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THE PROMISE OF STORAGE

Integrating Renewable Energy in Mini-Grids

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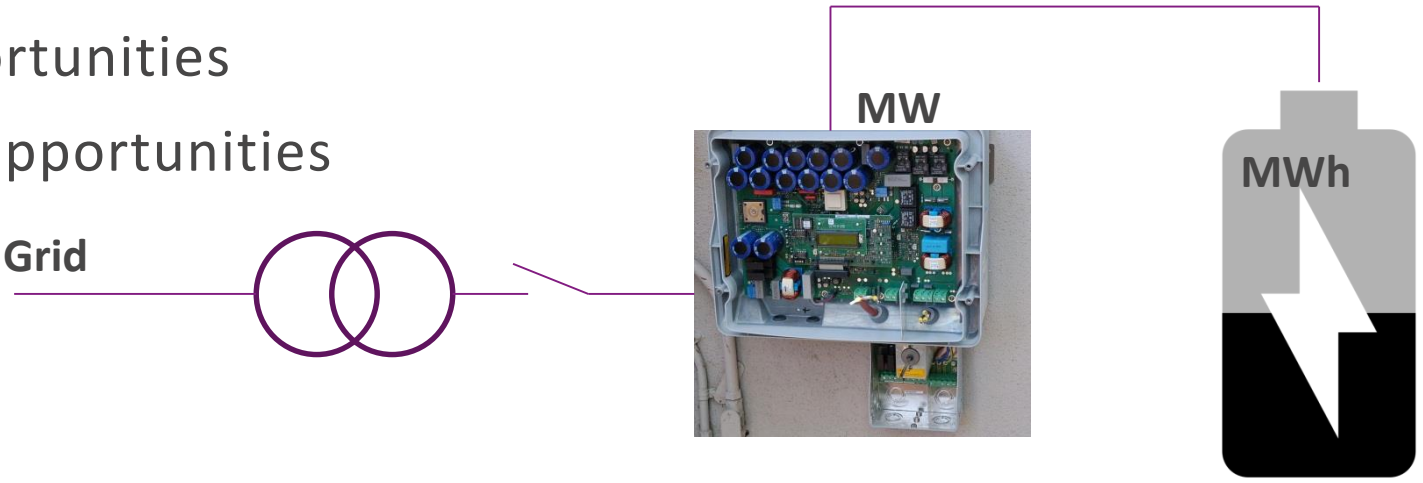
AGENDA

Assumptions

The easy cases…micro-grids

The not so easy ones: medium to large mini-grids in the MW scale

- Technical opportunities
- Price opportunities
- Deferred opportunities



ASSUMPTIONS

If hydro power and storage exists, this changes the mix

- Pushes back or removes need for battery storage (with some reconfiguration as RE increases)

Otherwise, at mini-grid scale, battery storage will beat new PHP

MICRO-GRIDS - VILLAGES

Off-the shelf equipment

Solar + battery (+backup diesel)

- Lithium ion or lead acid battery with large autonomy (1-5 days)
- Very low ratio of power to energy storage (>20 hour)

Grid forming inverters with defined configurations

Reliability not critical

High cost of energy but fixed costs inevitable at this scale

MINI-GRIDS (MEGAWATT SCALE – MAIN ISLAND)

“Easy wins” out the way (~15% solar) – what next?

Wind if you can – peak and night generation without storage

Battery to store the excess?

…or curtail instead?

Curtailing means active control of distributed generating assets:

- A network (island) wide control system
- Short term load balance

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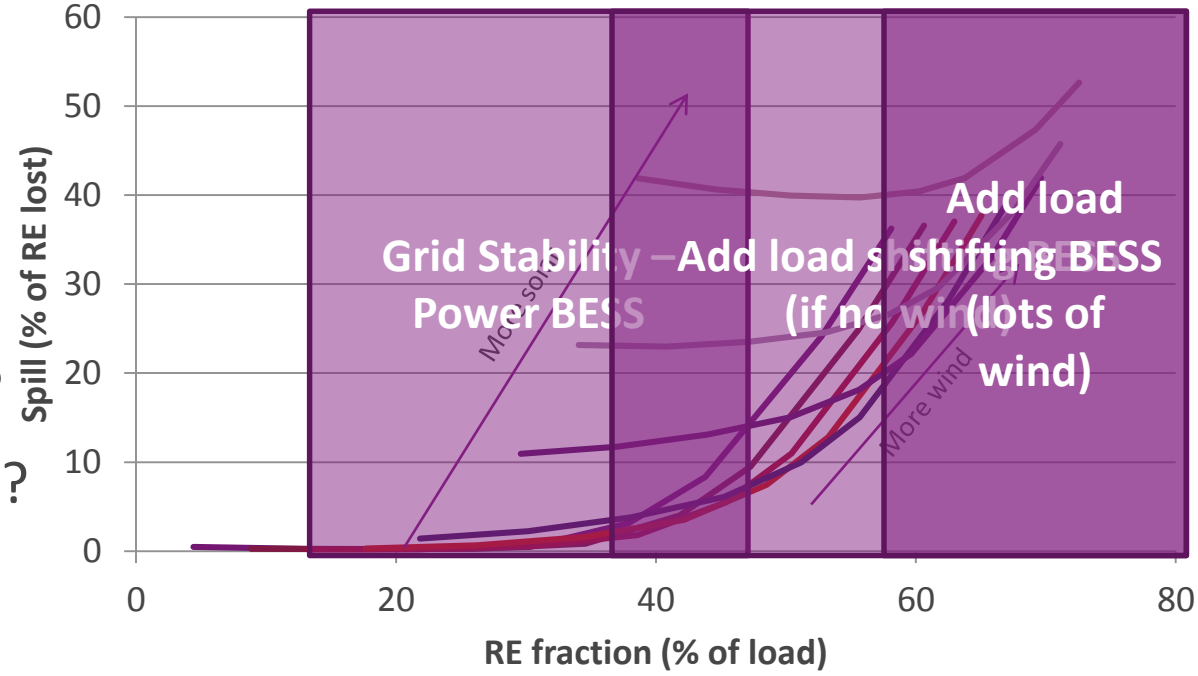
BESS = Battery Energy Storage System
Battery cells + Inverter / Power Conversion System

MINI-GRIDS
WHICH BATTERY FIRST?

