Energy Storage and Its Applications In the Development of a 21st Century Electrical Grid

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Power networks

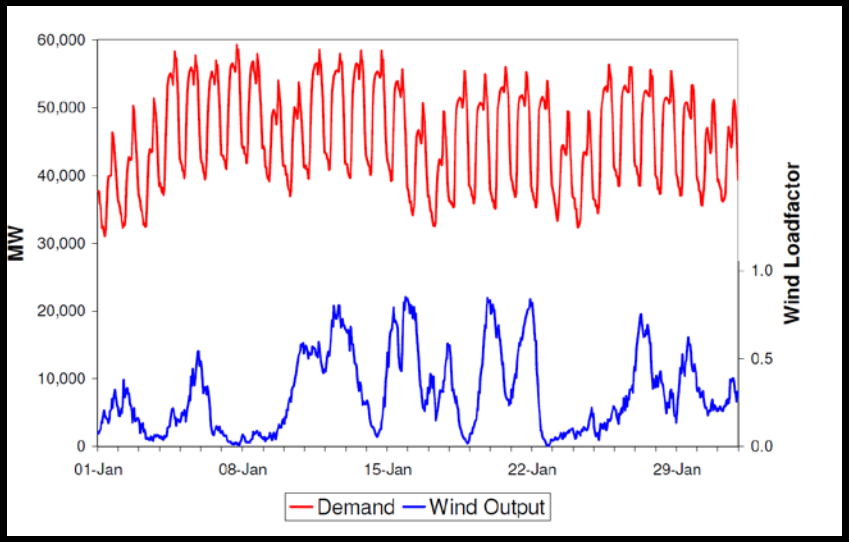
Today's network

- Large scale generation, through transmission, distribution to users
- Limited embedded generation
- Limited number of self suppliers
- System planned to meet peak demand plus reserves – spare or under utilised assets
- Low level of interconnections to other systems
- Regulated wires businesses
- Facing substantial change

The future

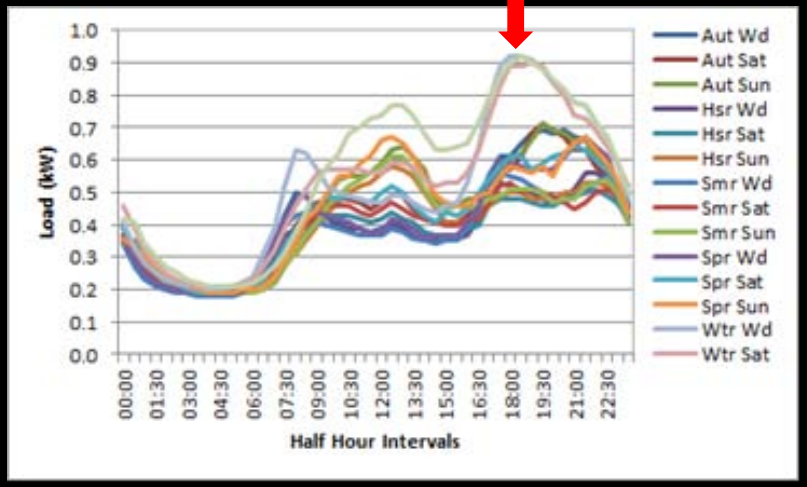
- Shift from dispatchable generation to time variable generation
- Peaky demands from digital society, switch to heat pumps, electric vehicles
- Distributed community and domestic level generation and trading
- Average and peak domestic demand likely to increase
- Balancing the system requires more flexibility

