2025 IERE-TPC Taipei Net-Zero Workshop

Micro Grid in Black Start and Seamless Technology

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Delta /EISBG ADVII. Dep (Power System R&D)
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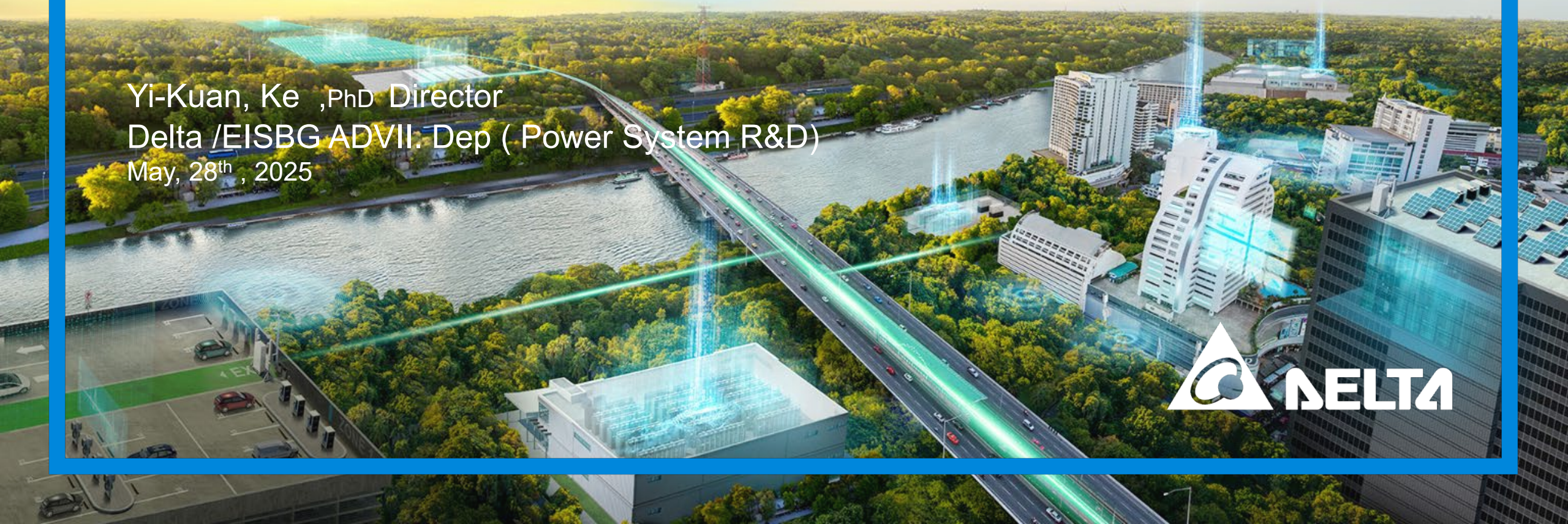
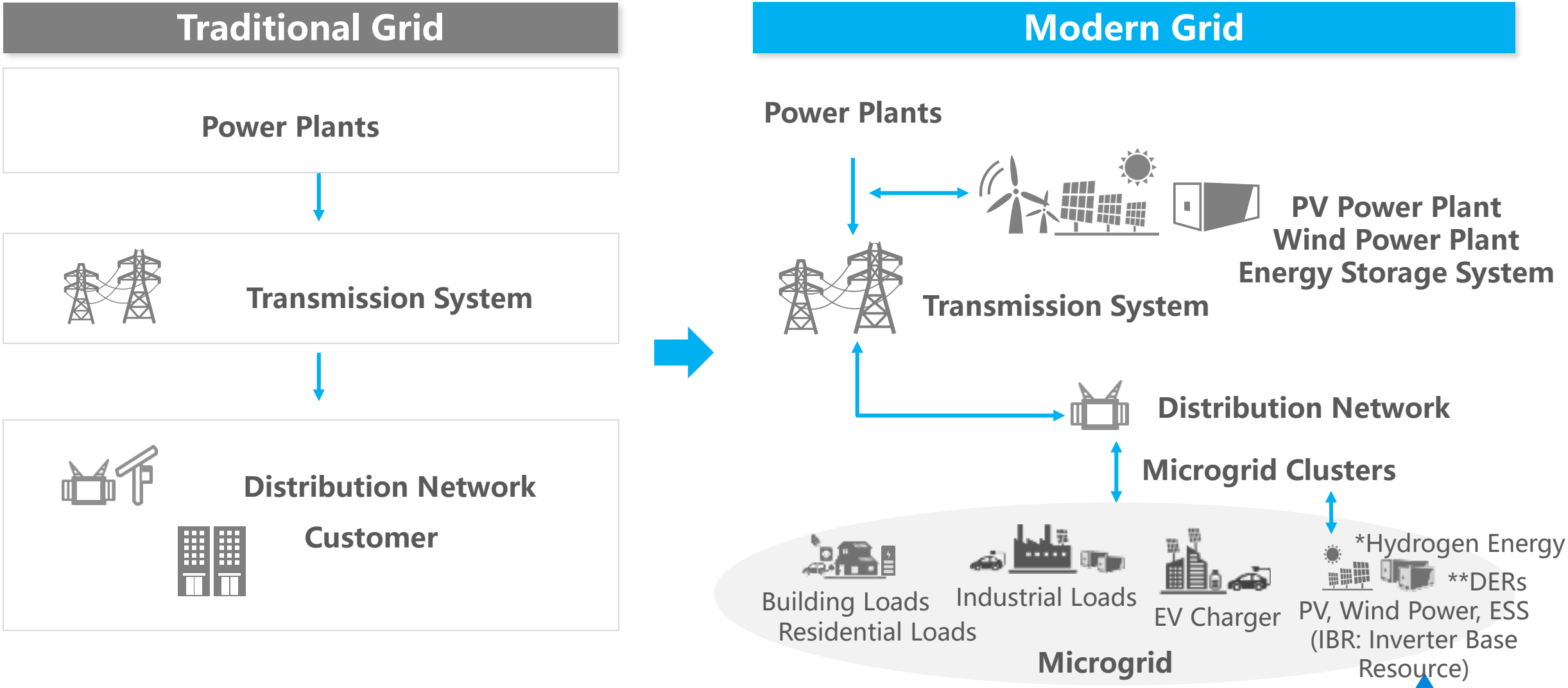


