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2026 Energy Storage System Workshop and Learning Visit

Microgrid Technology Powered by Renewable Energy & Battery Storage Systems

From a single storage device to a system that can be repeated

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WHO IS SPEAKING

Electric Power System Research Lab., KIER Jeju

A research group working on how distributed resources connect to, and support, a real power grid

A

Microgrid & MBB

Modular building blocks that make microgrids repeatable instead of one-off projects.

B

VPP & Demand Response

Aggregating distributed resources into a single dispatchable and tradable entity.

C

Power Conversion & Grid Support

Grid-forming converters, synthetic inertia, MW-class wind turbine power electronics.

D

Storage & New Loads

BESS, supercapacitors, reused batteries, EV charging hubs, AI data centres.

The group

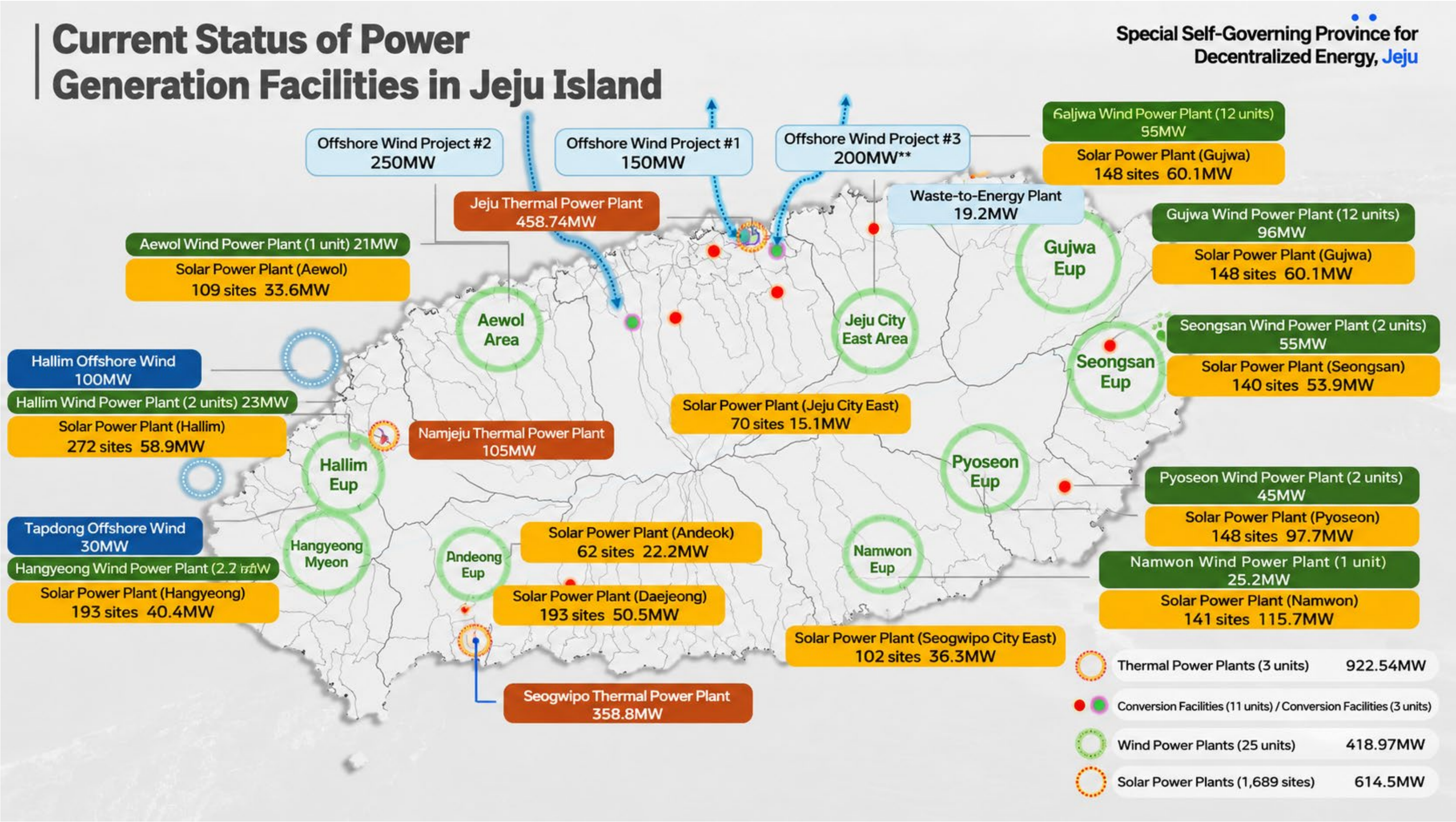
- Nine researchers (8 PhD, 1 MSc), based in Jeju
- Upgraded to a full research laboratory in 2023
- Origin: Convergence Platform Demonstration Lab (2016)

Why Jeju

- An island grid with high renewable penetration and real curtailment
- Everything we design has to survive a small, weak, variable system
- That is the same constraint most of your countries are working under

We are not a battery laboratory. We are a power-system laboratory that uses batteries.

Look around: Jeju itself is one big experiment



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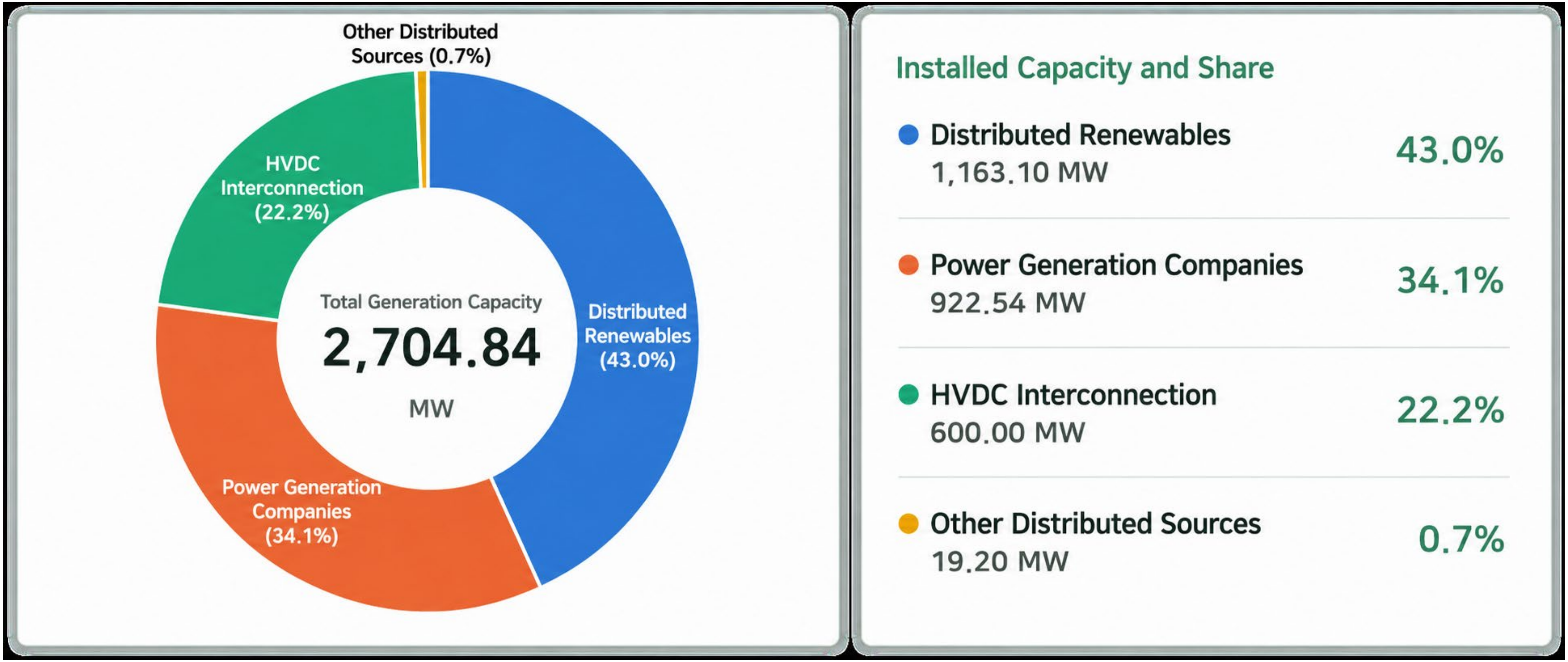


AGENDA

What we will cover in the next 30 minutes

1

Why a microgrid

The problem your systems actually have, and why storage alone misses it

2

What is a microgrid?

Boundary, modes, architectures, and the six jobs of storage

3

Grid-forming, proven on Kaua'i

The control technology islands cannot avoid — and the island that proved it in the field

4

The future microgrid: MBB

Why microgrids fail to spread, and a standard building block — concept, modules, simulation, hardware

5

Beyond one microgrid

The same architecture scaled up: VPP, data centres, and the EV station outside

6

What to take home

A framework for your own country, and for your idea note

Three questions are waiting for you at the end. Please hold them until then, or write them down now.

PART 1 OF 6

Why a microgrid?

1

Three problems almost every island shares — and why one battery does not solve them.

Two slides only: the problems you already live with, and what changes when you draw a boundary around the battery.

Three problems almost every island shares

Whatever the country, the day-to-day story is surprisingly similar

Diesel is expensive

Fuel arrives by ship or truck. Every litre is imported, and the price is decided far away from your island.

The grid is fragile

One generator trips and the whole island feels it. Voltage dips, flicker, and blackouts are part of daily life.

Sunshine is wasted

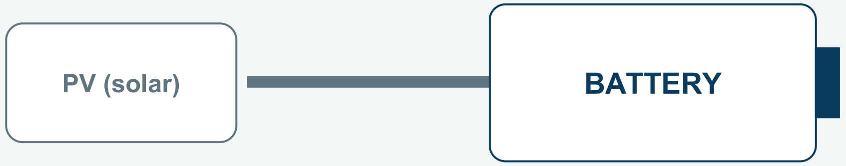
The diesel cannot go below its minimum, so on a sunny day the extra solar is switched off. At night the diesel runs again. You paid for the panels, not for all their energy.

Three different bills — one root cause: energy is there, but **there is no system to control it.**

What happens if you only add a battery

The most common request we receive — and the most common disappointment

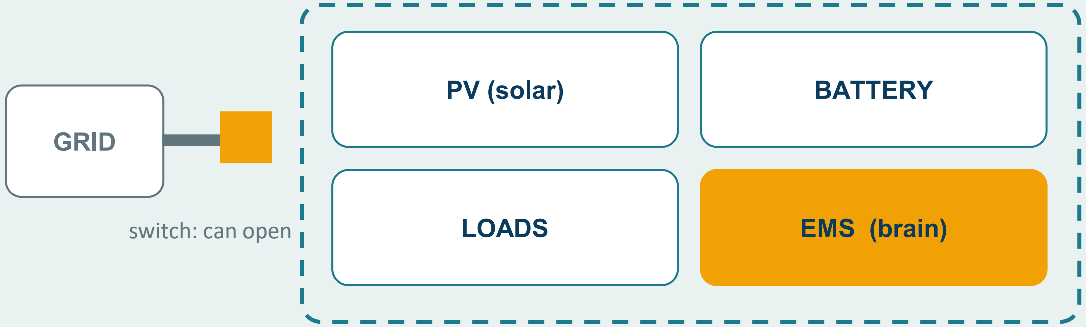
Battery only



a solar-plus-battery installation, on its own

- ✗ It does one job only — usually peak shaving
- ✗ When power runs short, nothing decides what stays on
- ✗ No brain: a fixed set-point, frozen after handover
- ✗ Custom-built — the next village starts from zero

The same battery, inside a microgrid



- ✓ Six jobs from the same battery
- ✓ When power runs short, the brain keeps the critical load alive
- ✓ A brain (EMS) decides — and it is documented
- ✓ Documented once → copy it to the next village

* Six jobs : Energy shifting, Smoothing, Frequency support, Voltage support, Virtual inertia, Islanding & restart

Same battery, same price. The difference: a boundary, and a brain inside it — and that, you can copy.

PART 2 OF 6

What is a microgrid?

2

A boundary you can point at, a brain that decides, and two ways to operate.

What exactly is a microgrid?

The U.S. Department of Energy definition, broken into its three essential parts

1 A clearly defined electrical boundary

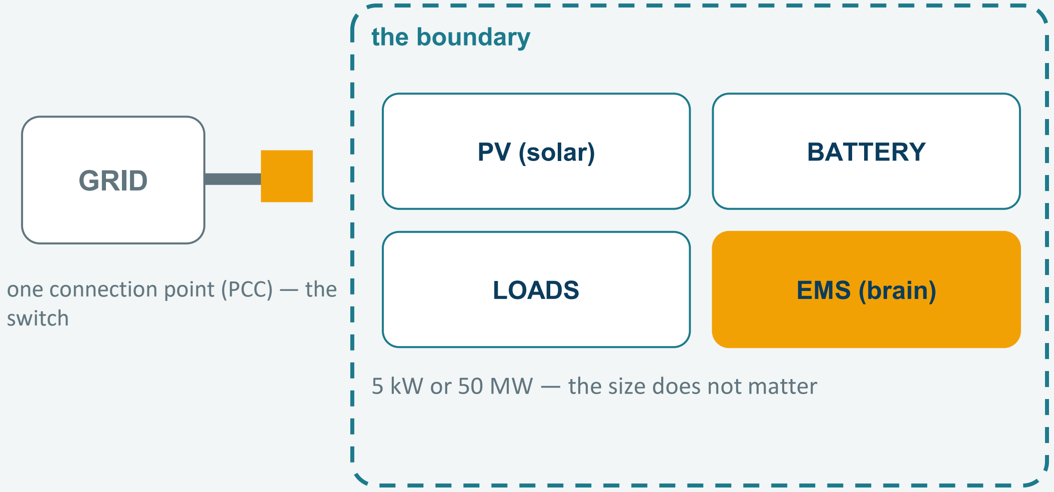
You can point at one connection point and say: inside this line is mine.

2 A single controllable entity

From the grid's side, everything inside behaves as one resource with one brain.