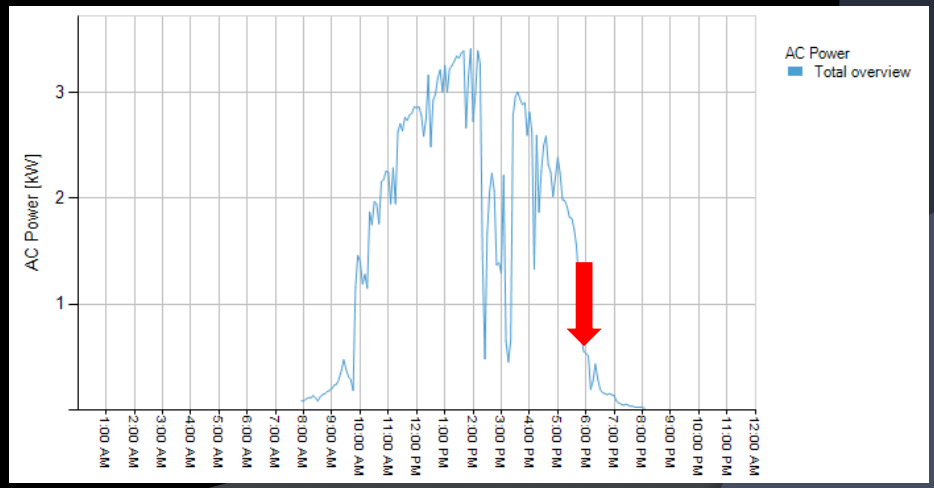
The Problem



Demand

Wind





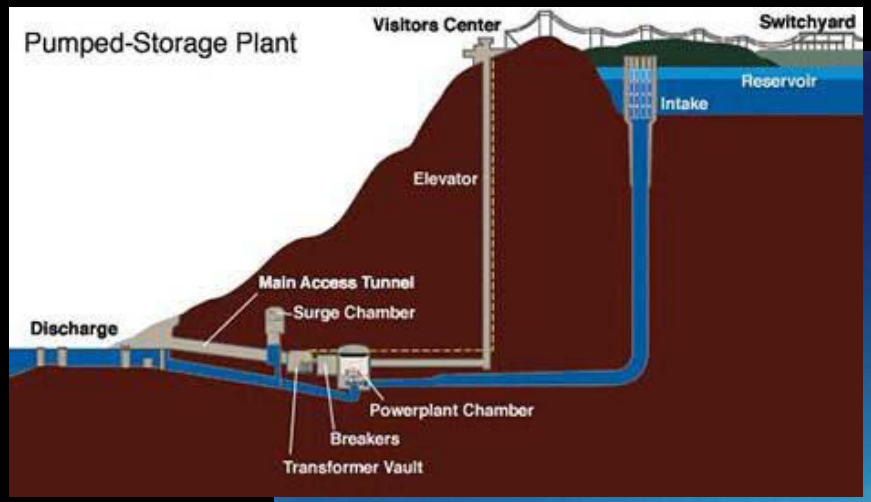
Typical Household

Daily Solar

Storage can help with this and more!!

