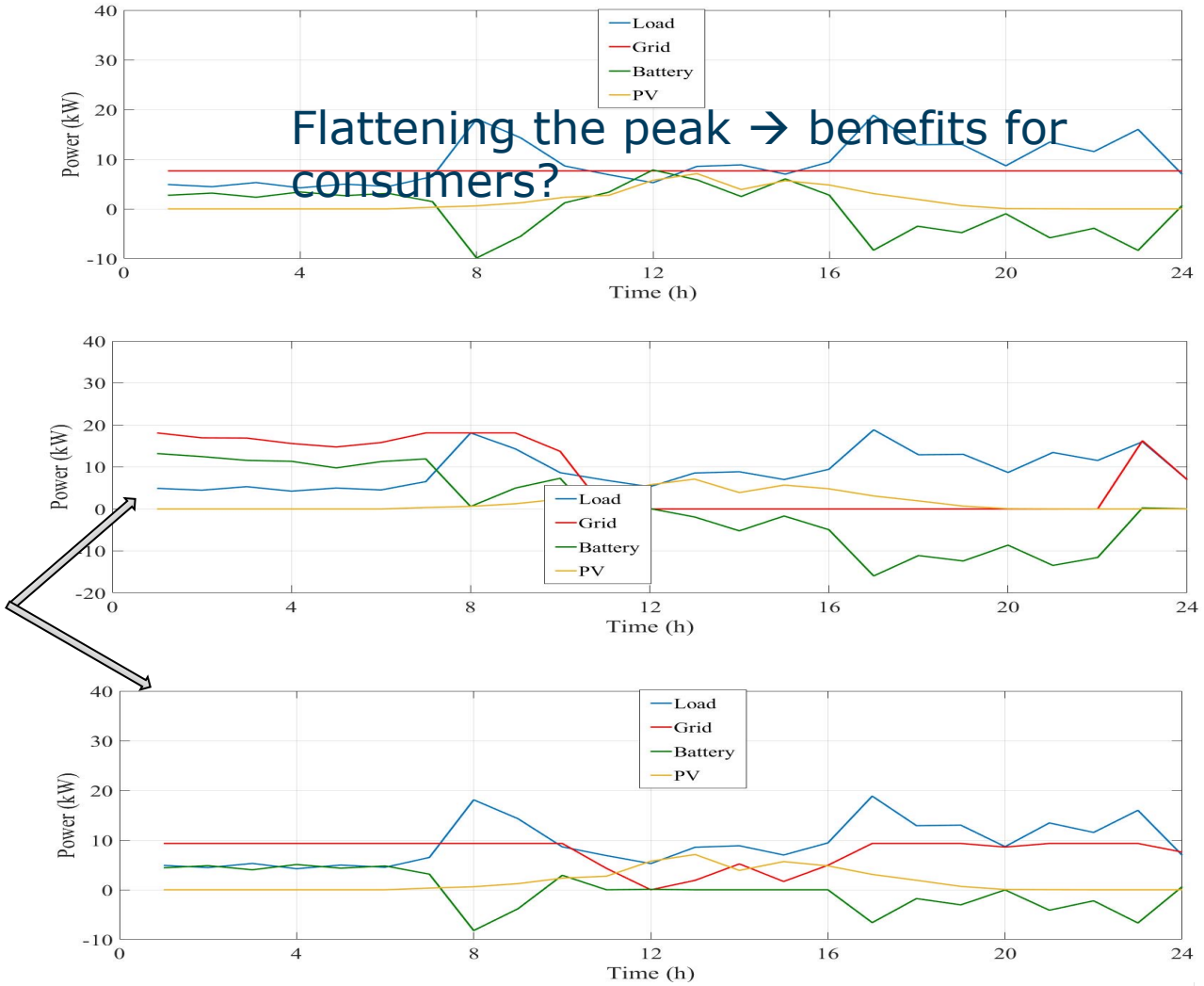
# The Cobra Effect



# Conclusion




Adopting a novel tariff Scheme:
- Shift the consumption to the night time
- Minimise the Peak during night time




Flattening the peak → benefits for consumers?

## ❑ Key Findings

- ✓ How to maximise the utilization of ESS even when there is no separate regulation for storage installation in LV network (has to follow under the microgeneration regulation)?
- ✓ Whole system integration
- ✓ How to motivate passive consumer to become energy active consumer?
- ✓ Doing research with high TRL and developing solution for multi-stakeholders benefit
- ✓ Developing innovative business case for the benefits/value proposition of all involved stakeholders (Aggregator, DSO, Utility supplier, Consumer)

## ❑ Key Findings

- ✓ No separate regulation for storage installation
- ✓ Funding mechanism
- ✓ Purchasing equipment
- ✓ Hardware and software standard and reliability
- ✓ ICT solution (internet connectivity)
- ✓ Consumer engagement (especially in remote/village areas)
- ✓ Introducing local ambassador (to motivate the community participants for the demonstration of the solution)
- ✓ Secure data sharing mechanism