3 Able to connect and disconnect

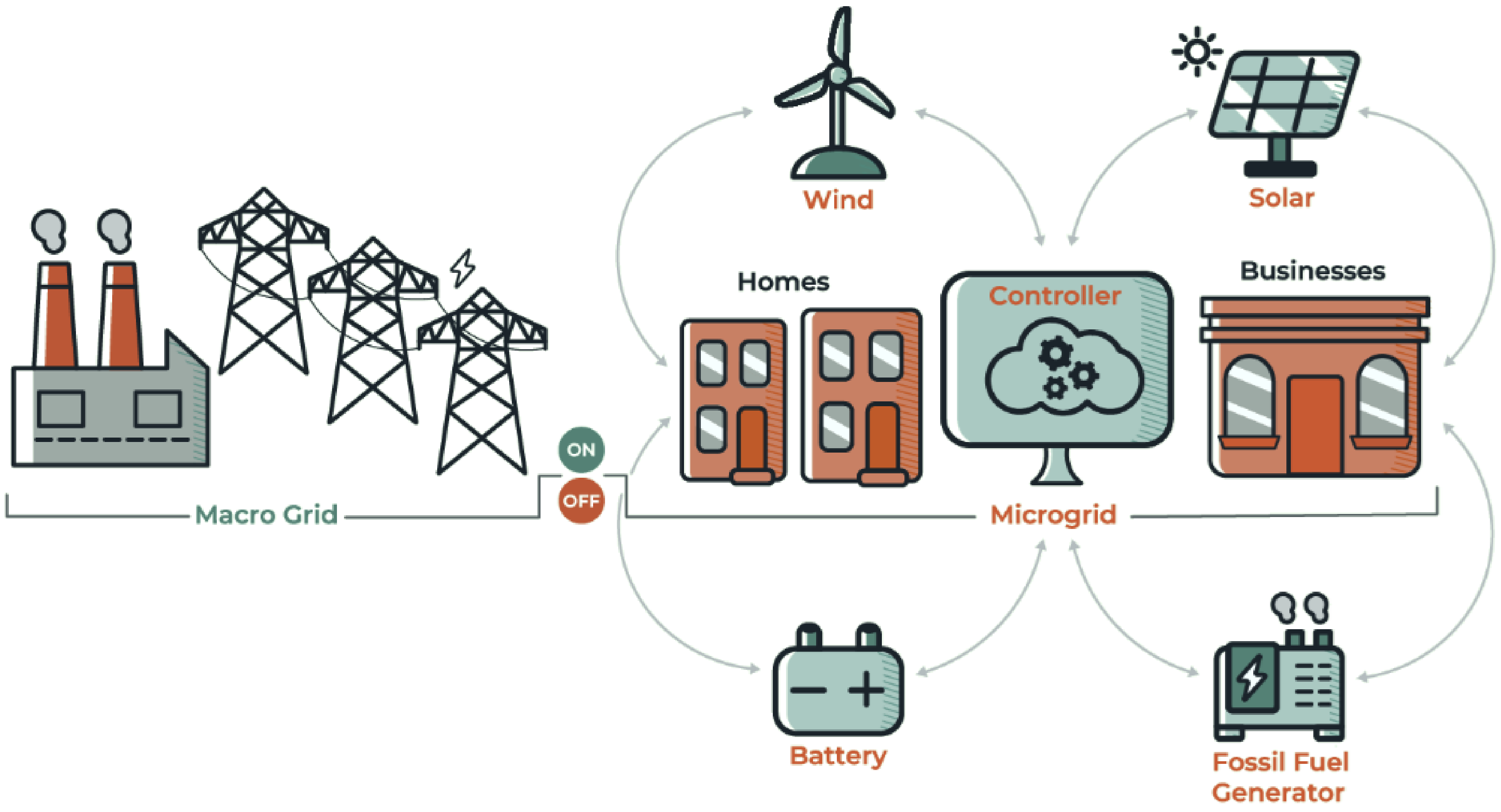
It runs with the grid, and it runs alone. Both modes are designed, not accidental.



Note what is NOT in the definition: size, solar, batteries, being off-grid. A 5 kW village system and a 50 MW port can both be microgrids. (Source: U.S. DOE)

A boundary you can point at, a brain that decides, a switch that can open. That is the whole definition.

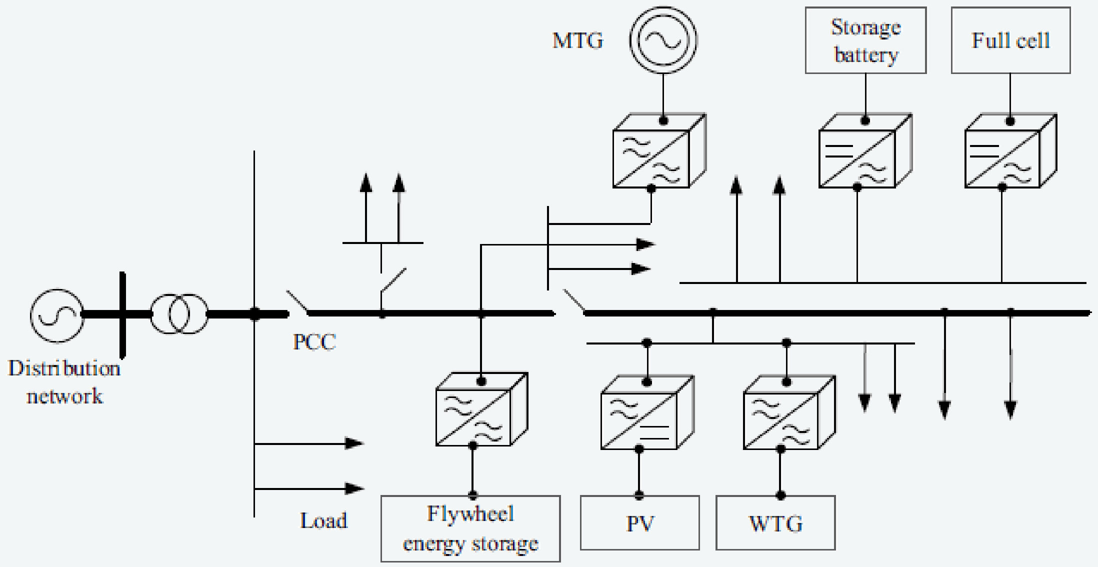
Two operating modes, two different design problems



Most of your systems need both modes in the same asset: connected when the grid is there, islanded when it is not.

AC microgrid

Distributed generation, storage and loads share a common AC bus



Topology of an AC microgrid

Advantages

- Compatible with existing grids and loads, which are almost all AC
- Mature protection schemes and standard equipment
- Easiest to interconnect with the utility

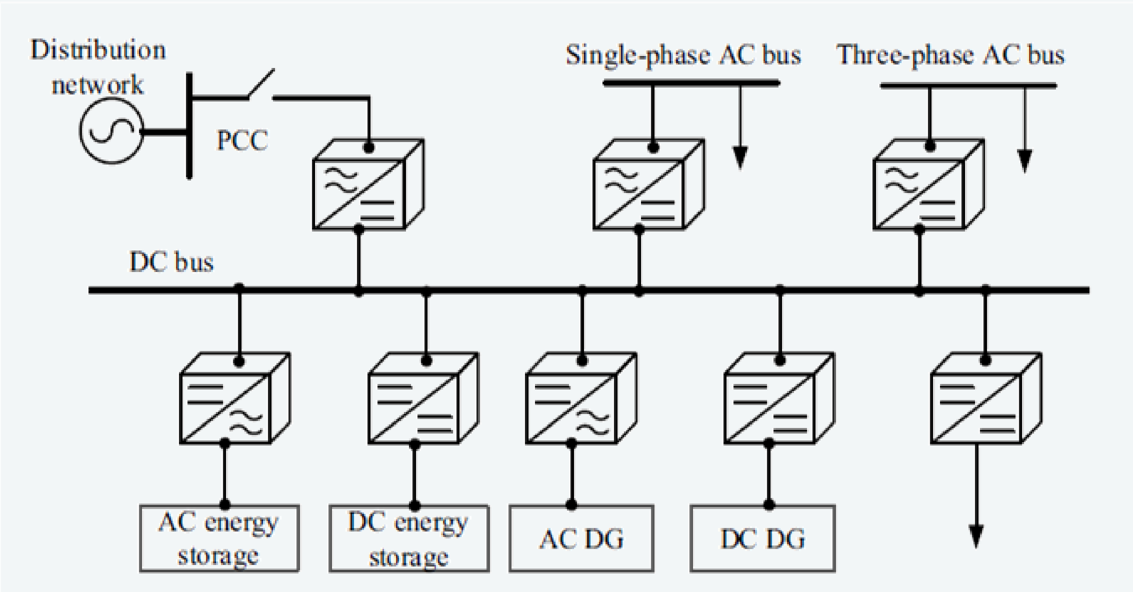
Limitations

- Renewables and storage are natively DC, so several conversion stages are needed
- Each conversion stage costs efficiency
- Reactive power and synchronisation must be managed

Default choice when you are extending or reinforcing an existing AC distribution network.

DC microgrid

Resources and storage share a DC bus, connected to AC systems through a single converter



Topology of a DC microgrid

Advantages

- Fewer conversion steps, so higher end-to-end efficiency
- Natural fit for PV, batteries, EV charging, telecom and data loads
- No reactive power, no synchronisation between sources

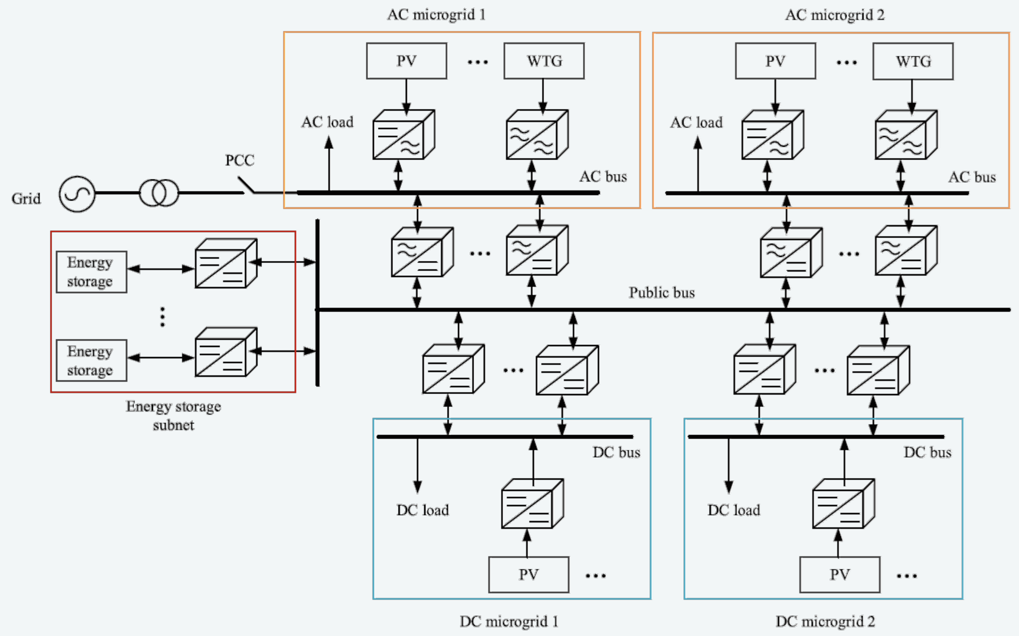
Limitations

- DC protection is still challenging. Unlike AC, breaking DC fault current is difficult.
- Fewer qualified installers and less local supply chain
- Existing AC appliances need an interface

Strong candidate for a new-build village system where you choose the appliances too.

Hybrid AC/DC microgrid

AC and DC sub-systems linked through a common coupling bus



Topology of a hybrid AC/DC microgrid

Advantages

- AC resources (wind, motors, existing loads) and DC resources (PV, battery, EV) each connect where they belong
- Removes unnecessary conversion, improving overall efficiency
- More resilient: several independent energy paths

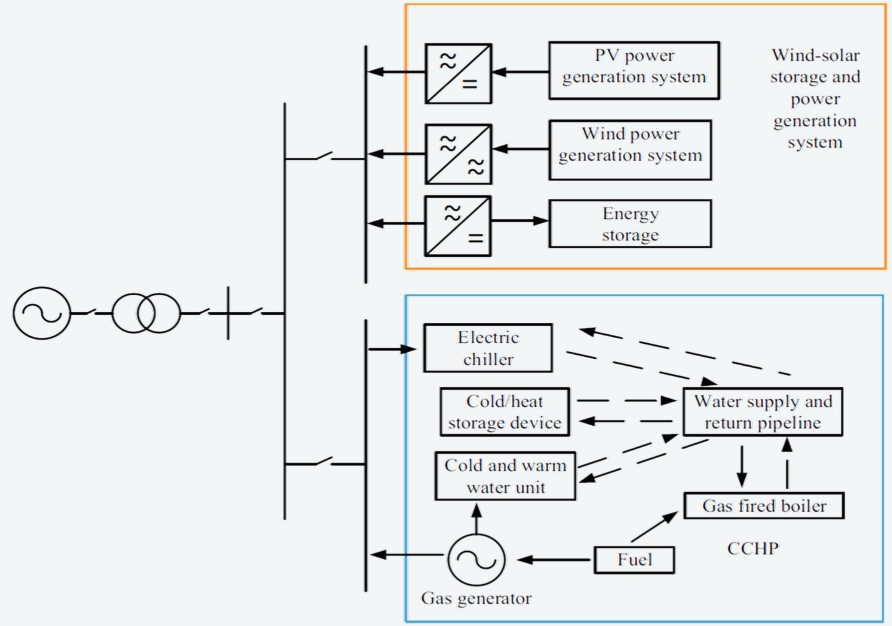
Limitations

- Power flow between the AC and DC sides must be actively coordinated
- Protection design is harder because the two sides behave differently
- More complex commissioning and more to maintain

Where most real systems end up, because real sites already contain both AC and DC equipment.

Multi-energy microgrid (combined cooling, heating and power)

Electricity is not the only output; heat and cooling are part of the same optimisation



Topology of a CCHP (multi-energy) microgrid

Why it can matter to you

- Waste heat from generation becomes a product instead of a loss
- Cooling is often the largest and most weather-correlated load in tropical systems
- Thermal storage is far cheaper per kWh than electrochemical storage

What it demands

- Electricity, heat and cooling must be balanced at the same time
- Requires a genuine energy management system, not a relay scheme
- Only pays back where the thermal demand is real and continuous

Before buying more batteries, ask whether the load you are trying to shift is actually a cooling load.

Where storage actually sits in a microgrid

One asset, six jobs. This is why storage inside a microgrid is worth more than the same storage outside one.

1

Energy shifting

Move midday solar into the evening peak so that fuel-based generation can be switched off.

2

Ramp and smoothing

Absorb cloud transients and load steps so the diesel units are not forced to cycle.

3

Frequency support

Fast active-power response, faster than any rotating machine can deliver.

4

Voltage support

Reactive power at the point where the voltage problem actually occurs, at the feeder end.

5

Virtual inertia

With a grid-forming converter, storage supplies the inertia that retiring machines used to provide.

6

Islanding and restart

Hold the critical load alive through the transition, and re-energise the system afterwards.

A battery procured for job 1 alone is usually 3 to 5 times more expensive per delivered benefit than the same battery doing all six.

PART 3 OF 6

Grid-forming, proven on Kaua'i

3

When the engines stop, who makes the waveform?

Jobs 5 and 6 on the last slide — inertia and islanding — need a new kind of inverter. A real island already proved it.

Grid-following or grid-forming: the question islands cannot avoid

Grid-following (GFL)

- Measures the existing voltage and frequency, then injects current in step with it
- Needs someone else to define the waveform
- Almost all installed PV and battery inverters worldwide are of this type
- In a system with few synchronous machines, it has nothing left to follow

Grid-forming (GFM)

- Creates the voltage and frequency reference itself, like a synchronous generator
- Can start a dead system and hold an island alone
- Provides synthetic inertia and a defined fault current contribution
- Costs more in control design and requires proper commissioning

Why this is not an academic distinction

Large-scale events in Chile in February 2025 and on the Iberian peninsula in April 2025 both occurred in systems with a very high instantaneous share of inverter-based generation. As rotating machines retire, system inertia and short-circuit capacity fall. A small island grid reaches that condition at a far lower renewable share than a continental grid does, and it reaches it first.

<The basic difference>

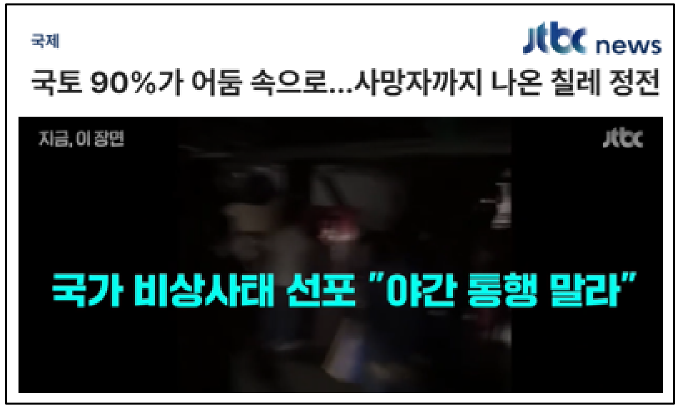
- Grid-following inverters need an existing grid to follow.
- But grid-forming inverters can create the voltage and frequency reference themselves.