Outline

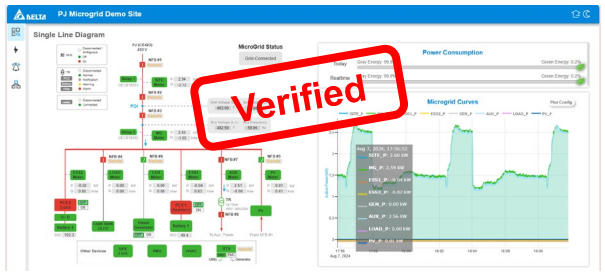
- Microgrid Introduction
- Microgrid Seamless Transition Technology
- Delta PCS(Power Conversion System) Seamless Transition Experiments
  - Seamless Un-intentional Islanding
  - Seamless Reconnect
- Delta Develops Virtual Inertia Technology
- Black Start with Parallel
- Conclusion

Microgrid Introduction

- **Traditional Grid vs. Modern Grid**



Delta Micro Grid New Technology



Utility Power

*PCC

PLL

On Grid → Off Grid (Seamless)

Off Grid → On Grid (Seamless)

Transformer

Load1

Load2

Generator

ESS

PV

Microgrid:
Loads without interruption

ESS
Seamless

PV
Without interruption

*1. On-Grid to Off-Grid Seamless

*2. PV Power Uninterrupted

*3. Auto Start/Stop of Generators

*4.Auto Load Shedding

*5. Prioritize Green Energy

*6. Autonomous Regulation, and Operation.

*7. Resilience (Virtual Inertia)

*8. Black Start

(1)ESS PCS1 Seamless
(Grid Following → Grid Forming)

- In Power Feeder lose power, microgrid is going seamless to keep load and PV power on.
  (PCS seamless and IEC61850 Relay)

(2)ESS PCS1 Seamless
(Grid Forming → Grid Following)

- As grid returns to normal, the microgrid is going to re-connect with the grid to avoid power load lose again. (PLL)

(3) Black Start

- For Black Start, PCS (GFM) builds V/F, then PV power and Load Sequence Control.