Storage Comes in Many Forms

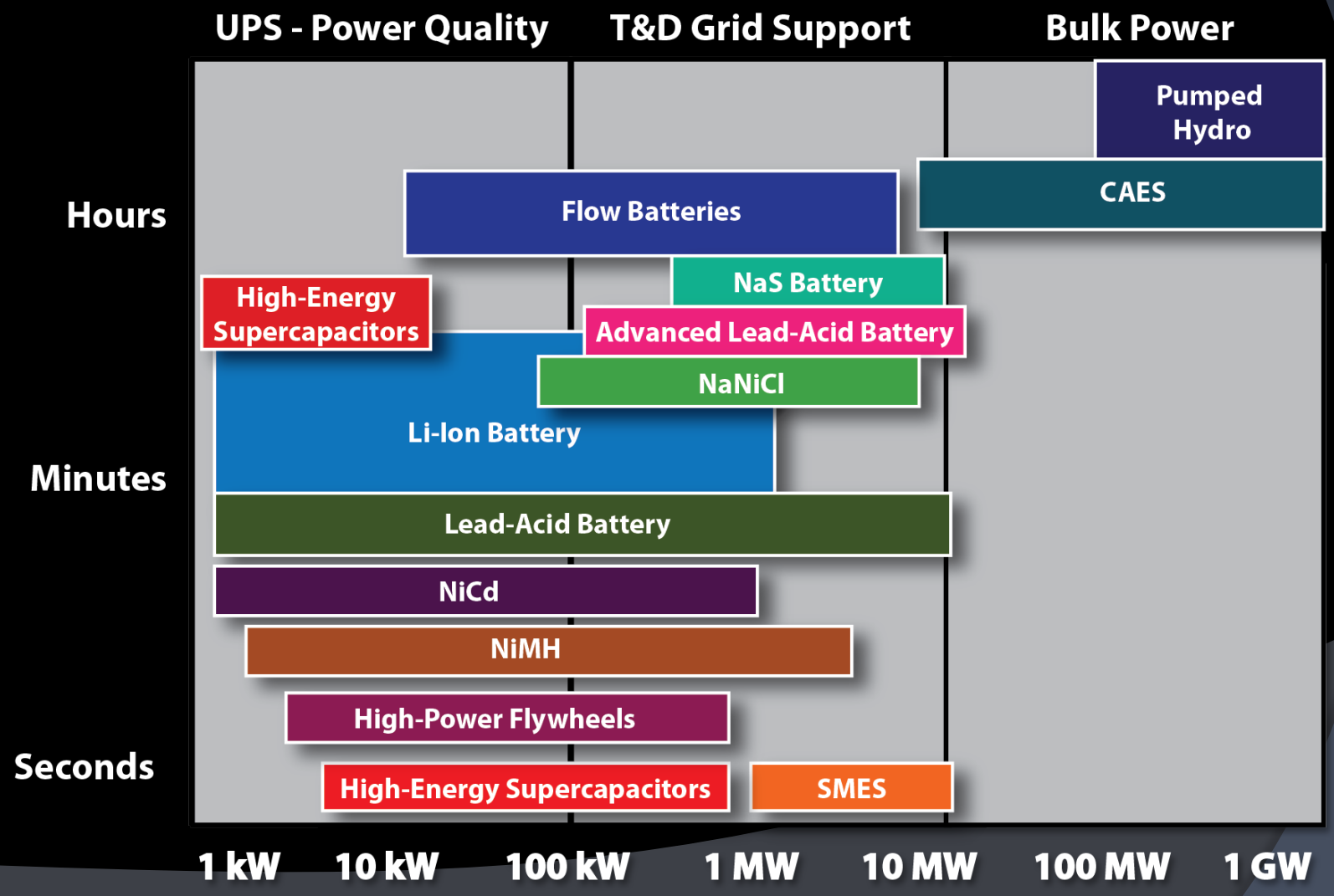
From this…



To this…

… and much in between

Storage Technologies



Distribution Systems

- These are no longer passive
  - Power now flows in both directions
  - Embedded renewable generation can be intermittent
  - Voltage becomes more difficult to control
  - Often phase loading is unbalanced making conventional voltage control back at the substation difficult.
  - Generation maximum output may not match demand maximums

- The use of distributed storage can help with many of these problems.

So what services can storage provide?