Grid-following or grid-forming: the question islands cannot avoid

Two nationwide blackouts in 2025 – Chile in February, Spain and Portugal in April.

Chile – 25 February 2025, 15:16 | renewables 38.6 % (2024)

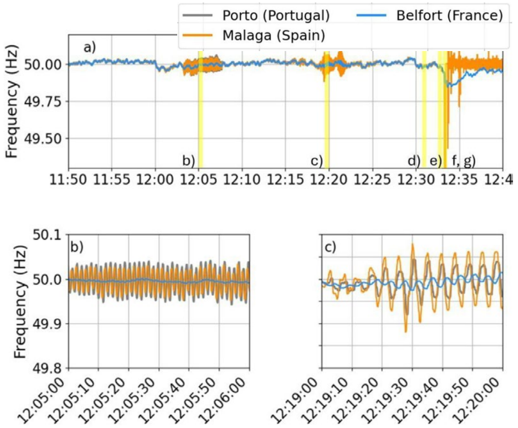
- (System) National load about 10.5 GW
  - Large solar output in the north was being sent to the south
  - The two 500 kV north–south lines were near full capacity
- (Cause) Double-circuit fault, then cascading generator trips
- (Impact) About 9 GW lost, over 7.5 million households
- (Restored) 07:00 next day – 16 to 17 hours



Chile: the north–central network, and the blackout in the news

Iberian peninsula – 28 April 2025, 12:30 | renewables 61.3 % (2023)

- Stage 0 (before the event)
  Voltage unstable for days; sharp swings that morning
- Stage 1 (12:03 – 12:19)
  Three oscillations; the damping actions pushed voltage up
- Stage 2 (12:32:57 – 12:33:18)
  Voltage kept rising; generators tripped one after another
- Stage 3 (12:33:18 – 12:33:30)
  Over-voltage trips, the link to Europe opened, then blackout



Iberia: frequency during the event, and the blackout in the news

Follower or leader: the same inverter, two personalities

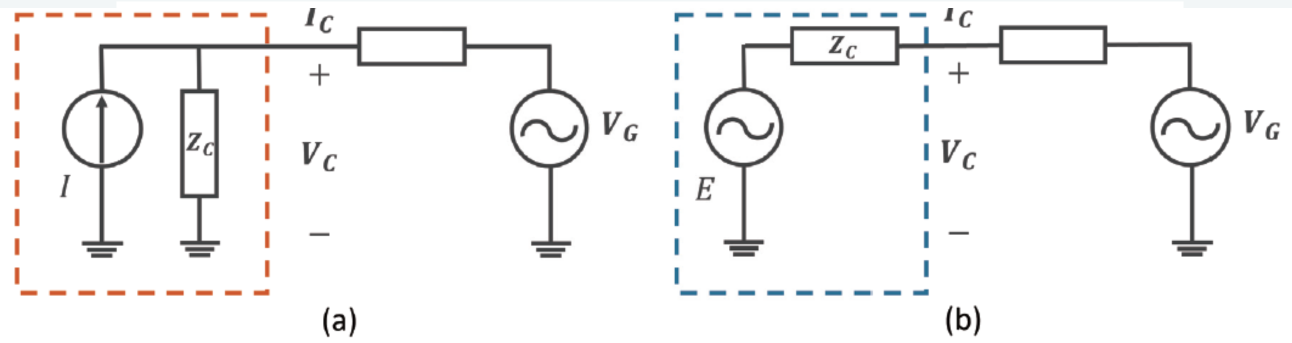
Thirty seconds of theory — and it explains everything you are about to see on Kaua'i

- GFL IBR controls output **Current**
- Is dependent on another source to synchronize to

- GFM IBR controls output **Voltage**
- Can make its own voltage waveform

GFL follows. GFM leads.

Grid-following (a) | Grid-forming (b)



GFL = a current source behind a parallel impedance. It injects current into a voltage someone else provides.

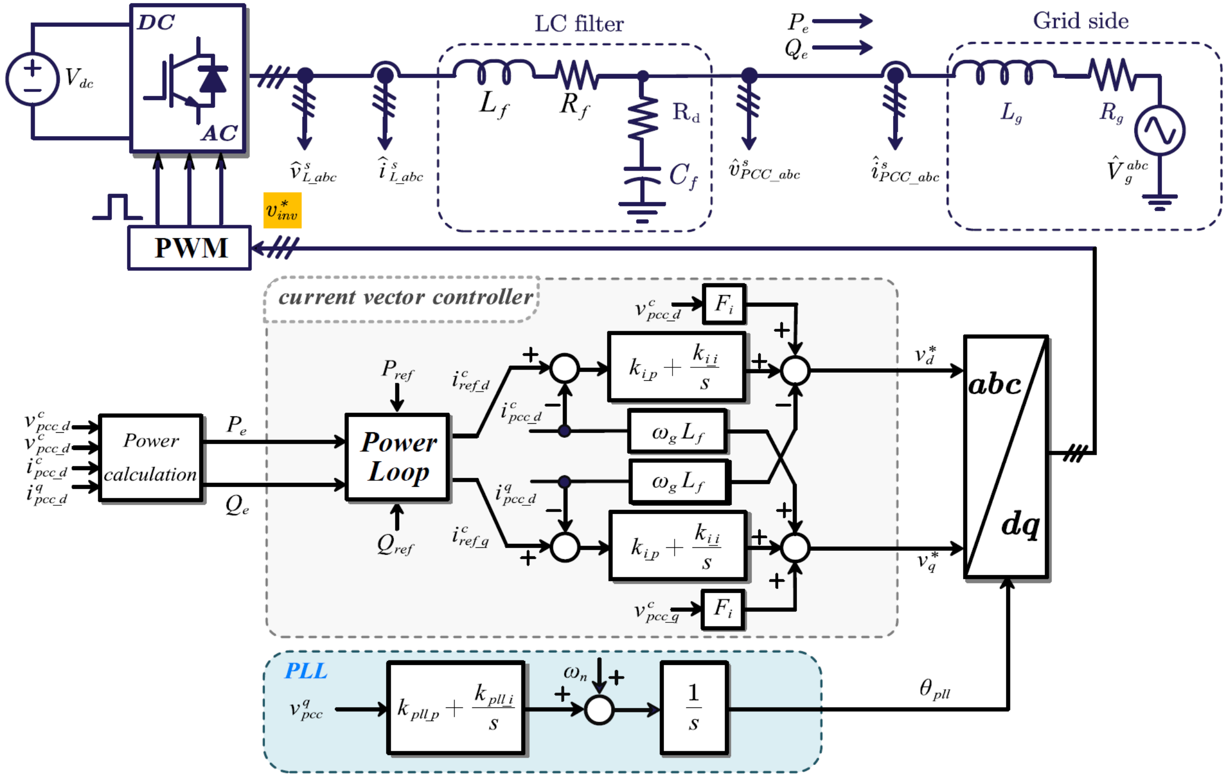
GFM = a voltage source behind a series impedance. It provides the voltage, and current follows naturally.

GFL in one line:
"Tell me the waveform, and I will push power into it."

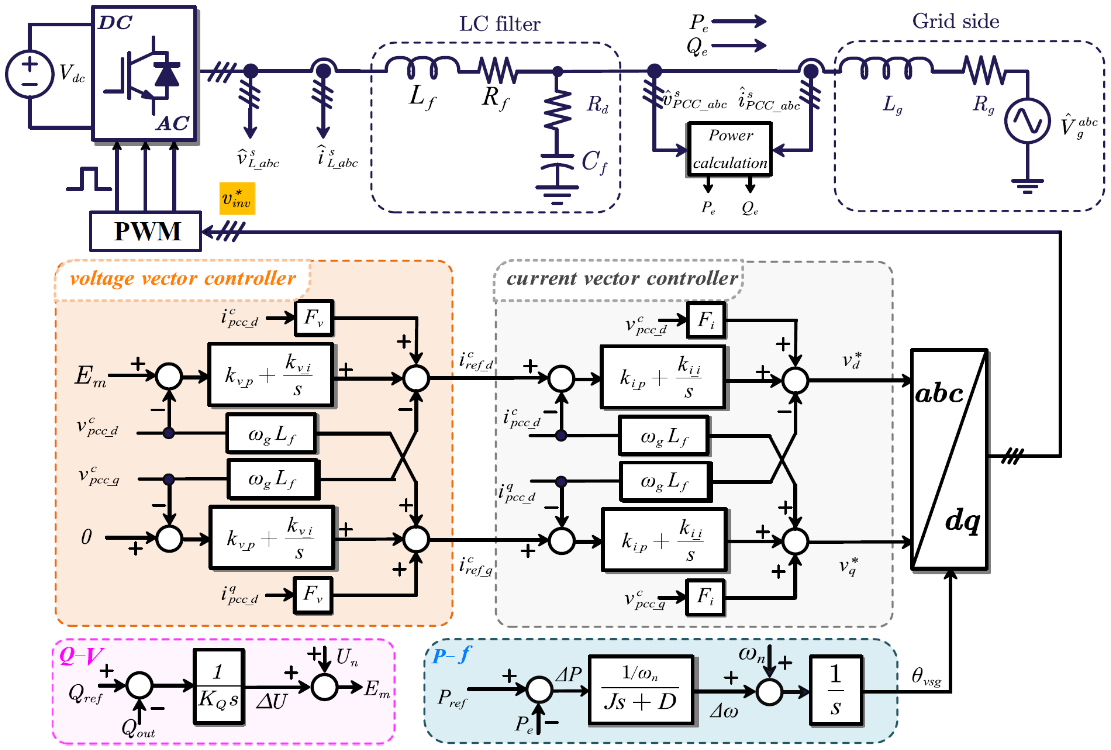
GFM in one line:
"I am the waveform."

GFL asks the grid what to do. GFM tells the grid what it is. On a weak island, somebody has to be the leader.

Follower or leader: the same inverter, two personalities



GFL(Grid Following Inverter)

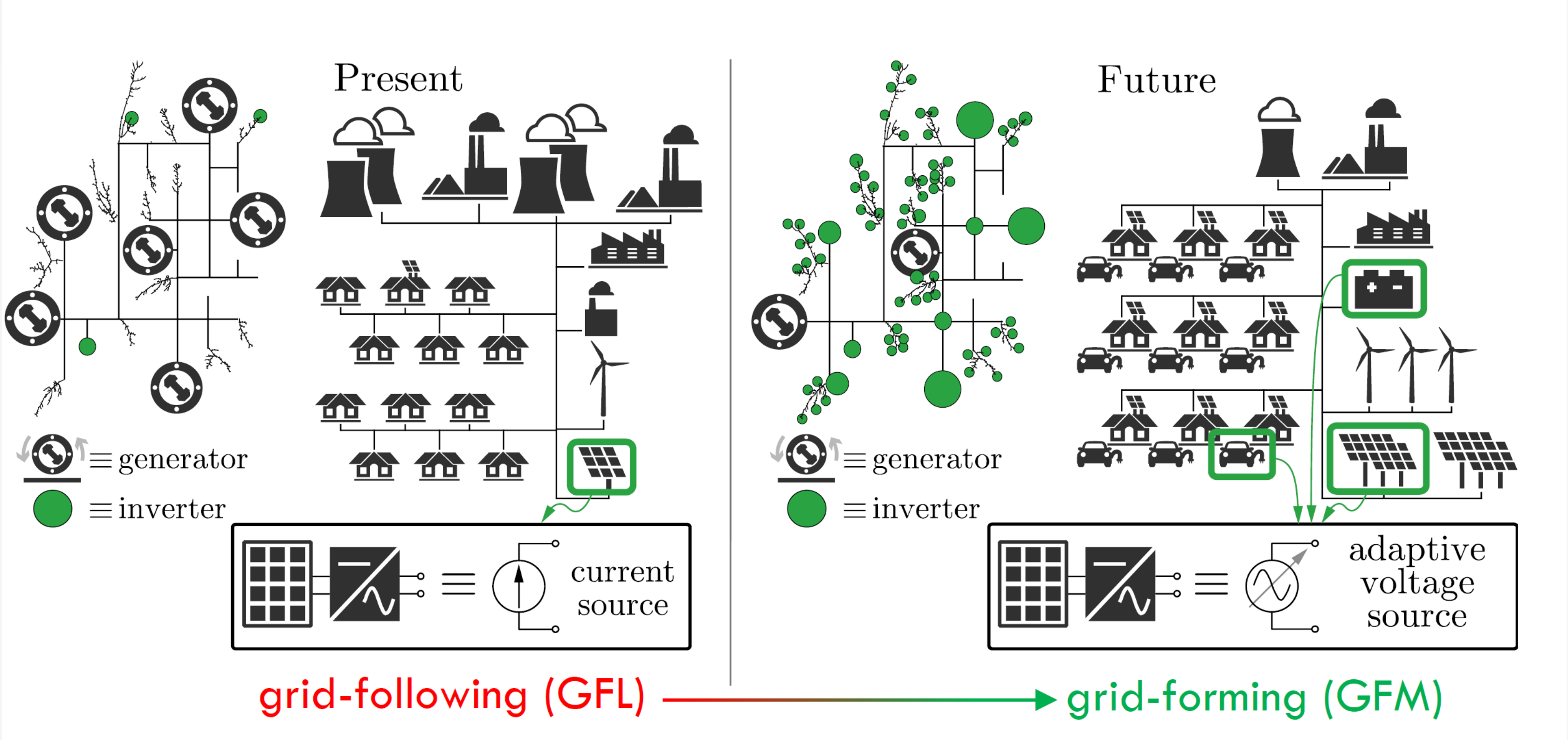


GFM(Grid Forming Inverter)

GFL asks the grid what to do. GFM tells the grid what it is. On a weak island, somebody has to be the leader.

The world is moving from following to forming

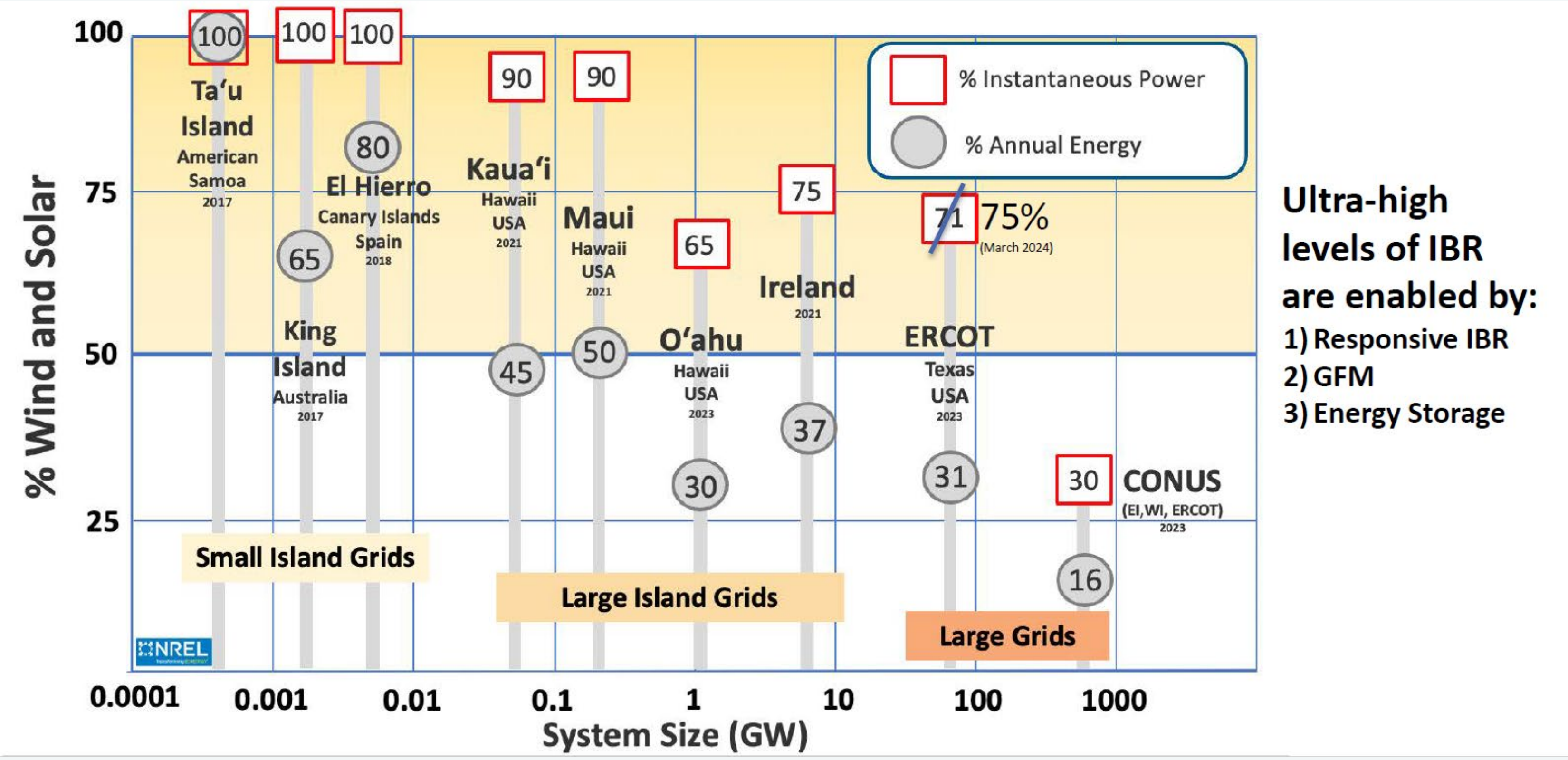
Where the voltage reference comes from: today, and in a high-renewable future (Univ. of Texas at Austin, 2023)



Today the reference comes from big rotating machines. Tomorrow it must come from inverters — inverters that can form the grid.