*PCC: Point of Common Coupling

Delta PJ Micro Grid New Technology

Verified

Patents

Seamless
(Un-Intentional)
+PMU+SPCP

GFL, GFM,
Seamless,
Black Start
GFM VSG

Virtual
Inertia

Virtual
Damping

AC Grid+
DC Grid,
AC Coupling+
DC Coupling

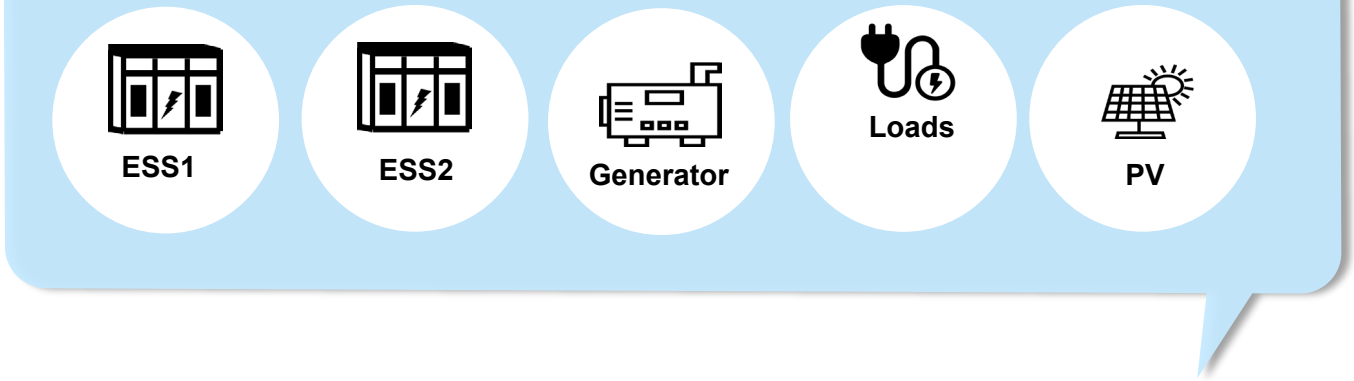
Delta PJ Micro Grid New Technology

Verified

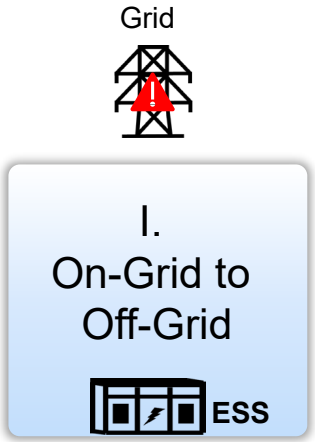
Patents

Energy Resources (DERs) in Delta PJ Microgrid

(DER: Distribution Energy Resource)

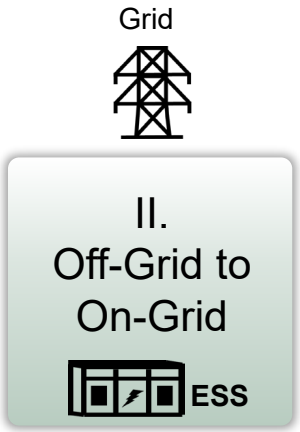


I. On-Grid to Off-Grid



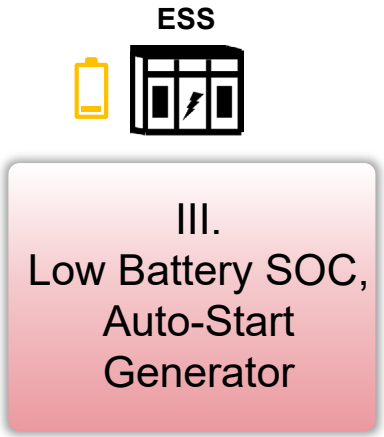
- **Without Seamless**
- **With Seamless**

II. Off-Grid to On-Grid



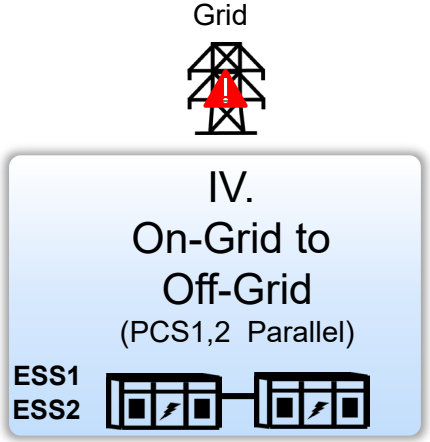
- **Without Seamless**
- **With Seamless**