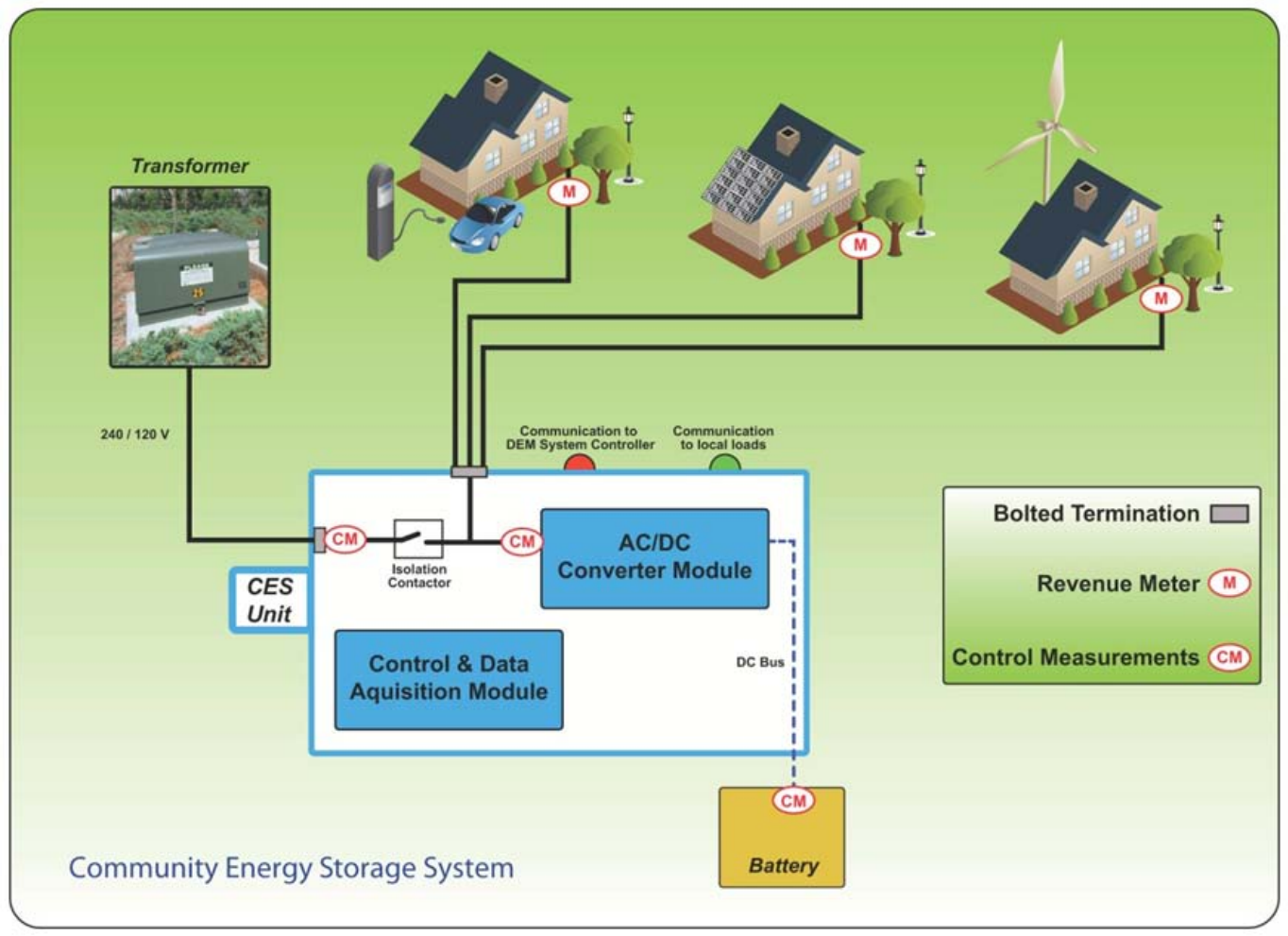
- Storage can provide a whole range of services that contribute to both the transmission and distribution system.
- Grid Tied Storage (located at the main substation)
  - Peak shaving by active power control
  - Fast response system balancing services
  - Power factor support by reactive power Control
  - Voltage support by both active and reactive power control
  - Reserve system balancing services
  - Wholesale market services

So what services can storage provide?

- For distributed/embedded storage
  - Protection from Power Outages
  - Peak shaving
  - Load factor improvement
  - Voltage profile improvement
  - Reverse current flow mitigation