Small islands got there first

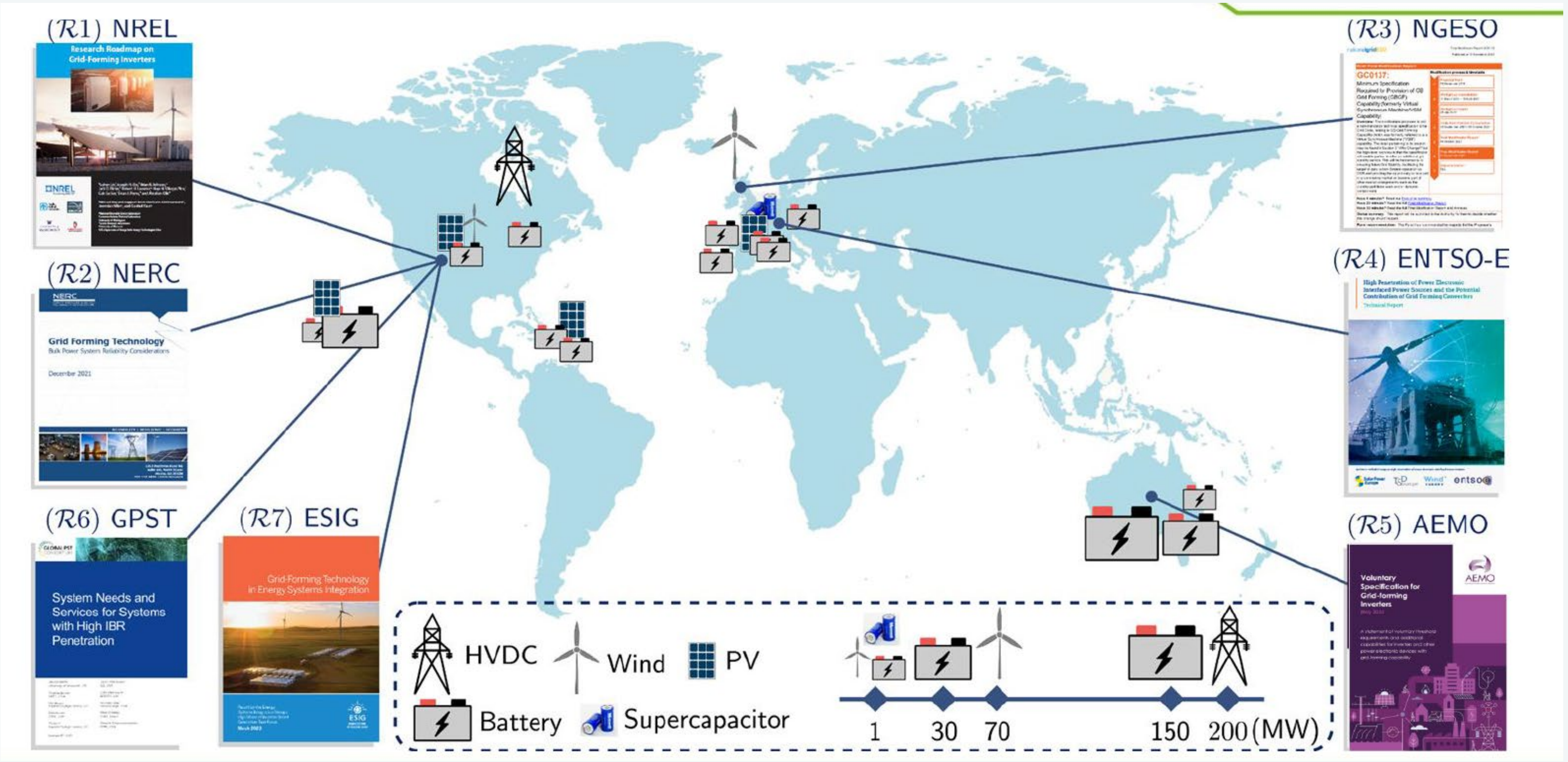
Measured shares of wind and solar in real operating power systems (NREL, 2024)



Kaua'i already runs at up to 90 % instantaneous inverter power — enabled by responsive IBR, grid-forming control, and energy storage.

And the rulebooks are being written right now

Grid-forming roadmaps and requirements published by system operators and research bodies (IEEE PES GM, 2023)



NREL, NERC, National Grid ESO, ENTSO-E, AEMO — every major operator is specifying grid-forming today. You can cite these documents in your own grid codes.

Kaua'i, Hawai'i: a small island that runs on sunshine

Why this island matters to this room: it is small, isolated — and it already lives in your future

About 100,000 people

Roughly 70,000 residents plus 30,000 visitors — the size of many provincial grids in your countries.

About 70 % renewable

The highest share in the United States. On sunny days, solar alone covers up to 90 % of demand.

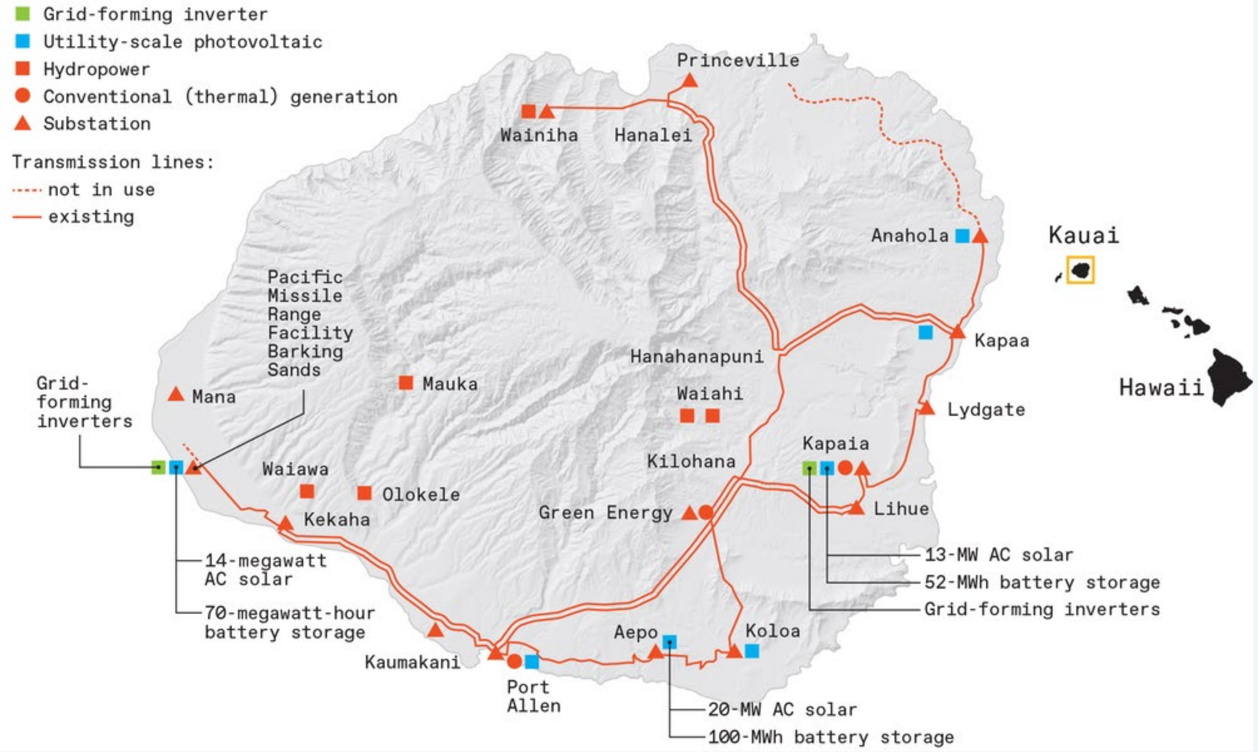
Completely alone

No cable to any neighbour, a 57.1 kV grid from the sugar-plantation era. Every problem is solved on the island.

One utility cooperative, one small grid, a world-record renewable share. If it works here, the physics works for your islands too.

Two grid-forming plants anchor the whole island

Solar-plus-storage with grid-forming inverters in the southwest and southeast (IEEE Spectrum)



PMRF: 14 MW solar + 70 MWh storage (U.S. Navy)

The photovoltaic panels at the Kapaia solar-plus-storage facility, operated by the Kauai Island Utility Cooperative in Hawaii, are capable of generating 13 megawatts under ideal conditions. TESLA

Kapaia: 13 MW solar + 52 MWh storage (Tesla / KIUC)

Kapaia, PMRF, Port Allen: storage at every corner of the island — and two of these plants can form the grid by themselves.

The same generator tripped twice — two very different evenings

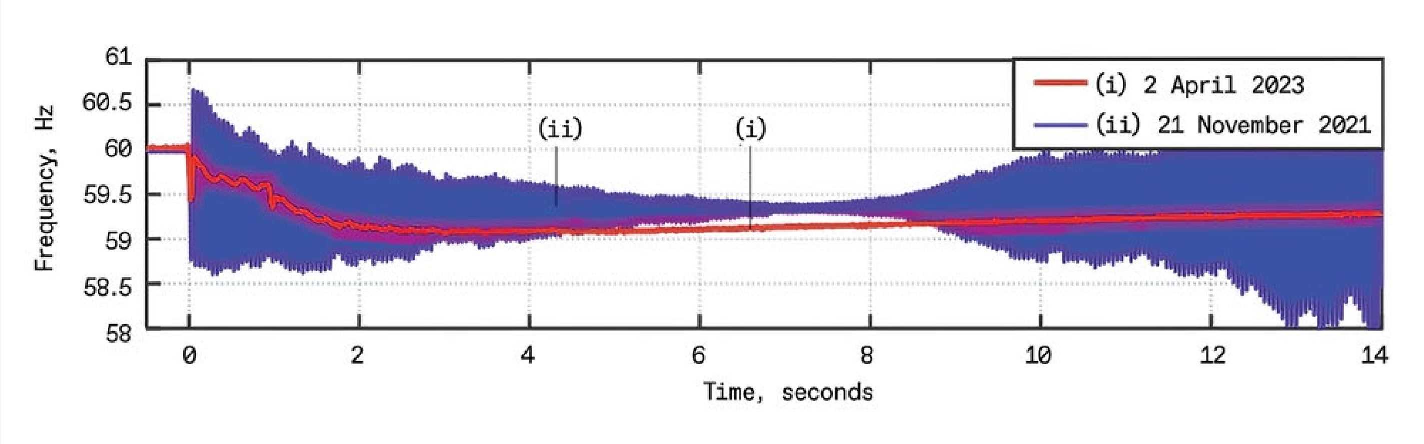
Plant A, the island's largest machine (~26 MW), tripped in Nov 2021 and again on 2 April 2023, near sunset

21 Nov 2021 — one grid-forming plant

The trip excites a 19.5 Hz oscillation across the island. The following inverters fight each other, and the blue trace keeps ringing. The island survives — barely.

2 April 2023 — two grid-forming plants

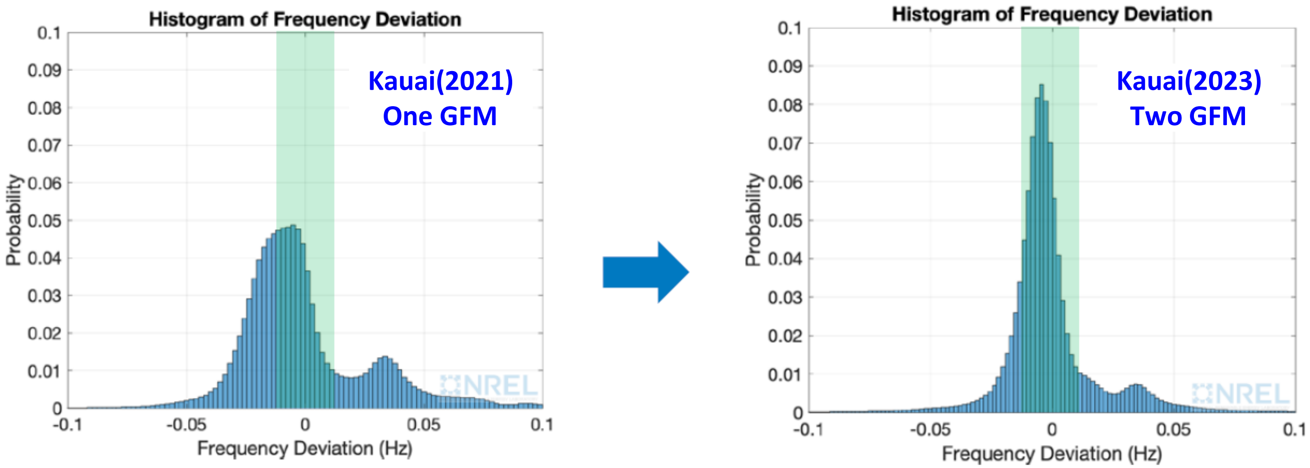
The same plant trips at the worst moment: sunset, solar ramping down. Batteries respond in milliseconds behind grid-forming inverters. The red trace dips once and settles.



Between the two evenings, exactly one thing changed: a second inverter plant was switched from following to forming.

Not only in emergencies: everyday frequency quality

Distribution of frequency deviation, before and after the second grid-forming plant (NREL)



2021 Kaua`i system with one GFM
[-0.01Hz, 0.01Hz] Probability = 34.19%

2023 Kaua`i system with two GFMs
[-0.01Hz, 0.01Hz] Probability = 60.05%

After converting IBR1 from GFL to droop-based GFM mode, we improve the frequency dynamics by reducing the frequency deviation (thanks to GFM's fast frequency responses).

- Figure credit: Our NREL colleague Hongfei

NREL | 15

Time spent within ±0.01 Hz: 34 % with one grid-forming plant, 60 % with two. The island runs smoother every single day.