III. Low Battery SOC, Auto-Start Generator



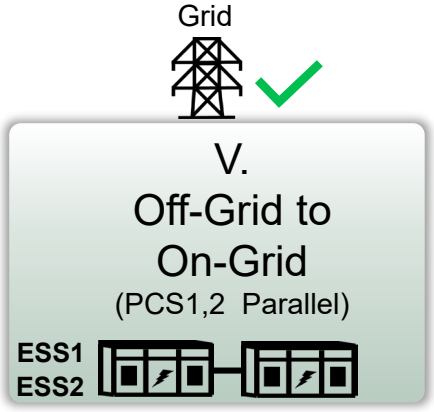
- **With Seamless Solution (Auto)**

IV. On-Grid to Off-Grid (PCS1,2 Parallel)



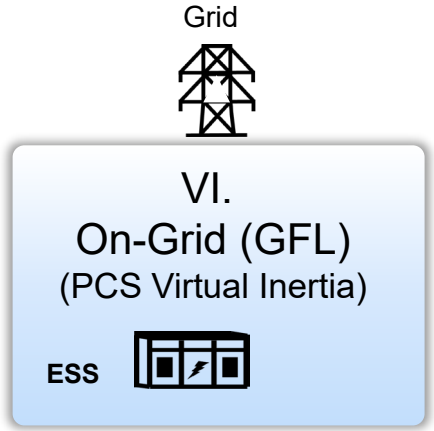
- **Without Seamless**
- **With Seamless**

V. Off-Grid to On-Grid (PCS1,2 Parallel)



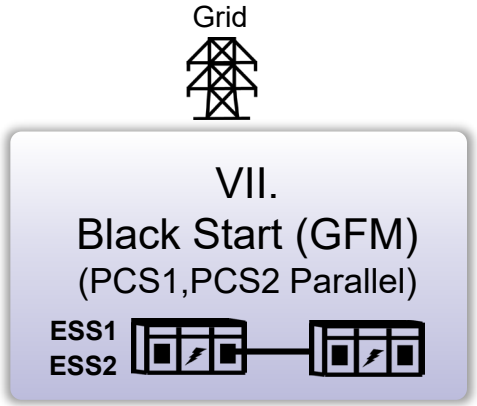
- **Without Seamless**
- **With Seamless**

VI. On-Grid (GFL) (PCS Virtual Inertia)



- **IBR Virtual Inertia**

VII. Black Start (GFM) (PCS1,PCS2 Parallel)



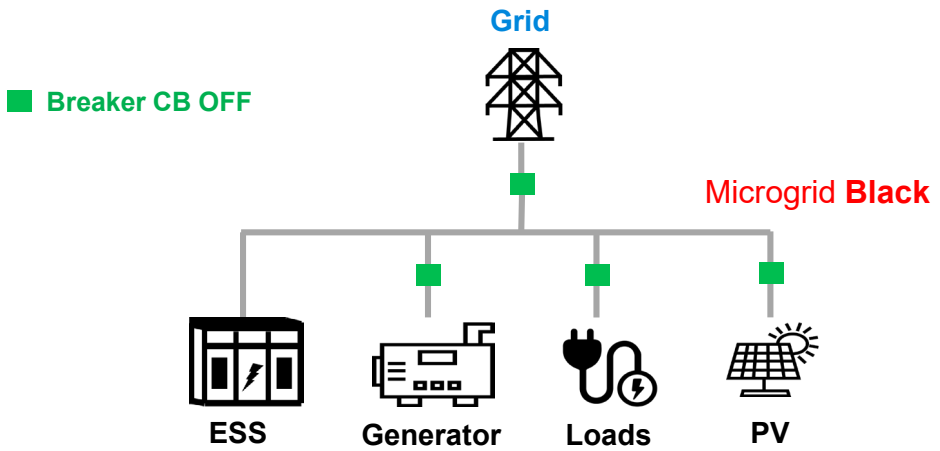
Micro Grid Topology
Scenario #1. On-Grid to Off-Grid (Power Outage in Grid)

Scenario Description:

Unexpected power failures happen in the Grid, posing a risk of power loss to our microgrid.