Community Energy Storage

- One way to provide this embedded storage is to use Community Energy Storage

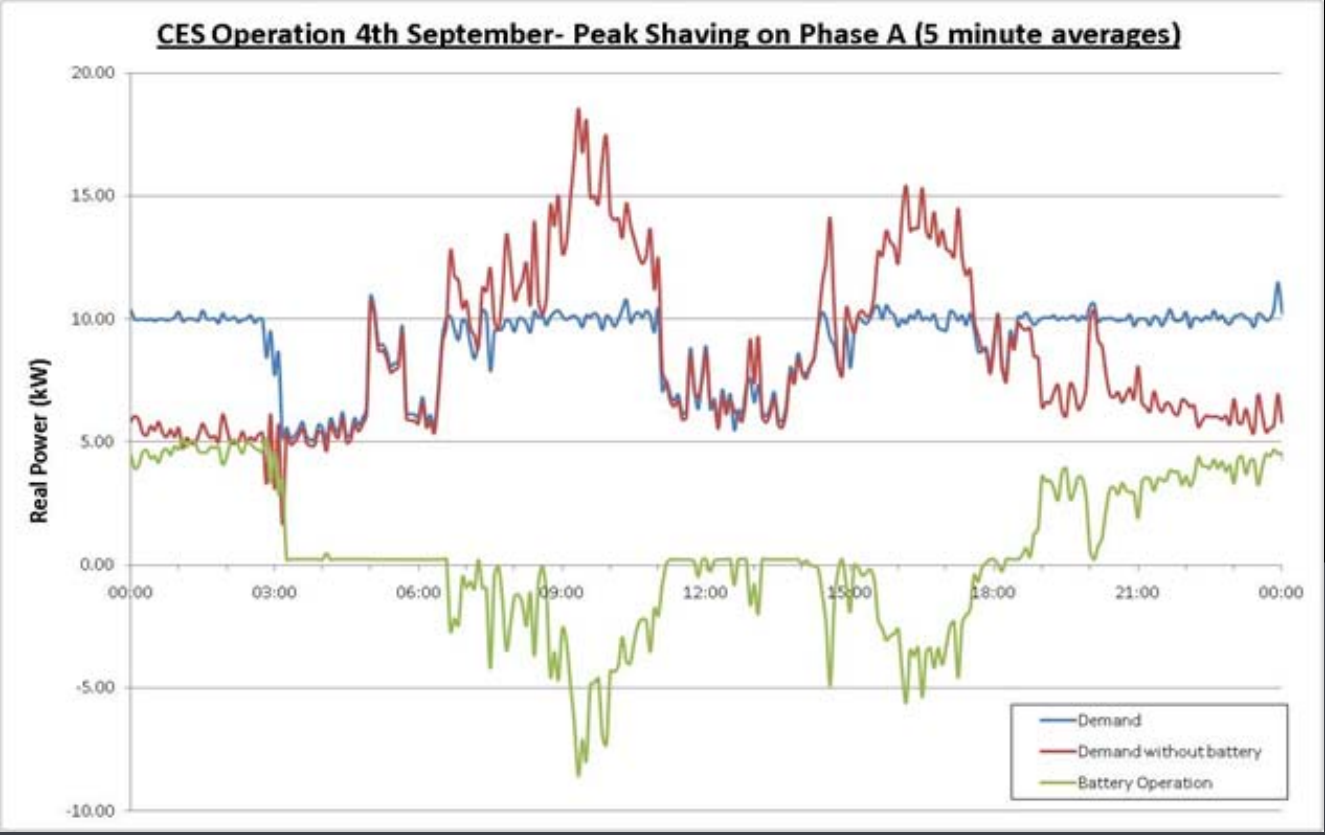


Protection from Power Outages

- The use of storage can protect communities from power outages.
- The storage can support the load for the period in which it is off supply.
- This can either be for short interruptions or longer periods depending on the amount of storage installed.