Grid-forming storage is no longer an experiment

Grid-forming battery projects deployed or under construction (IEEE Spectrum · NREL, 2024)

Table I.1: GFM BESS Projects Deployed or under Construction

Project Name	Location	Size (MW)	Time
Project #1	Kauai,USA	13	2018
Kauai PMRF	Kauai,USA	14	2022
Kapolei Energy Storage	Hawaii, USA	185	2023
Hornsdale Power Reserve	Australia	150	2022
Wallgrove	Australia	50	2022
Broken Hill BESS	Australia	50	2023
Riverina and Darlington Point	Australia	150	2023
New England BESS	Australia	50	2023
Dalrymple	Australia	30	2018
Blackhillock	Great Britain	300	2024
Bordesholm	Germany	15	2019

Hornsdale Power Reserve, Australia — 150 MW / 194 MWh, grid-forming

From 13 MW on Kaua'i to 300 MW in Great Britain — in seven years.

You can write grid-forming into a tender today, and vendors can deliver it. Ask for the capability by name.

What Kaua'i proves — and what it leaves unsolved

What it proves

- A small island can run on inverters — if some of them form the grid
- Storage is the muscle behind grid-forming: the MWh matter as much as the MW
- Small systems meet this future first, and can lead it
- The technology is commercial — this is procurement, not research

What it does not solve

- Kaua'i was engineered as a one-off, by a well-supported utility
- Every interface, protection setting and control study was custom work
- Your countries need thousands of small systems — without an engineering army for each one
- The missing piece is not physics. It is a repeatable, standard building block

That missing piece is exactly what our MBB programme builds. That is Part 3.

PART 4 OF 6

The future microgrid: MBB

4

Kaua'i was hand-made, by experts, once. How do we make it repeatable?

So why is the world not covered in microgrids?

Six limitations we see repeatedly, in our own projects and in projects we review

1

Power quality degrades

Storage and renewables are present but not optimally controlled. Performance is acceptable at commissioning and drifts afterwards.

2

No dynamic reconfiguration

Connection points are fixed at design time. The system cannot rearrange itself when conditions or loads change.

3

Nothing is reusable

No standard for controllers, communication or power conversion. The next site starts from a blank sheet.

4

It does not scale

Each installation is an isolated project. Adding capacity means redesigning, not extending.

5

No business model

Value is real but not measured, so it cannot be sold, contracted or financed. The second unit never happens.

6

It dies after handover

No maintenance framework, no post-project support. Two years later the batteries are flat and nobody has the password.

Note that only the first of these six is a technology problem. The other five are problems of standardisation, measurement and ownership.

The shift we are trying to make: from project to product

	Conventional microgrid (passive, fixed)	Target microgrid (active, adaptive)
Power quality	Degrades; storage and renewables are not optimally controlled	Optimal control with monitoring and autonomous recovery
Control capability	Fixed connection points; no active reconfiguration	Real-time reconfiguration of resources
Reusability	No standard for controller, communication or conversion	Standardised communication and control interfaces per module
Scalability	Isolated, project-by-project construction	Plug and play: connect and integrate immediately
Business model	No route to revenue; economics never close	Resource aggregation and trading at microgrid level
After handover	Performance falls sharply; no O&M framework	Long-term operation of a demonstration centre; RE100 as an operating target

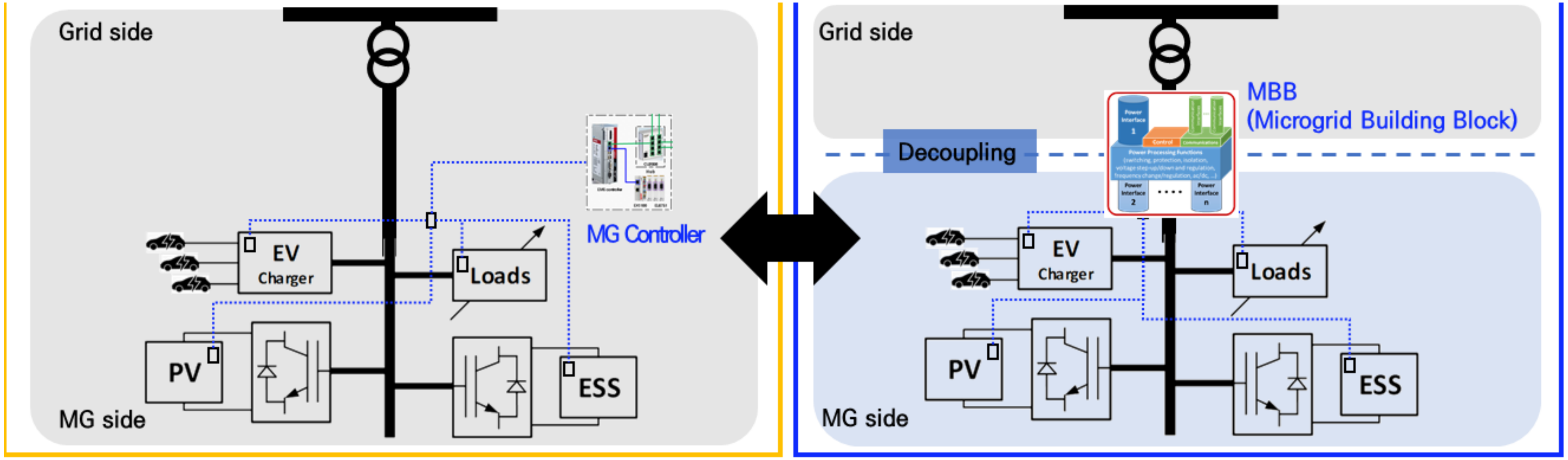
Three keywords hold the right-hand column together: Plug and Play | Scalability | Compatibility

What actually changes with MBB

Same resources on both sides — the difference is one standard block at the boundary

Conventional:
a custom controller wired to every device

MBB-based:
one standard module owns the boundary

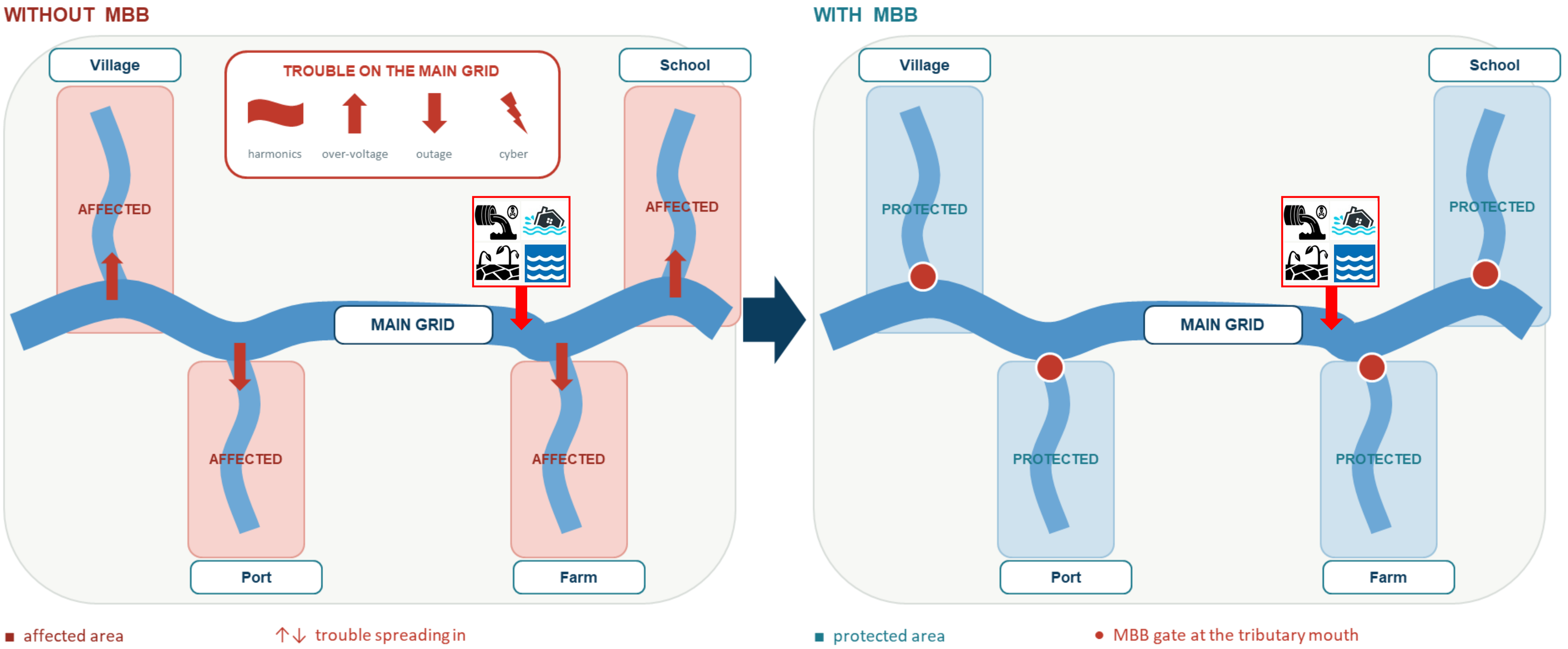


Custom structure · redesign to expand · central control only · engineered again at every site

Standard module · Plug & Play expansion · distributed + central control · any microgrid, same block

Everything downstream of that one standard box becomes repeatable. That is the whole idea.

Think of a river: a floodgate where the tributary meets the stream

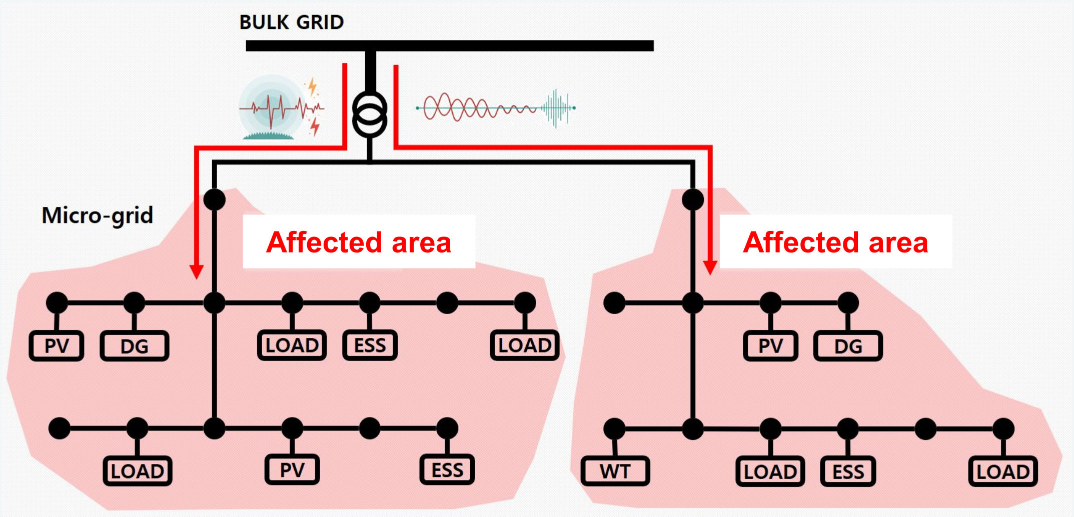


And the gate works both ways: it also stops a problem inside the microgrid from spilling into the main grid.

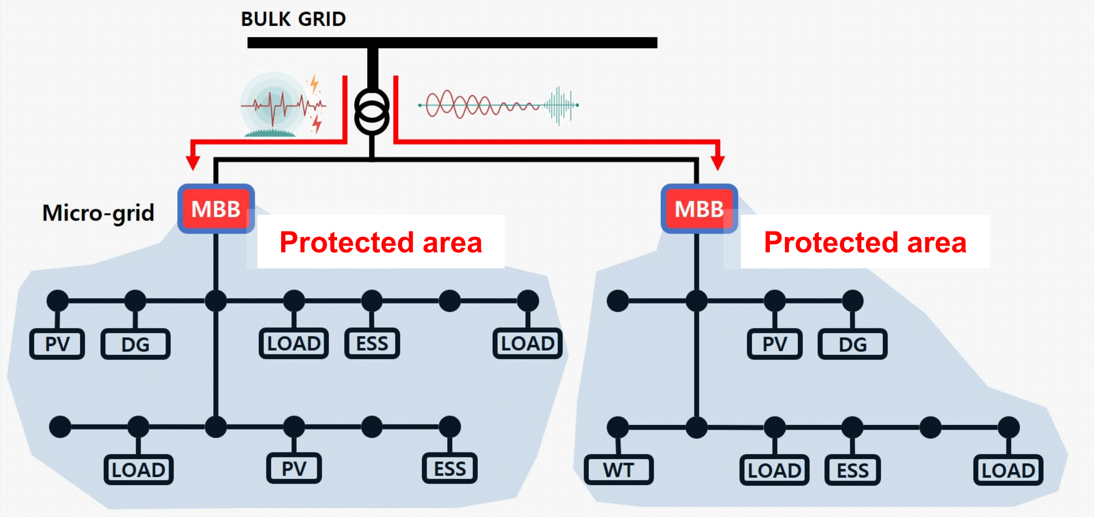
Think of a river: a floodgate where the tributary meets the stream

The main stream is the transmission grid. The tributary is your microgrid. The MBB is the gate.

Without a gate — trouble on the stream floods the tributary



With a gate — the tributary is protected, and manageable



In the figures: red = affected area · blue = protected area · MBB = the gate

And the gate works both ways: it also stops a problem inside the microgrid from spilling into the main grid.

Four kinds of flood, one gate

1

Pollution → harmonics and unbalance

Dirty waveforms outside stay outside. The block filters and rebuilds clean power for the microgrid.

2

Flood → over-voltage, over-frequency

A surplus surge from the grid is absorbed and regulated before it reaches your equipment.

3

Drought → outage, under-frequency

The block detects the failure, disconnects in milliseconds, and the microgrid keeps running alone.

4

Storm surge → cyber attack, noise

One hardened, standard interface to defend — instead of fifty different devices.

One standard gate, engineered once and tested once — instead of fifty custom fixes per site.

MBB: making the microgrid interconnection a standard module

Microgrid Building Block. A defined module that any resource plugs into, instead of a bespoke interface each time.

P

Plug and Play

A new resource connects through a defined electrical and communication interface. No redesign of the microgrid, no re-tuning of the controller.

S

Scalability

Capacity grows by adding modules rather than by rebuilding. The second unit costs far less than the first, which is what makes diffusion possible.

C

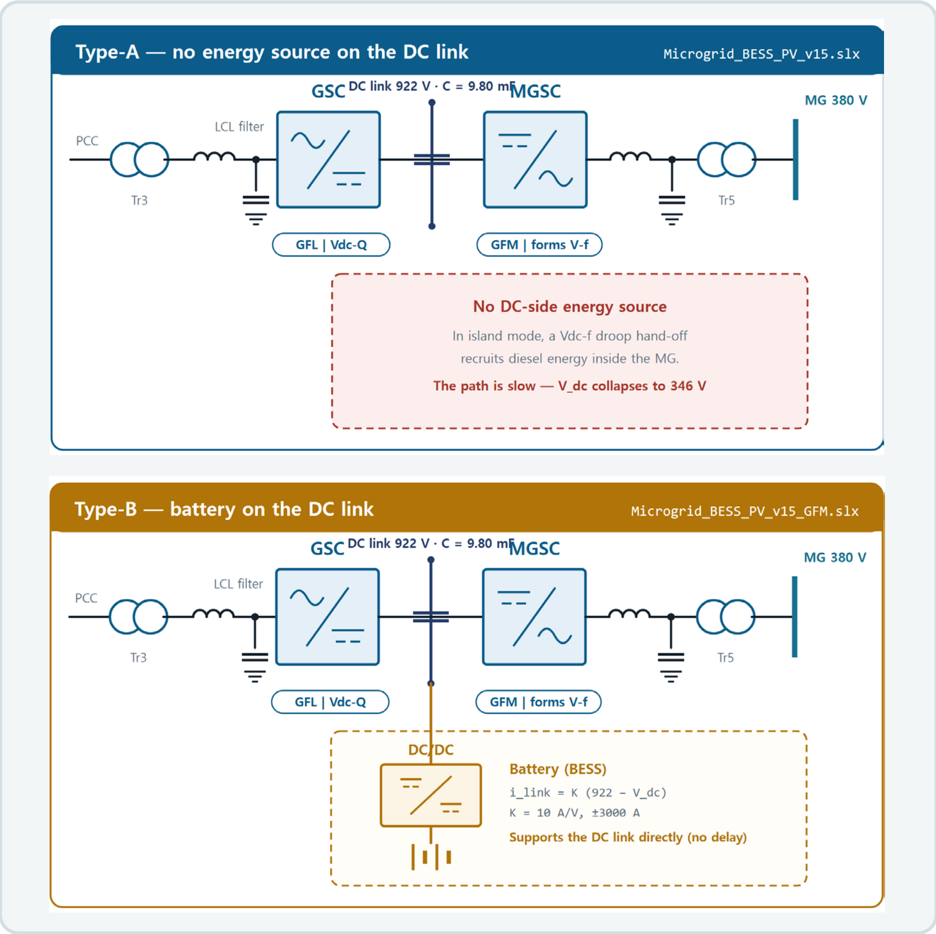
Compatibility

Standardised protocols and control interfaces, so equipment from different vendors and different vintages can operate in one system.