Without Seamless Solution

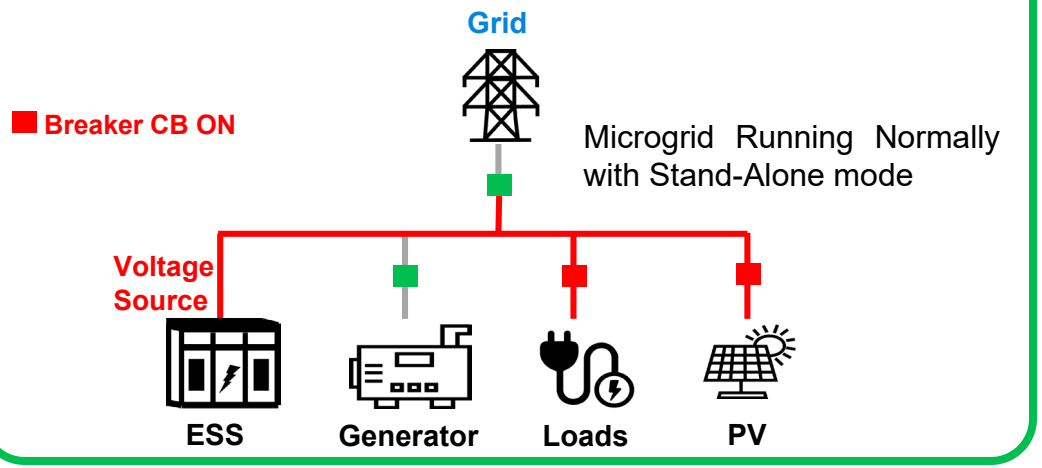
- Without any contingency measures, the Microgrid will immediately black out due to power loss.



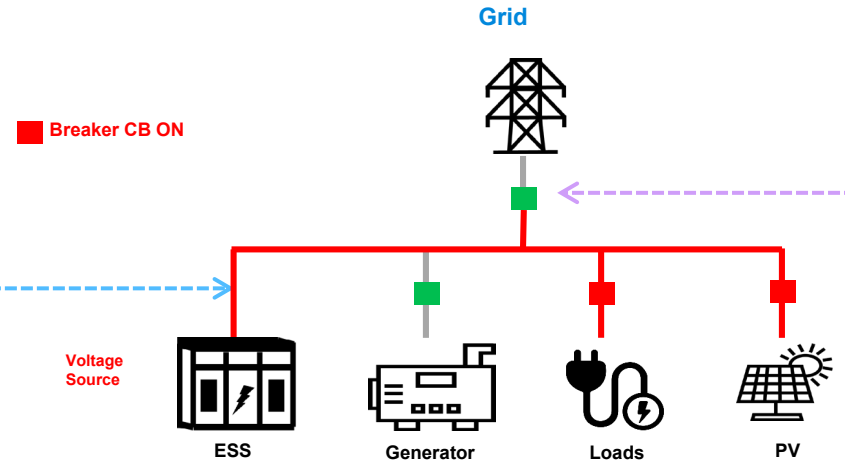
(Auto) With Seamless Solution

2023/11 Verified

- Make the **PCS transform to Stand-Alone mode seamlessly**, prevent our microgrid from losing power.