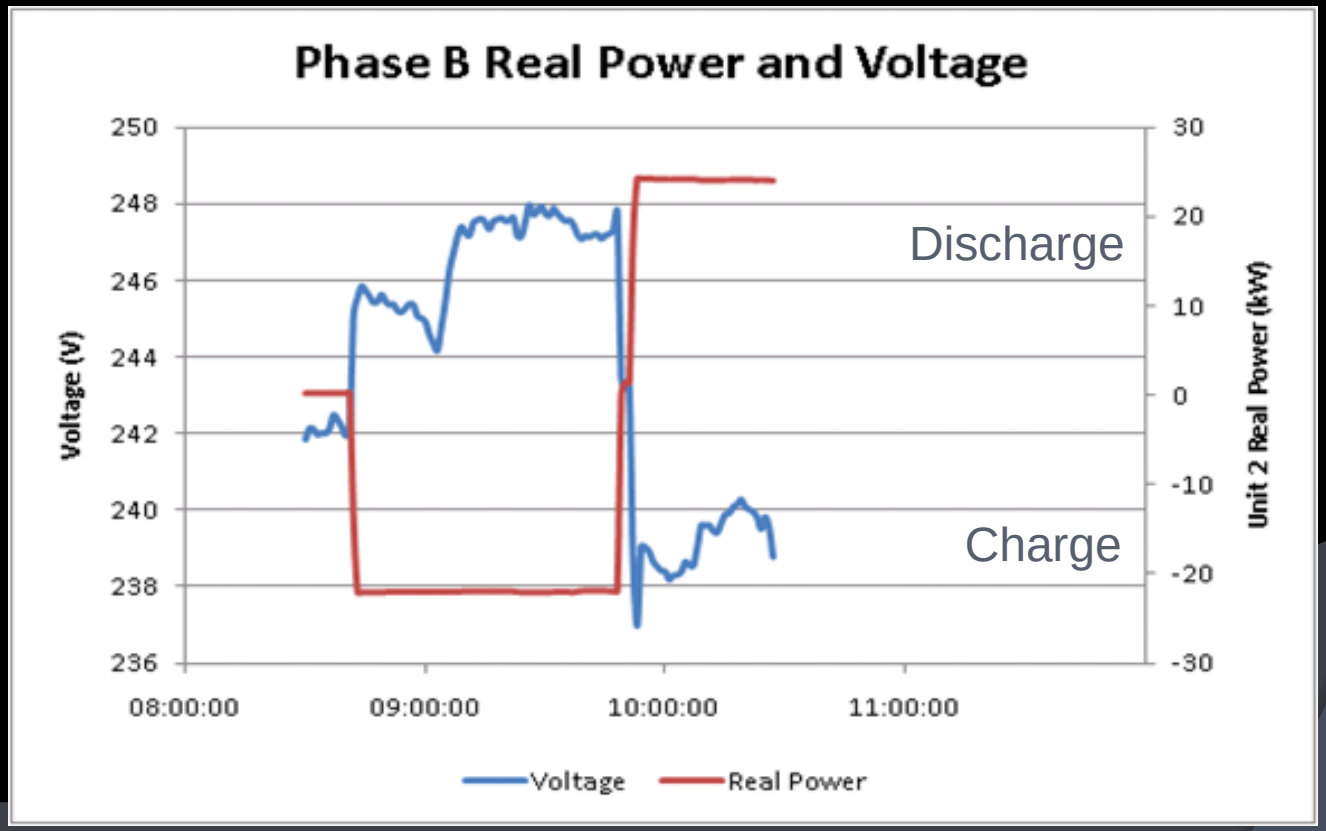
Load Factor Improvement

- By shifting the peak demand by discharging storage and then increasing minimum demand by charging the storage the load factor of the feeder can be improved. This may also allow asset replacement deferral.