Why this is the right target for a technology transfer programme

A bespoke microgrid transfers a facility. A standardised module transfers a capability. Once the interface is defined, local engineers can extend the system, local companies can supply parts of it, and the next installation does not require the original designer to fly back. This is the difference between a donated asset and an industry.

Two module topologies, chosen by what you need the module to do



Without internal storage

Sufficient when the objective is a power-quality barrier: isolating disturbances so that what happens outside the boundary does not enter it.

With internal storage

Required once you also demand seamless transfer to island operation and shock-free reconnection. Continuity of supply needs an energy source inside the module.

Decide first what the module must guarantee. The topology follows from the guarantee, not from the equipment catalogue.

Inside the block: three modules, one job each

1

Power module

A back-to-back converter that physically decouples grid and microgrid, with protection built into the hardware. Capacity grows by stacking blocks in parallel — like Lego bricks.

2

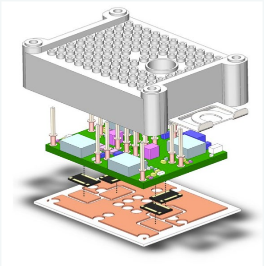
Control module

Grid-forming and grid-following in one device, with droop sharing, virtual inertia, and voltage-frequency restoration. Decides locally, in milliseconds.

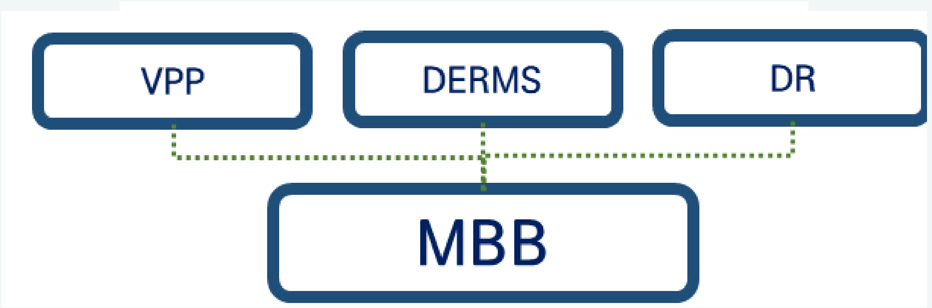
3

Communication module

Standard protocols — Modbus, CAN, RS-485 — and one standard data format, so any resource and any upper platform can plug in.

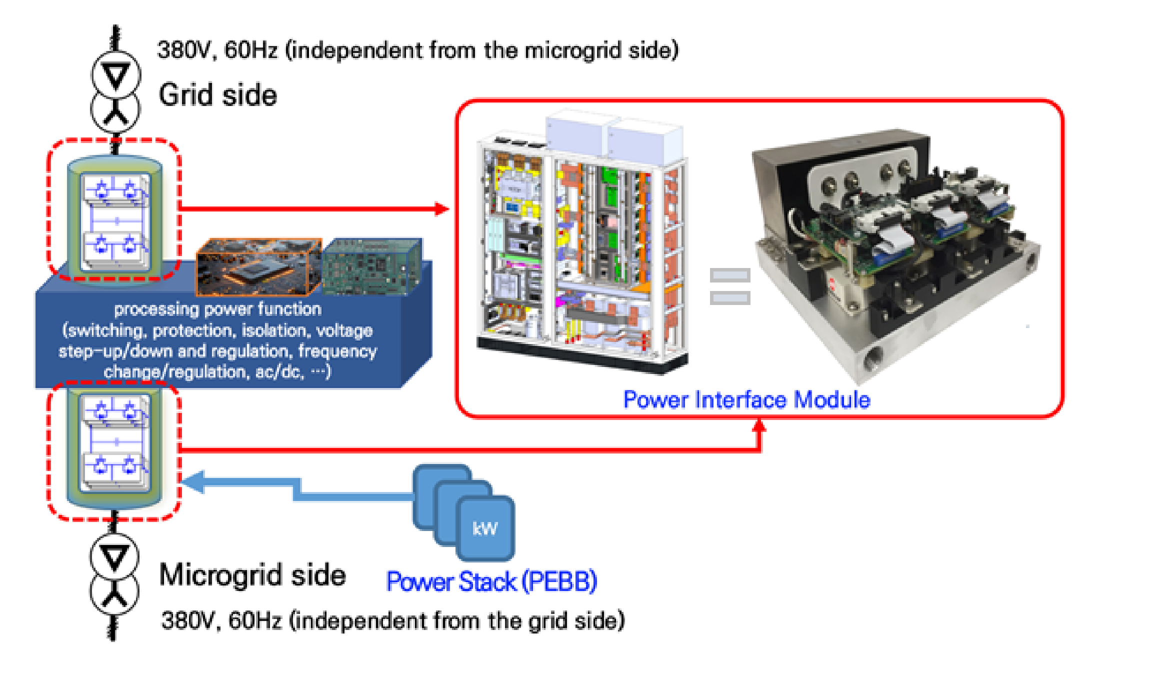


One power building block (PEBB)



Three modules, one discipline: standard on the outside, smart on the inside.

Module 1 — Power: capacity that stacks like Lego



What we are building

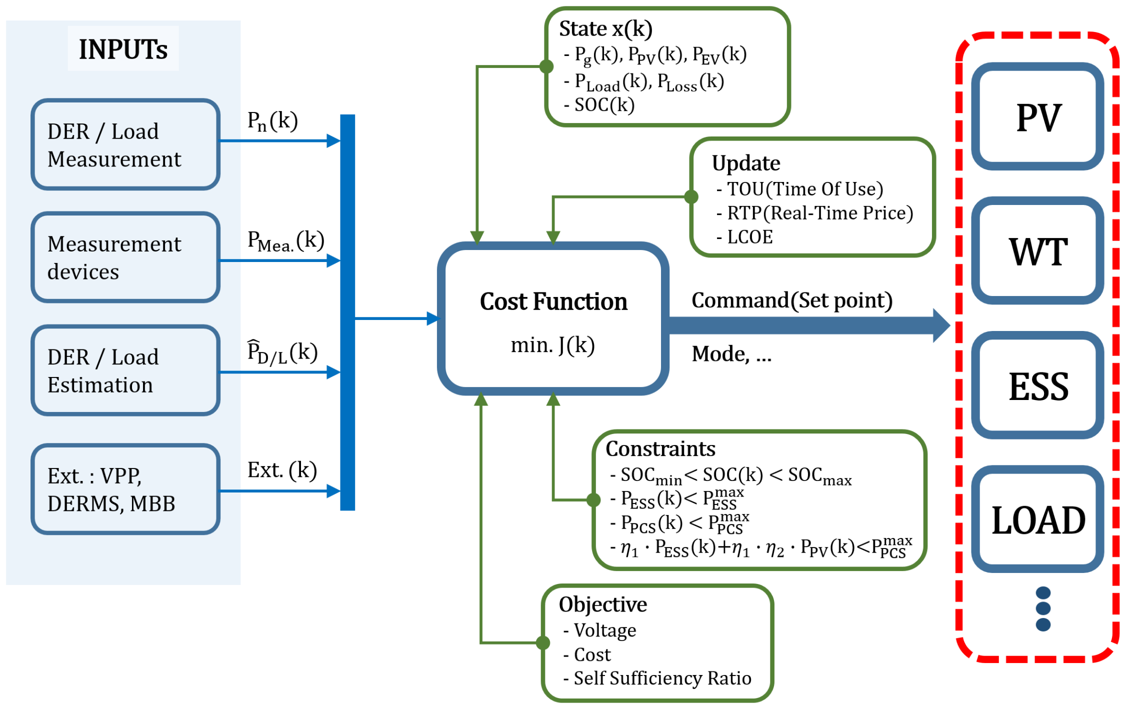
- Back-to-back conversion that fully decouples grid and microgrid
- Short-circuit and overload protection built into the hardware itself
- 10 kVA blocks in parallel: 10 → 100 kVA → MW-class, same design
- Harmonics held to IEC 61000-3-2 / IEEE 1547 on both sides
- 1.0 p.u. continuous, 1.2–1.5 p.u. short-time overload

2026 — design: 10 kVA software and key elements

2027 — verify: 10 kVA hardware proven on HILS

2028 — scale: 2×10 kVA parallel, then 100 kVA on the platform

Module 2 — Control: leader and follower in one device

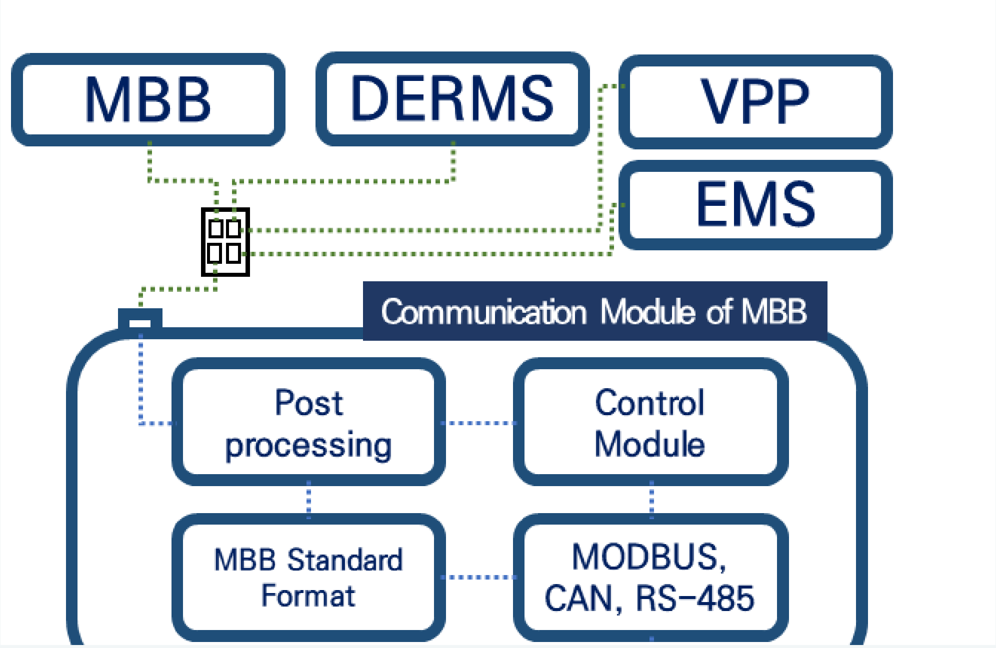


What it does

- Grid-forming (droop) and grid-following (PLL) — switchable in one controller
- Primary layer: droop curves share load between resources; virtual inertia softens the transients
- Secondary layer: PI control pulls voltage and frequency back to nominal
- Tertiary layer: optimises cost, reliability and the campus RE100 target
- Implemented as a state machine a local technician can actually read

The Kaua'i lesson, productised: the leader role is built into the module — not engineered separately at every site.

Module 3 — Communication: it speaks every language

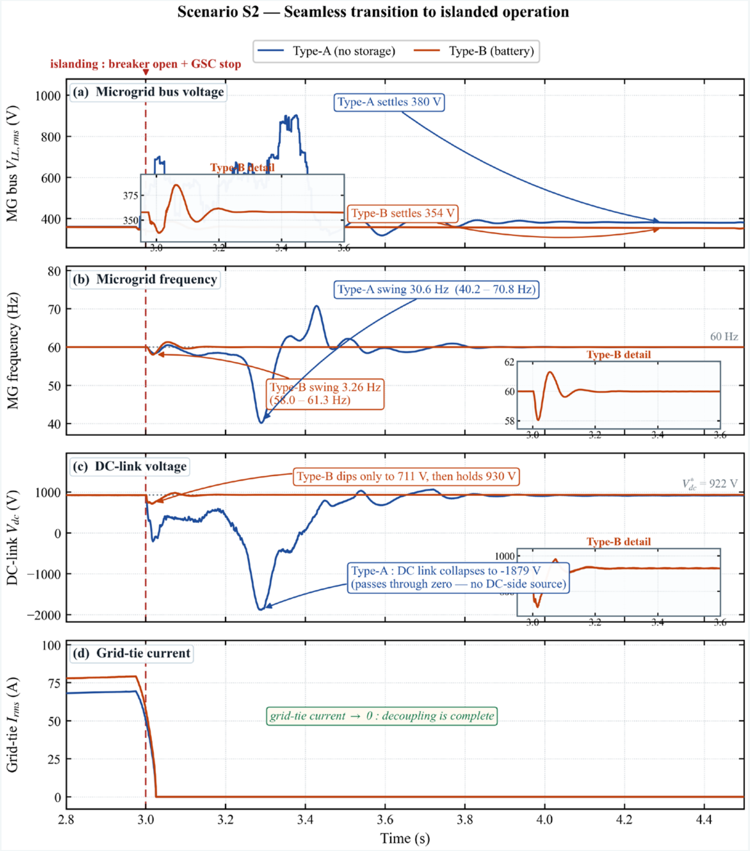


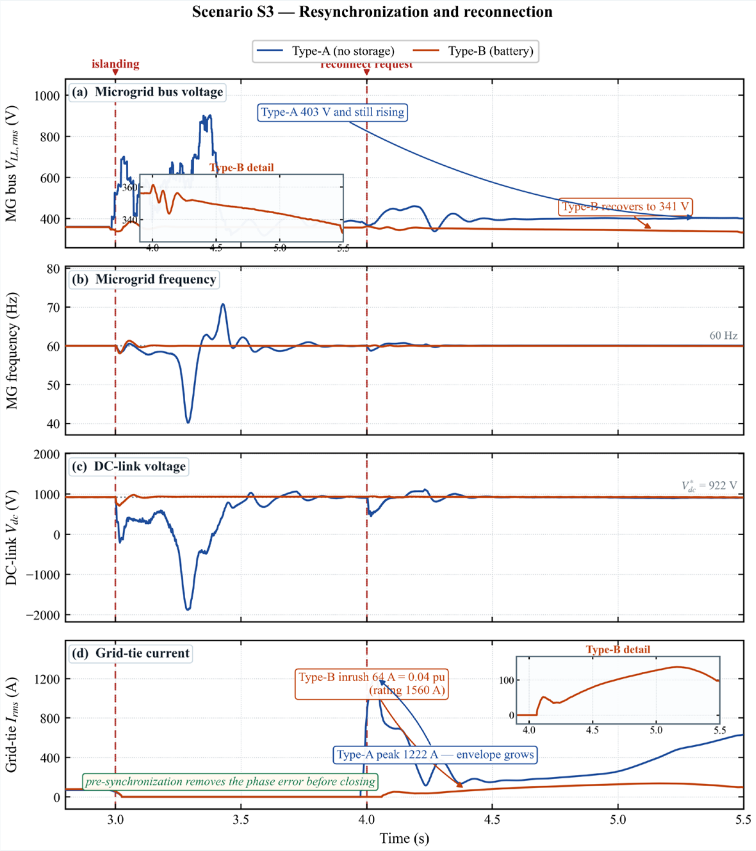
What it provides

- Standard interfaces — Modbus, CAN, RS-485 — wired and wireless
- Real-time, low-latency links to every resource, load and meter in the microgrid
- One standard data format shared by all modules: extend without re-engineering
- Connects upward to VPP, DERMS, SCADA and EMS platforms
- Cyber security enforced at one gate, instead of at fifty devices

Standard communication is what turns Plug & Play from a slogan into a commissioning schedule.