## ❑ Key Findings

- ✓ The project serves as a proof of concept for delivery of grid services from residential assets (energy storage). We see it as an important demonstration to facilitate the development of a marketplace for such services in Ireland.
- ✓ It presents a real-world demonstration and verification of the functionality of VPP software solution, FlexiGrid.
- ✓ It is highly energy efficient and intelligent solution
- ✓ Highly prospective
- ✓ Highly Replicable

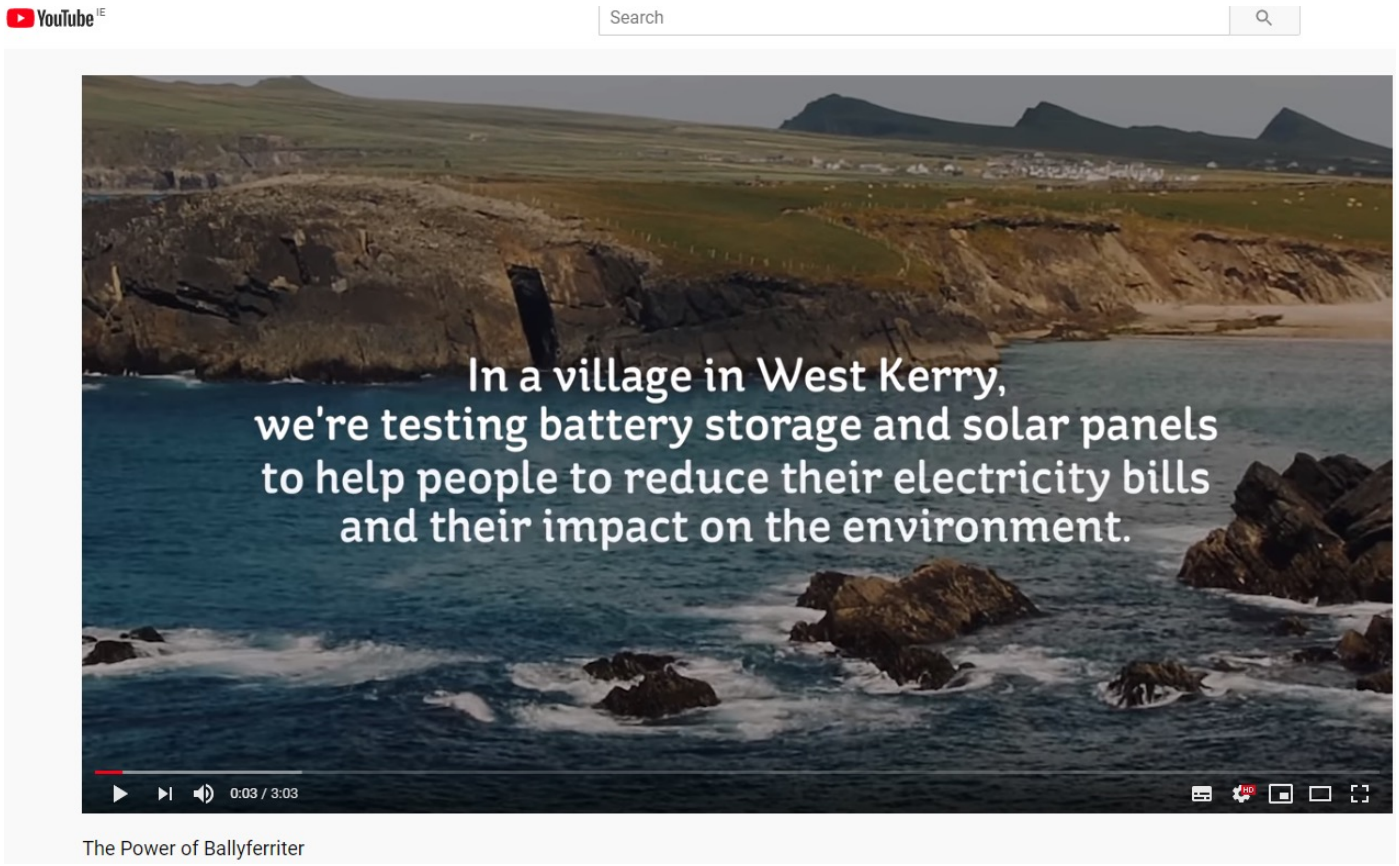
✓ TRL: 5 to 8

## ❑ Questions remaining, Other challenges to address

- Consumers interest on DSM participation
- How to improve the grid services (not only in the DSO level, decarbonize the LV network but also for DS3 services)
- Impact on Power quality (minimizing harmonics) due to high penetration of small scales renewables, PE converters, non-linear smart loads.
- Participation in peer-to-peer energy trading, energy market, from local to national/regional market

# ❑ Conclusion

## ✓ The real impact of **StoreNet**: The Power of Ballyferriter



# Thank you for your interest.

Shafi Khadem
shafi.Khadem@ierc.ie
+353-21-234-6694
PSMA Energy Storage Committee