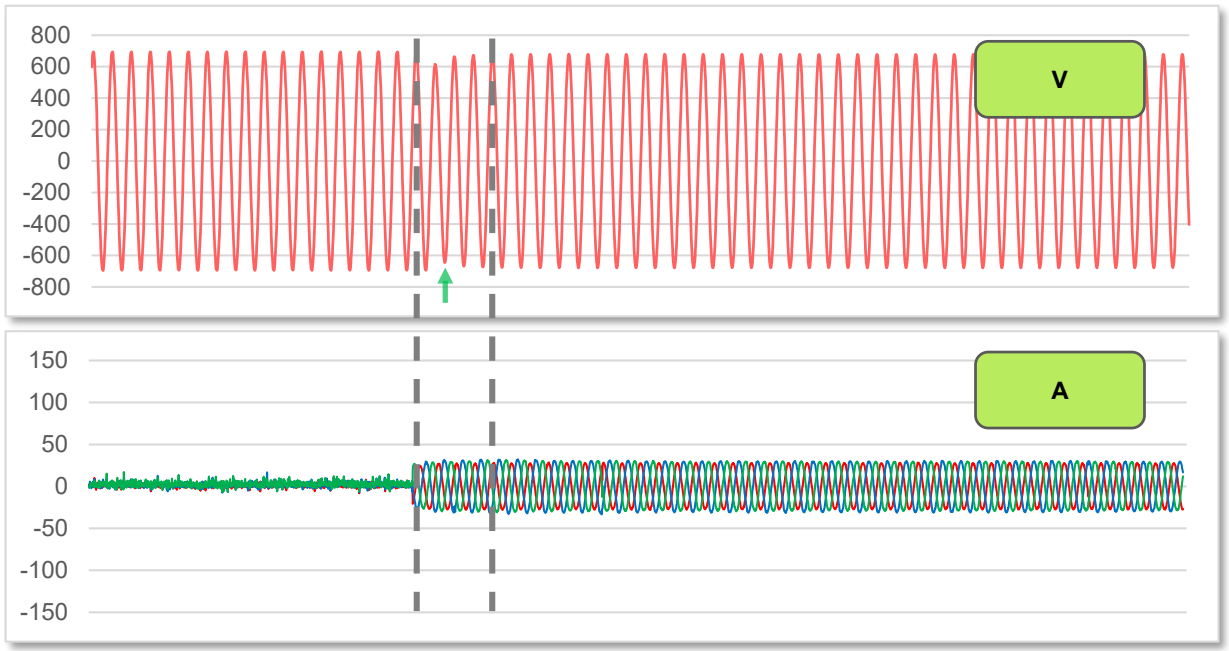
Scenario #1. On-Grid to Off-Grid (Power Outage in Grid)