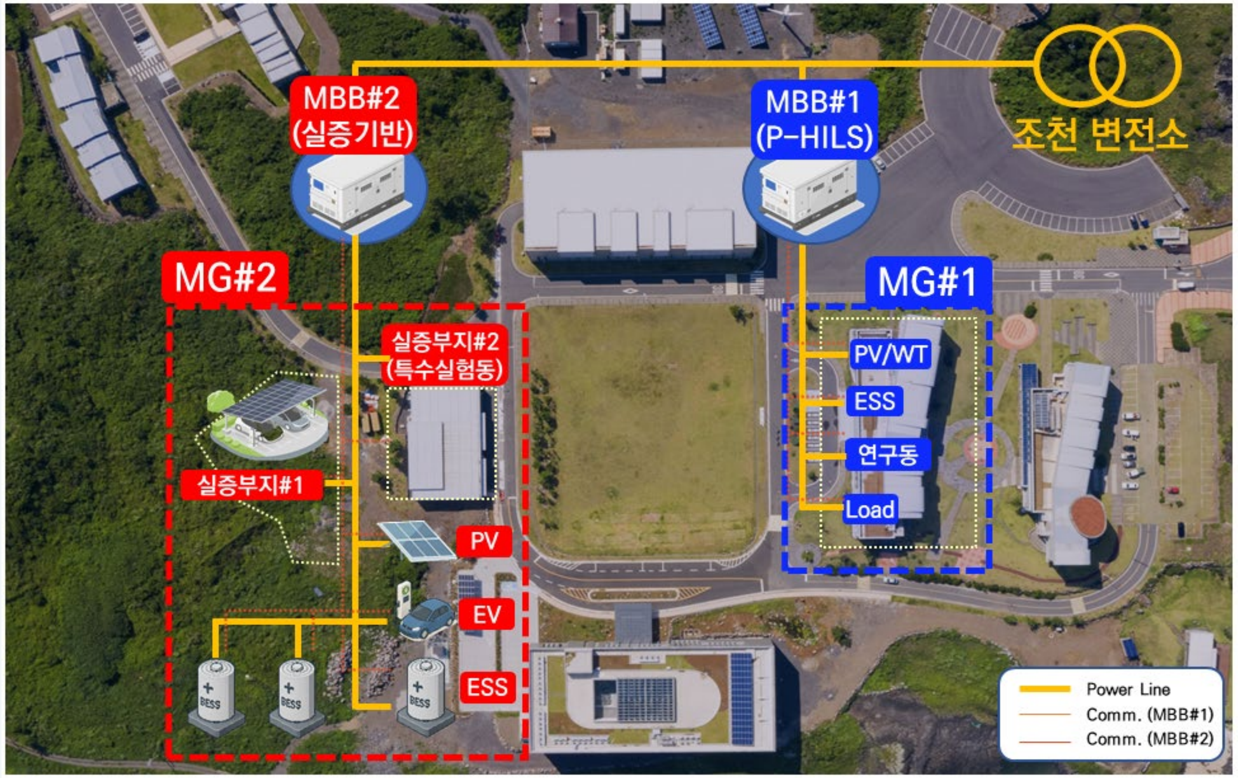
Quantified: what an energy source inside the module adds





Transfer: 3.3 Hz of swing instead of 40–71 Hz. Reconnection: 64 A of inrush instead of 1,222 A. A battery inside the block is what makes “seamless” honest.

Two blocks, one campus: the demonstration testbed



MBB #1 — the simulator rig

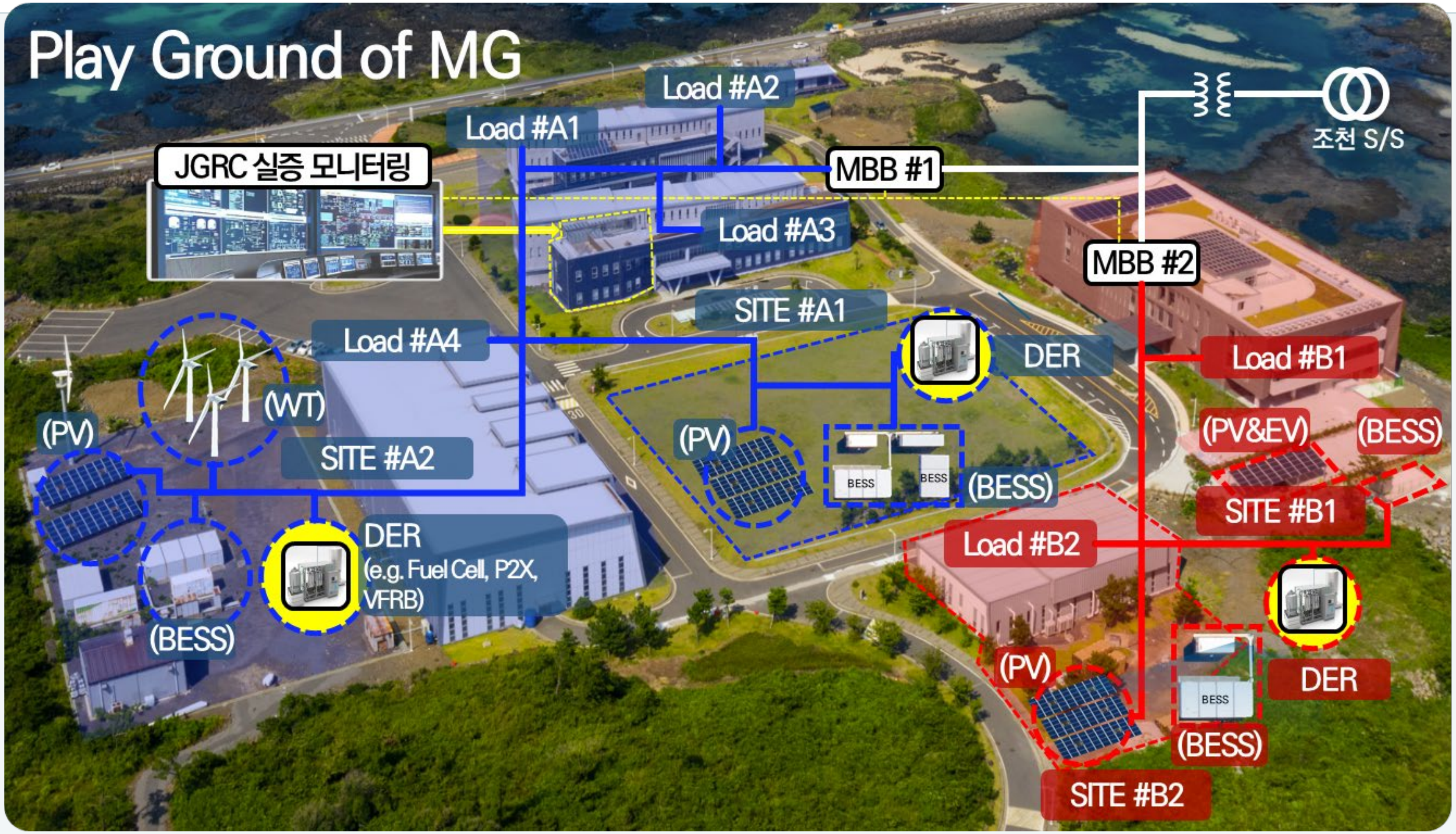
- 10 / 20 kVA module, capacity variable
- PV, wind and storage emulated by P-HILS, 30 kW each
- Grid simulator to 100 kVA: any weak grid we choose

MBB #2 — the field rig

- 10 / 100 kVA module on real resources
- 45 kW PV, 200 kW storage, EV chargers, real building load
- On the real 22.9 kV feeder from Jocheon substation

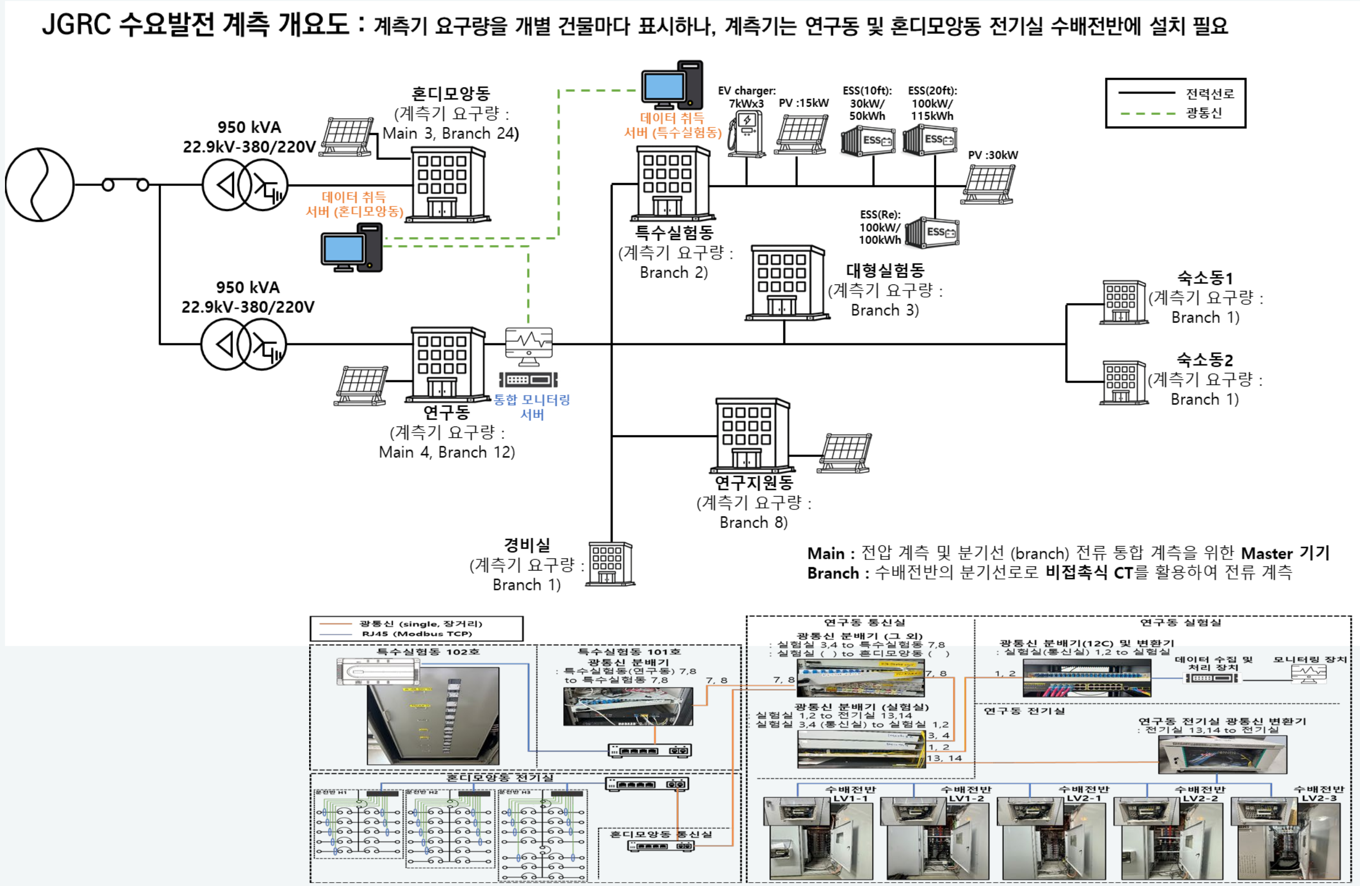
Same block, two worlds: broken safely on the simulator, proven honestly in the field.

The whole campus is the playground



Buildings are the loads, roofs are the generation, Jocheon substation is the boundary — and campus RE100 is the operating target.

Measured before controlled: every building, every branch



Why so many meters

- Main and branch metering in every building, on optical fibre
- Non-contact CTs — installed without shutting a single switchboard down
- A real load profile per circuit, instead of an assumed one
- Measured data is the evidence a financier will accept

We spent more design effort on measurement than on generation. Meters are cheap; assumptions are expensive.

Where this is going: the campus shows its own RE100, live

Every panel is a measured building; both blocks dispatch in real time. A digital twin of the campus — and the dashboard we will operate it by.

PART 5 OF 6

Beyond one microgrid

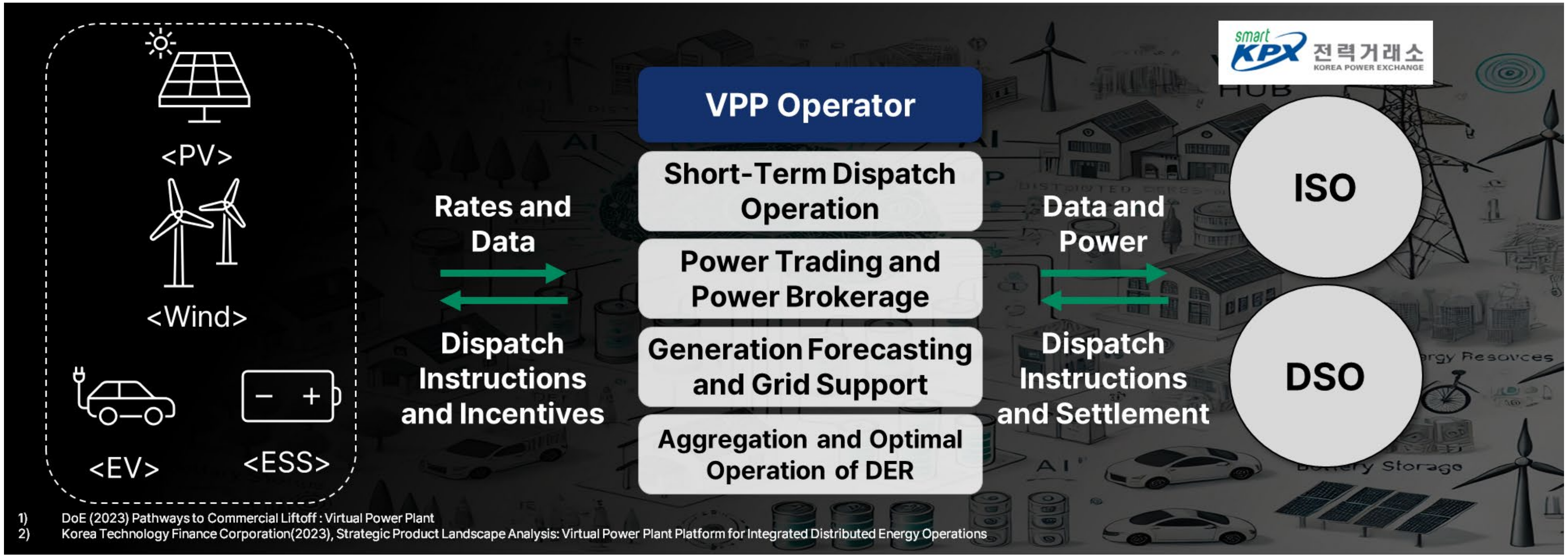
5

The same block, scaled up: virtual power plants, data centres, and an EV station you can touch.