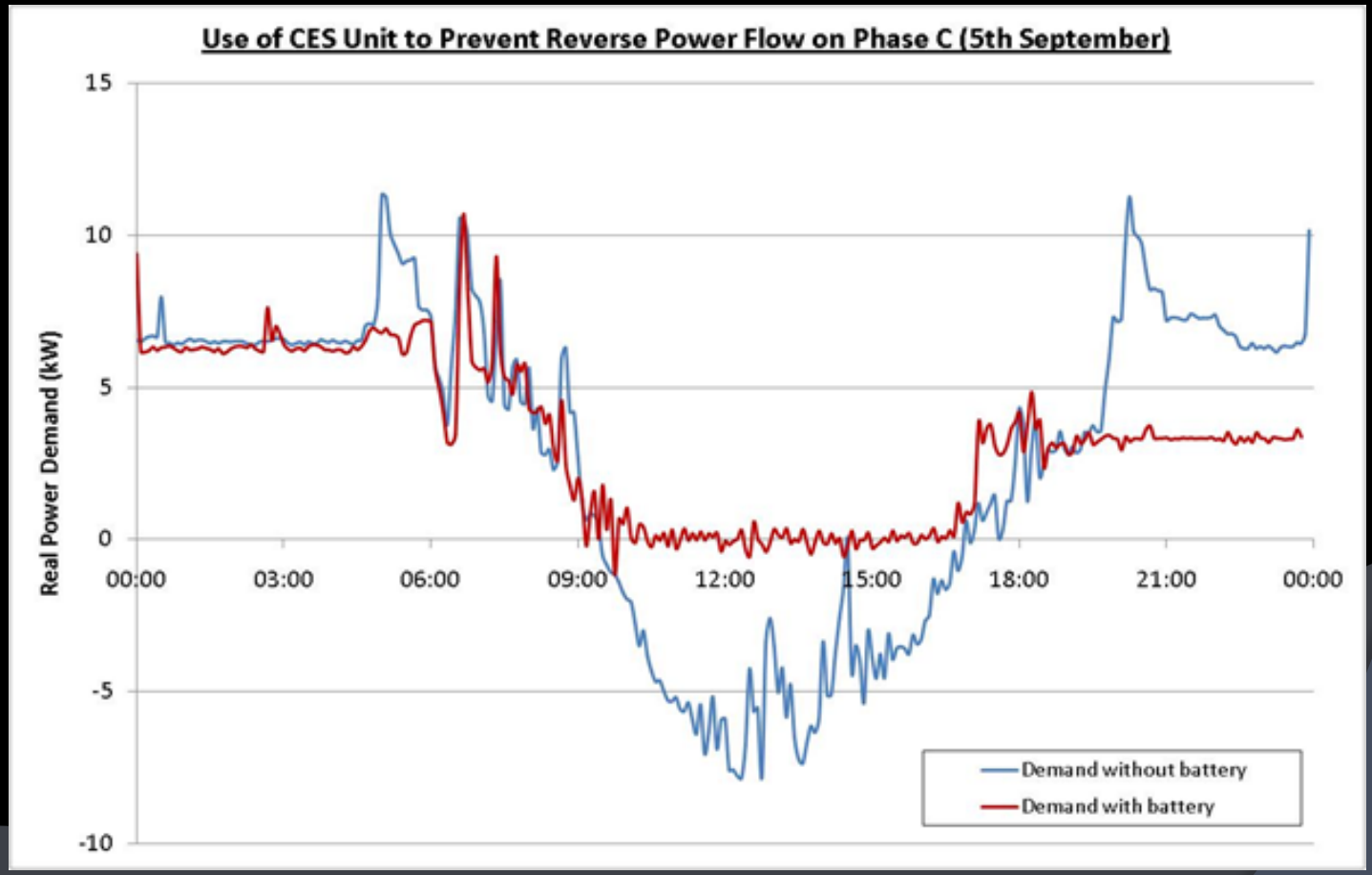
Voltage Profile Improvement

- Storage can be used to help keep voltages within statutory limits.
- On lower voltage systems this is mainly affected by real power flows.



Reverse Current Flow Mitigation

- The introduction of embedded renewable generation often causes reverse current flow. Many utilities would like to avoid or keep this to a minimum.