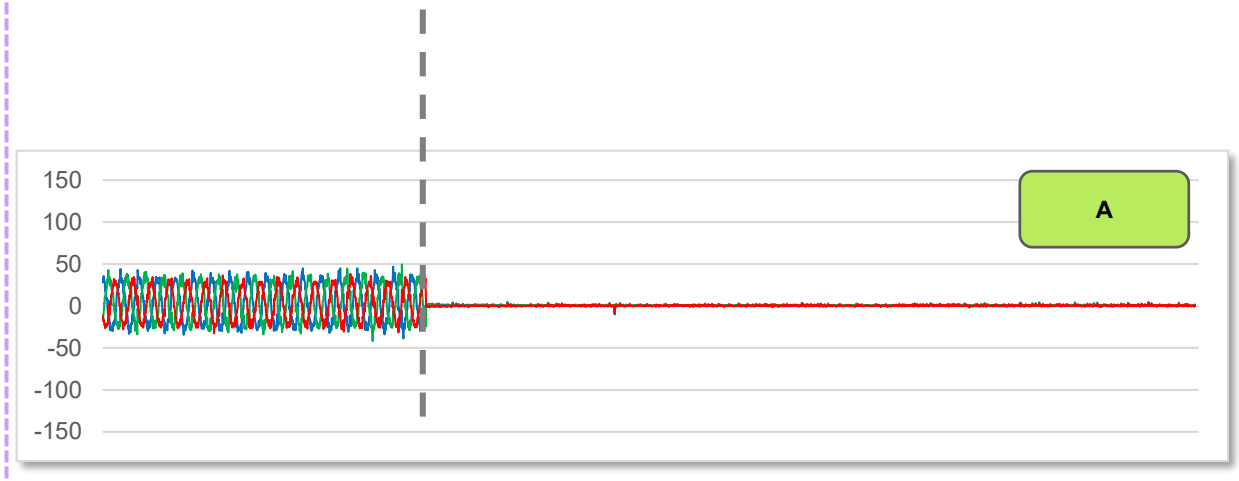


Verified

PCS

Grid





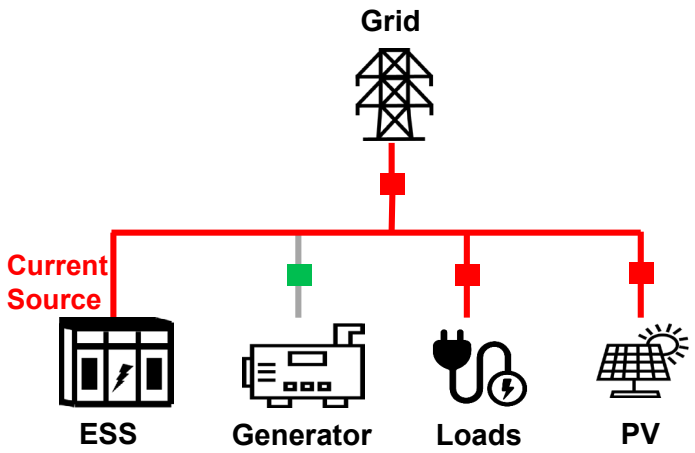
Scenario #2. Off-Grid to On-Grid (Auto)

Scenario Description:
As grid returns to normal, the microgrid is going to re-connect with the grid to avoid power load lose again.

With Seamless Solution **(Auto)**

Verified

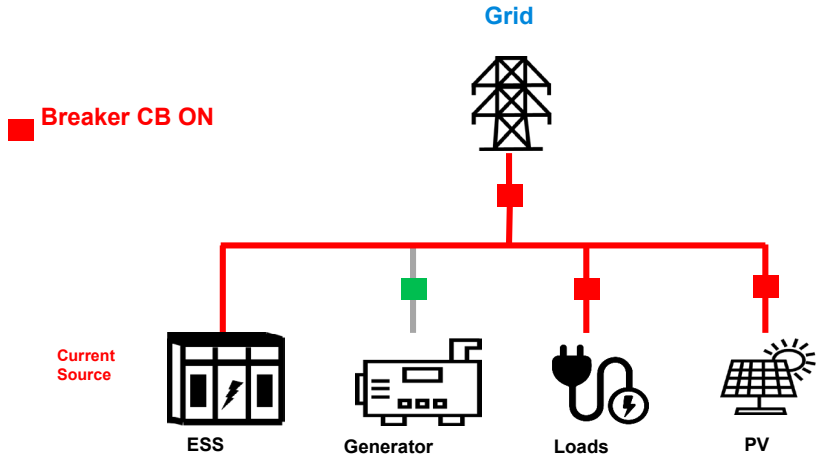
- After making sure the power in the grid has recovered, and Make the **PCS transform to Grid-tied mode seamlessly**.
- With such procedure, the load will not lose power during the transition.
- Automagically transfer to ON-Grid after Synchronous