From one microgrid to many: the aggregation layer

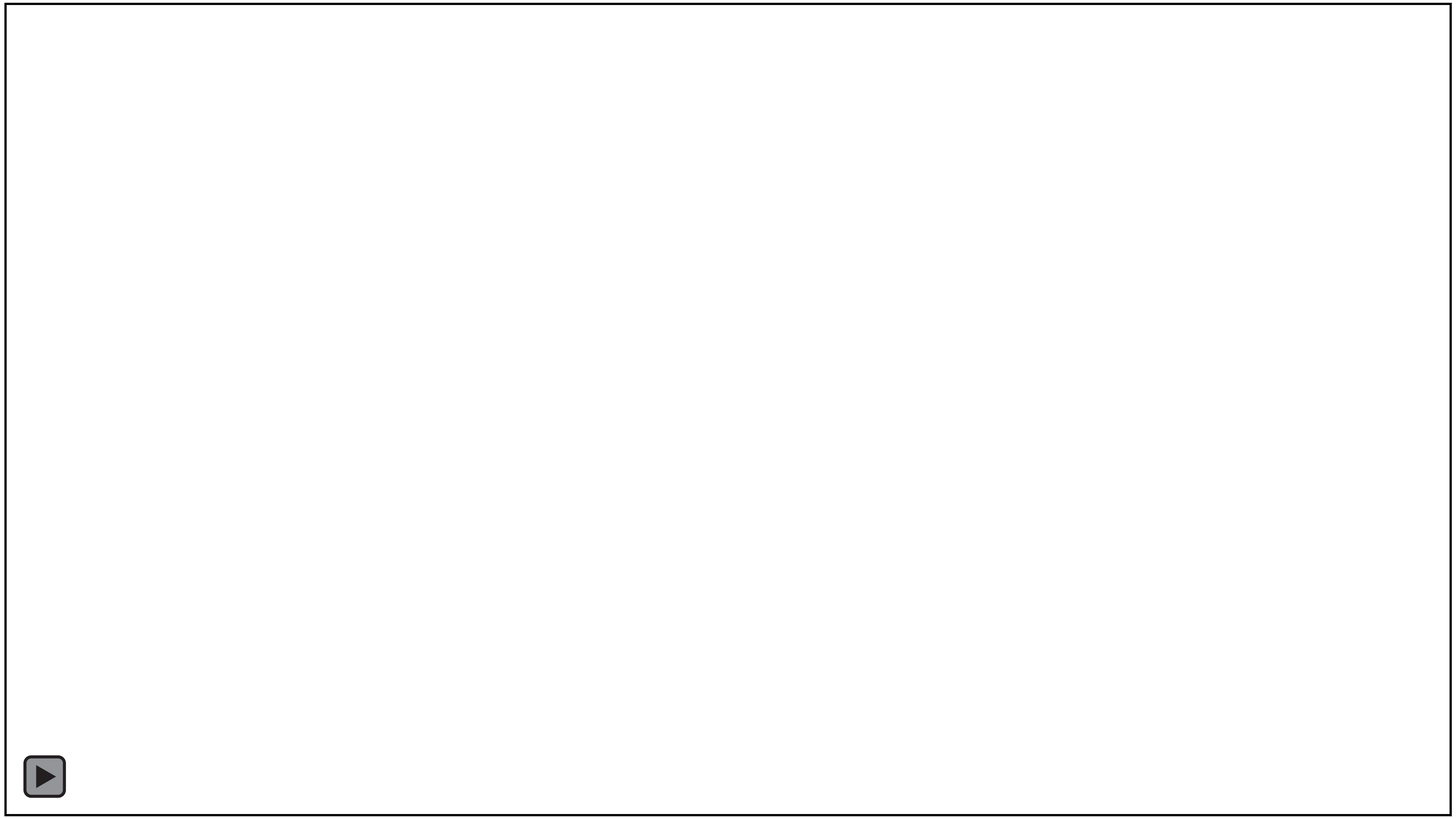
VPP (Virtual Power Plant)

→ A VPP is a technology that aggregates distributed energy resources, balances power supply and demand, and provides utility-scale grid services.



A virtual power plant bundles many small resources into one power plant that the market can see, dispatch — and pay.

From one microgrid to many: the aggregation layer



Our KIER-VPP platform on a real-time simulation of the whole Jeju system: hundreds of resources, dispatched and settled together.

From one microgrid to many: the aggregation layer

A microgrid is the building unit. A virtual power plant is what you build out of many of them.

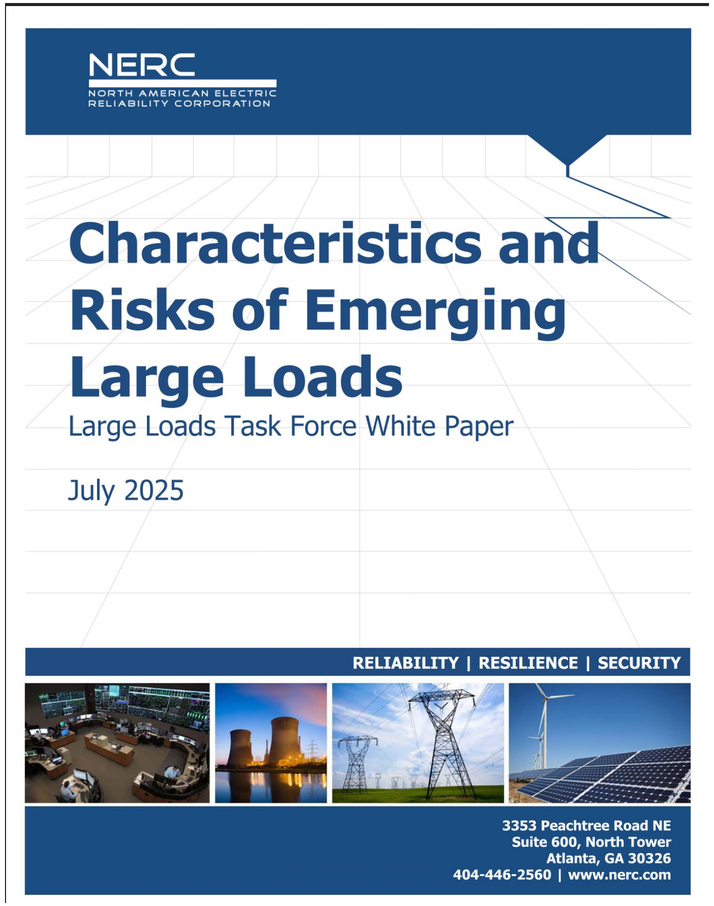
Resource	Capacity in the Jeju-scale simulation
Wind	190 MW
Solar PV	325 MW
Battery storage	55 MW / 220 MWh
Electric vehicles	100 MW
Demand response	50 MW
Power-to-X	10 MW

What the platform does

- Aggregates 500 MW of distributed resources across 6 zones and 11 substations of the Jeju system
- Real-time grid simulation with day-ahead and real-time market bidding
- AI-based generation forecasting, automated bidding and dispatch
- Ancillary service provision and settlement management
- Validated first against real JGRC assets, then extended in simulation

For an island utility, this is the same platform: it does not care whether the resource behind the meter is one battery or one microgrid.

The newest microgrid problem is also the fastest growing one



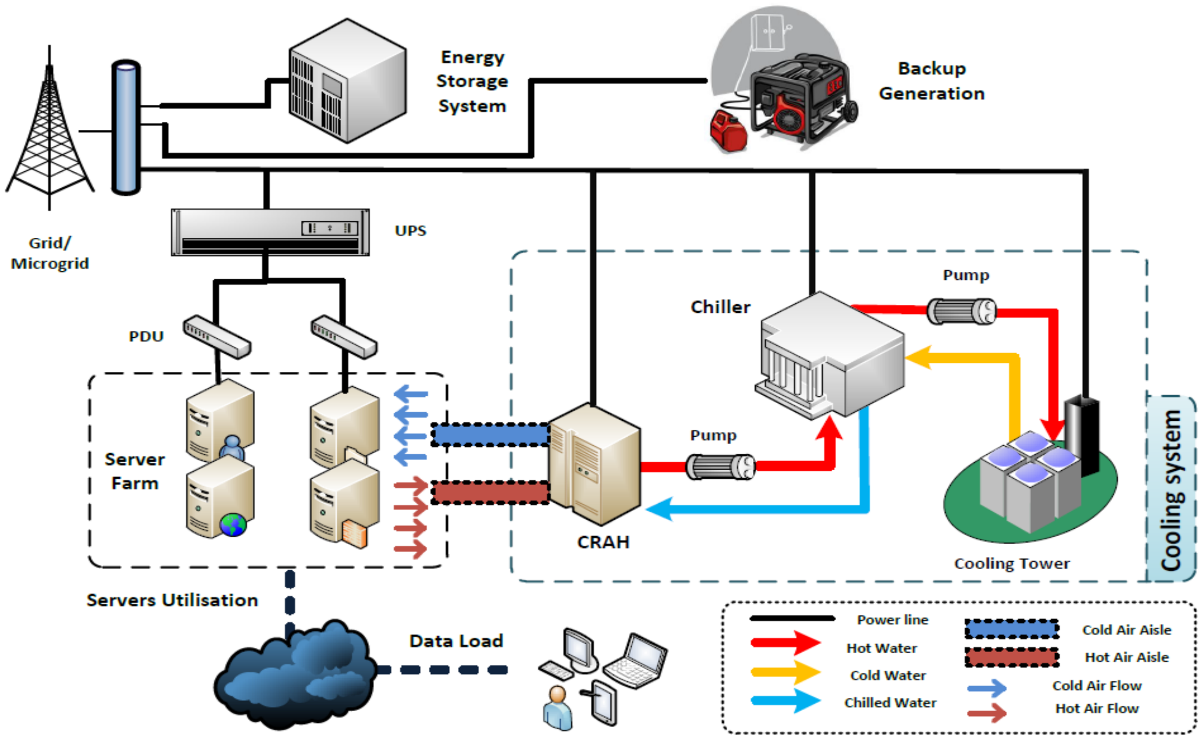
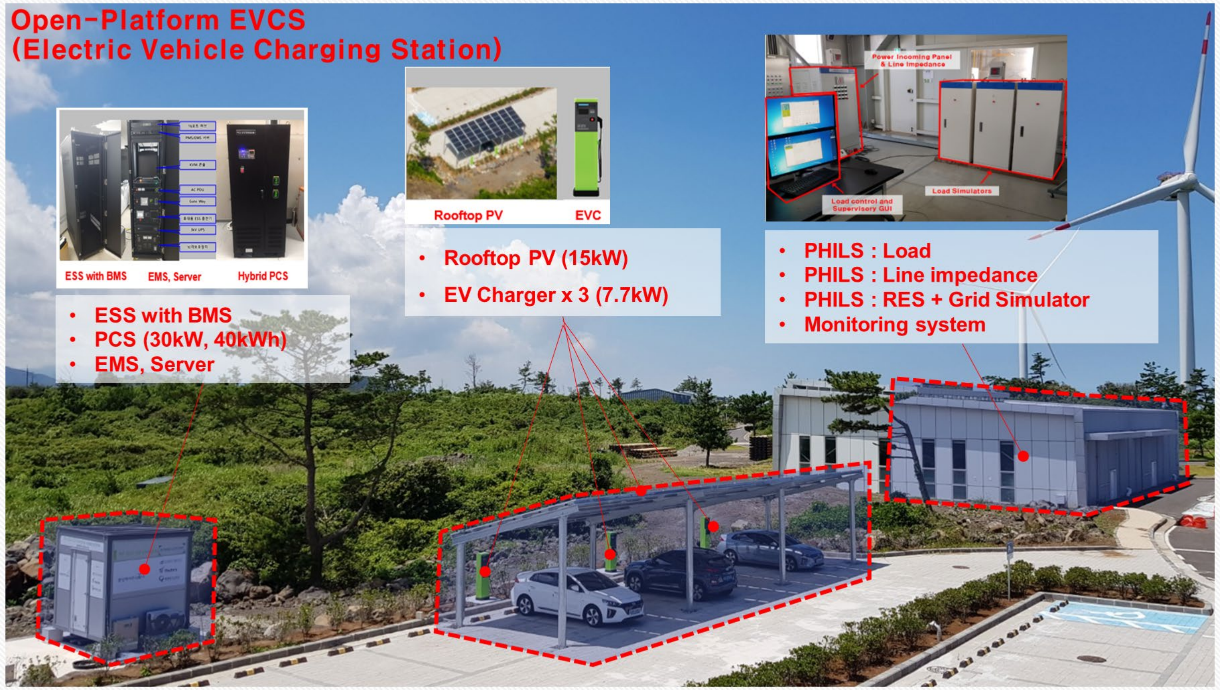


Fig. 1. The interconnection of components in a typical data centre.

Sources: IEA, Energy and AI (2025); MIT Supercloud TX-GAIA GPU telemetry dataset.

And the smallest one: an EV charging station, forty metres away



EV Charging station with RES + BESS (Jeju, Korea Institute of Energy Research)

A complete microgrid in miniature

- 15 kW rooftop PV, a 30 kW / 40 kWh battery, three EV chargers
- A weak feeder emulated by power hardware-in-the-loop
- Voltage held at the connection point while charging continues
- Net-zero ratio — your RE ratio — measured continuously

Every element of the microgrid definition from Part 1 is present, instrumented, and running daily.

You will walk through it at 11:00 — please treat it as a site inspection, not a display.

PART 6 OF 6

What to take home

A framework for your idea note — then we walk at 11:00.

6

Which microgrid are you actually building?

Four archetypes. Identify yours before anyone shows you a product datasheet.

Archetype	Situation	Primary driver	Role of storage	Main risk
A. Off-grid village	No grid, and no grid is coming	Access and fuel cost	Daily cycling; sized by the worst low-resource period	Operation and revenue collection after handover
B. Weak-feeder edge	Grid exists but is unreliable at the end of the line	Reliability and voltage quality	Ride-through, voltage support, peak relief	Interconnection rules and protection coordination
C. Critical facility	Hospital, port, airport, water plant, telecom	Continuity of a specific service	Seamless transfer and backup duration	Under-specifying what must never go dark
D. Island system	A whole island network with rising renewable share	Curtailment, inertia, fuel displacement	System services: frequency, inertia, reserve	Buying energy capacity when you needed system services

Many countries have all four. They are four different procurements, four different tariffs and four different operators. Do not merge them.

This talk on one page

1

A microgrid is a system

A boundary plus control turns the same battery from an accessory into infrastructure that can be financed — and repeated.

2

Islands lead, and grid-forming wins

Kaua'i runs at up to 90 % inverter power because two plants form the grid. Small systems meet the future first.

3

MBB makes it repeatable

One standard block — power, control, communication — verified in simulation, becoming hardware, demonstrated on this campus.

4

One architecture, many markets

The same block serves villages, EV stations, data centres and virtual power plants. That is what makes it affordable.

A battery is a device. A microgrid is a system. Only a system can be repeated.

What you will see at 11:00, and what to look for

The lab tour is not a display. Please treat it as a site inspection and ask difficult questions.

1

MBB platform and control room

Look at: how the module is physically connected, and what happens on the screen when we island it.

2

EV charging microgrid

Look at: the PCC, the metering, and the state-machine logic. Ask what happens when the network drops.

3

BESS containers

Look at: thermal management, fire safety separation, and how a reused-battery unit differs from a new one.

4

P-HILS and simulators

Look at: how a simulated 50 kW wind turbine exchanges real power with a real battery on the same bus.

Thank you.

I look forward to the discussion, and to walking the site with you at 11:00.

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