50% spill doubles LCOE – similar cost to BESS throughput

But (practical constraints):

- Land?
- Windy?
- RE goals?
- Install capacity?
- Network constraint?
- Short circuit current?



MINI-GRID: GRID STABILISING BESS TECHNICAL ISSUES

Short term load balance:

- Solar + wind + fossil fuel generation (+BESS) = load
- Resource fluctuations = trip (BESS adds spinning reserve/load)

Plus:

- Smoothing; Voltage support; Reactive power support
- Grid forming (voltage source mode)
- Limited fault current

But not (yet):

- Inertia and full fault current

MINI-GRIDS: LOAD SHIFTING BESS TECHNICAL ISSUES

Can you get enough power to it?

- High RE system will generate >3x network load to BESS
- Feeder constraint

Co-locate with generation?

- Reduce and smooth power flows
- Use control modes to manage local voltage issues or provide power factor support

MINI-GRIDS: GRID STABILISING BESS FINANCIAL CASE

Benefit:

- More RE can be connected while maintaining a functional and reliable system*

Cost:

- Energy throughput consumes life: $260/MWh dropping
- Use-it or lose-it: 5/10/20 year calendar life
- Inverter costs marginally higher than load shifting
- Spilt energy from RE
- Losses (minimise throughput)

MINI-GRIDS: LOAD SHIFTING BESS FINANCIAL CASE

Benefit:

- Spilt RE available for use (less round trip efficiency of 12-20%)
- Possible reliability benefit

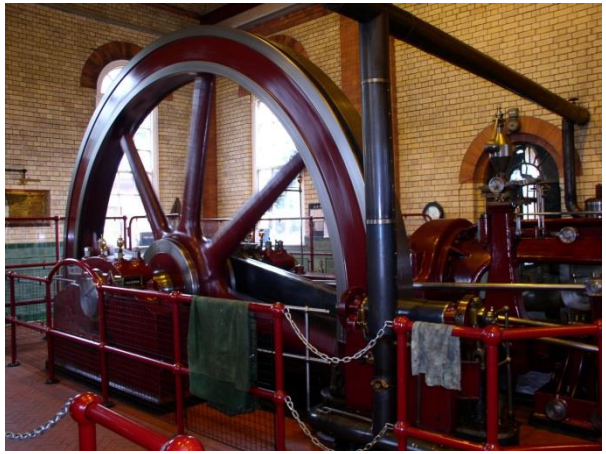
Cost:

- Energy throughput consumes life: $260/MWh dropping
- Use-it or lose-it: 5/10/20 year calendar life

MINI-GRID BESS: COMPARISON

- ½ hour BESS with grid stability functions can enable about 2 x rated power in new solar
- 4 hour load shifting BESS stores energy from about 1 x rated power in new solar
- Grid stabilising benefit up to 8 x load shifting for mid range RE
- Only load shifting can achieve high RE

MINI-GRID BESS: RELIABILITY



BESS are not the answer to everything (yet)

Still need inertia

- Diesel on-line or synchronous condenser
- Fastest response to fault conditions and high fault current

BESS synthetic inertia

- Low maturity and ratio of RE that can be supported are not fully aligned with applications

MINI-GRID BESS:
OPTION OF DEFERRED INVESTMENT

Capex ⇩

Functionality ⇧

Maturity ⇧

But…

RE targets?

Reliability?

Control, forecasting and curtailment can offer some relief (while you wait)

KEY MESSAGES

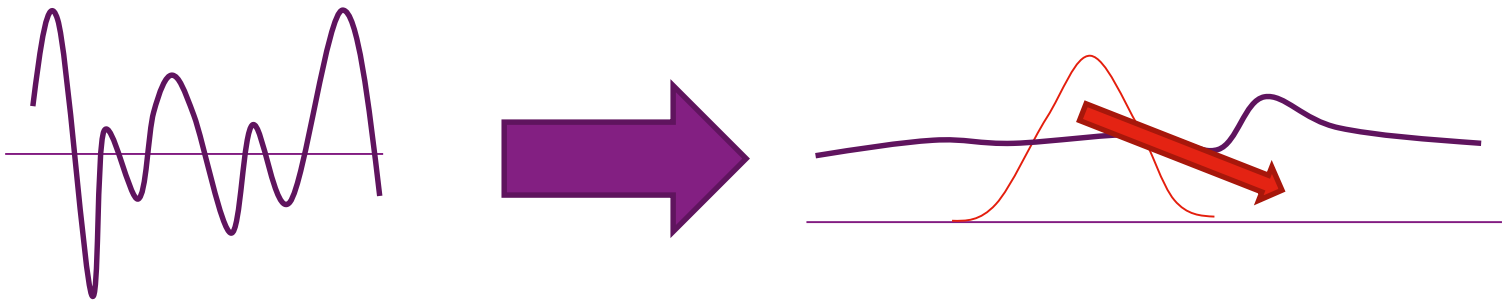
Batteries can enable high penetration RE

First grid stabilising BESS so you can add lots more renewables

Combine with integrated control, maybe some inertia

Then load shifting BESS to store excess

Consider waiting for lower prices and better tech



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