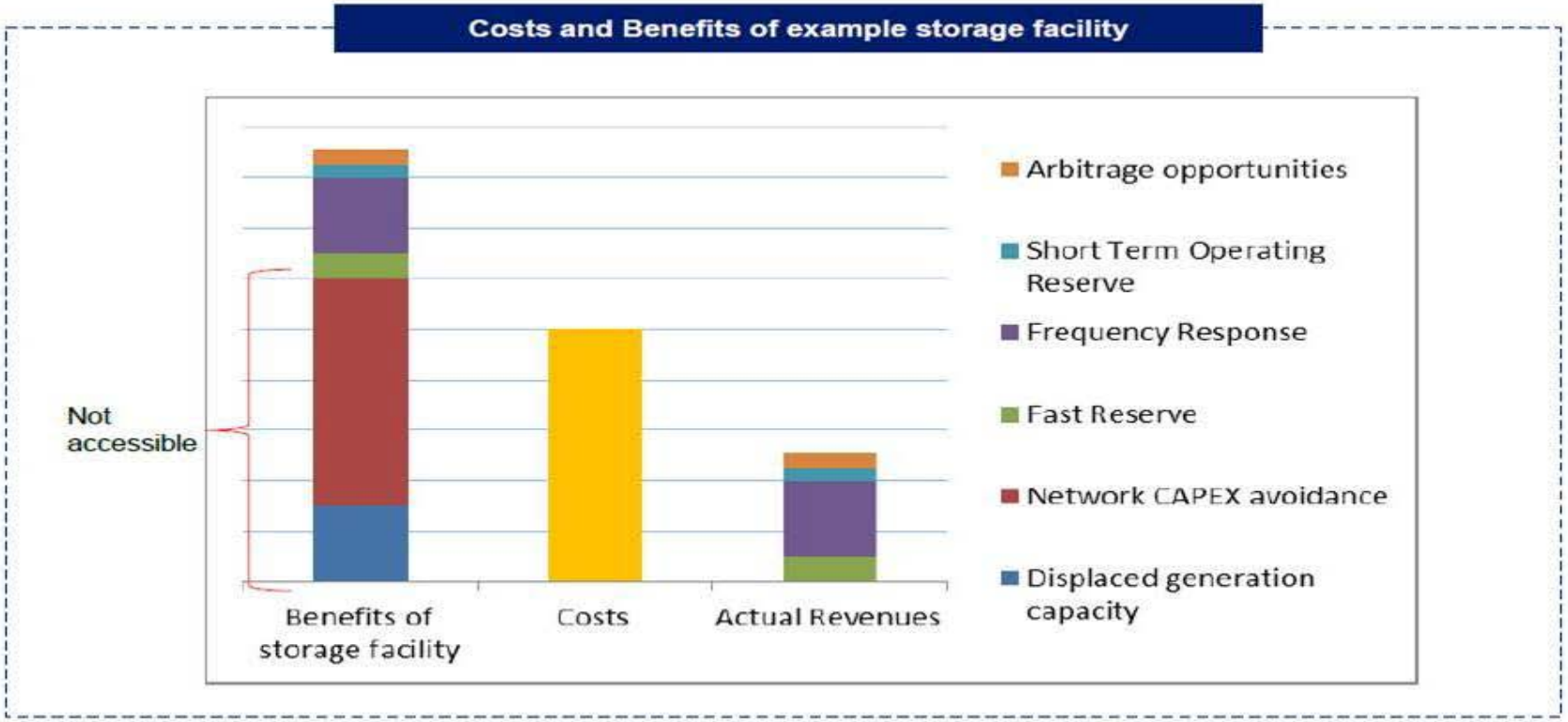


Micro-Grid Systems

- There are often reasons to create micro-grids
- These could be small grids that need freedom from power interruption.
- Or isolated communities that would be very expensive to supply via traditional transmission/distribution.
- These are more and more attempting to use renewable sources of energy where possible.
- By combining this renewable energy with energy storage the use of expensive diesel generation can be avoided.

Locked Revenue

In reality some revenue streams are accessible and others not



Revenues attributable to wider system benefits – which is a large part of the storage value proposition - currently are not accessible

Storage – Europe

- Italy – 2% additional return if the TSO And DSO invests in energy storage - $320m market
- Germany – government introduced self consumption subsidy for storage linked to solar PV <30KWh - $100m market per annum
- Over $1.2bil of energy storage projects have received funding from EU
- Now over 256 storage projects operating in Europe but the majority only tackle a single challenge

Storage – North America

- California has set 1.3GW target of storage to ensure that it can meet its renewable targets - $3 bil market
- New York ISO using FERC order to use storage as better way for frequency response. 750MW @ av. $40MW but paid $3000MW in Jan cold spell.
- Currently over 320 storage projects operating in North America but the majority only tackle a single challenge

Storage – Africa

- South Africa round 3 Renewable Auction pays up to 2.6 times for CSP compared to PV since it can help with Winter Peaks. Renewables will be encouraged to provide ancillary services
- Kenya Light and Power claim for 10.2MW of off-grid built with solar and storage it saves them $550k per annum in operating costs.
- Only 30 recognised storage projects but well over 3000 if we consider lead acid projects that are not counted.
- Out of necessity they are trying to solve multiple challenges with storage

Conclusions

- Energy storage hold great potential for enabling embedded renewable generation.
- In countries where demand is rapidly increasing and where a greater proportion of the generation mix is renewable energy then storage will form an essential part of the system.
- The biggest barrier to large deployment of this technology is being able to realise it's full value chain.
- However, the momentum has started and more utilities are realising it's value and creating market mechanisms to support it.
- This will drive down cost in the same way that it has with wind and solar.