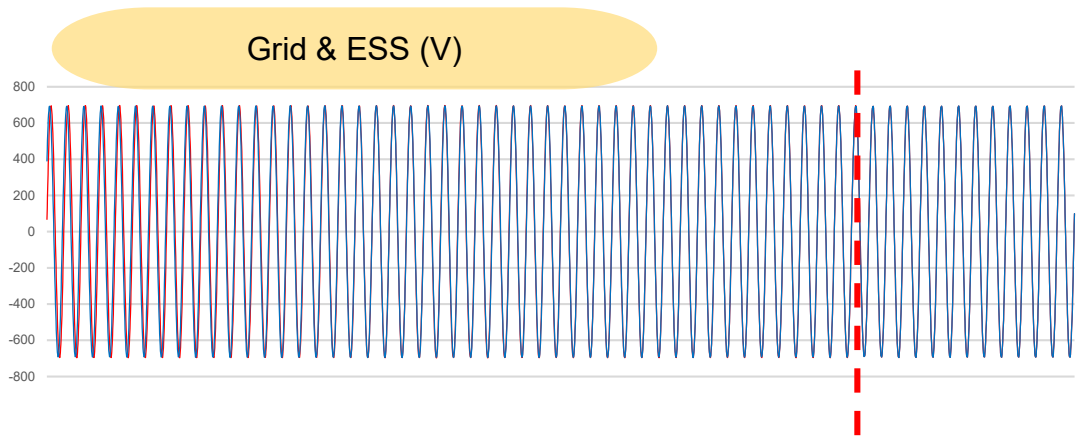


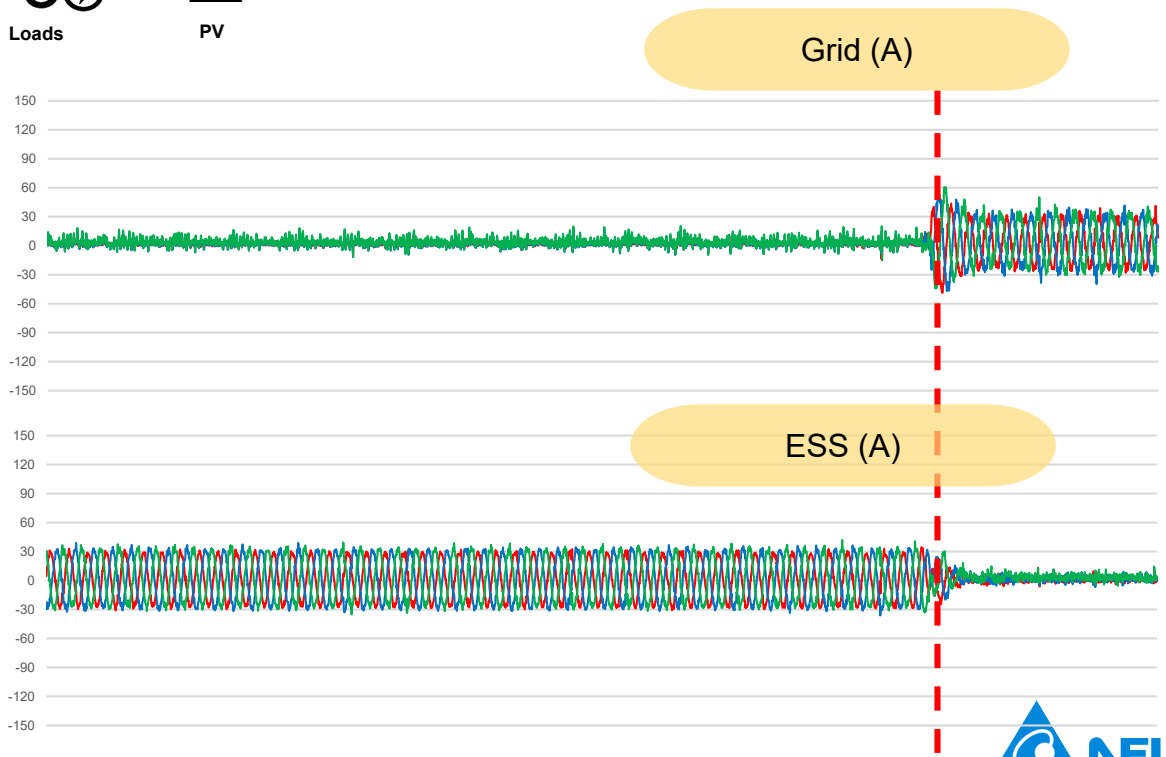
Scenario #2. Off-Grid to On-Grid

(Utility Power Recovery to Auto Transfer to On Grid after Synchronous

Verified







Scenario #3. Low Battery SOC, Start the Generator

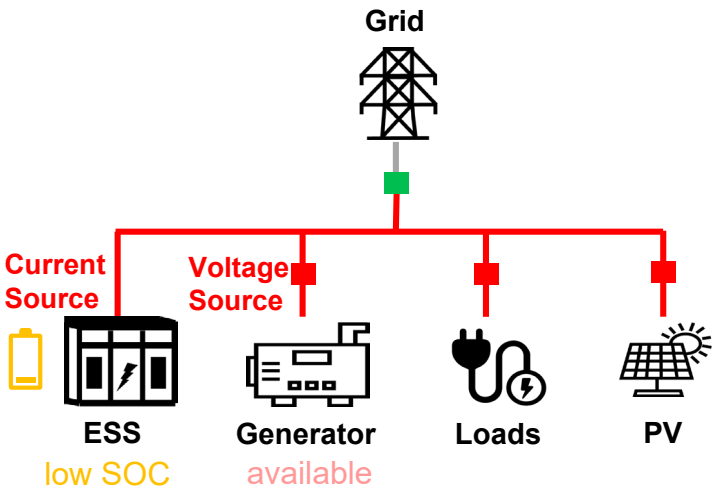
Scenario Description:

Under Stand-Alone mode, when the **SOC is lower than a threshold value** and the **generator is available**, the generator will be auto started up.

With Seamless Solution (Auto)

Verified

- The **generator will be started up.**
- The ESS will be transformed into a current source and let the generator seamlessly take over the role of voltage source.
- Auto Start Generator.



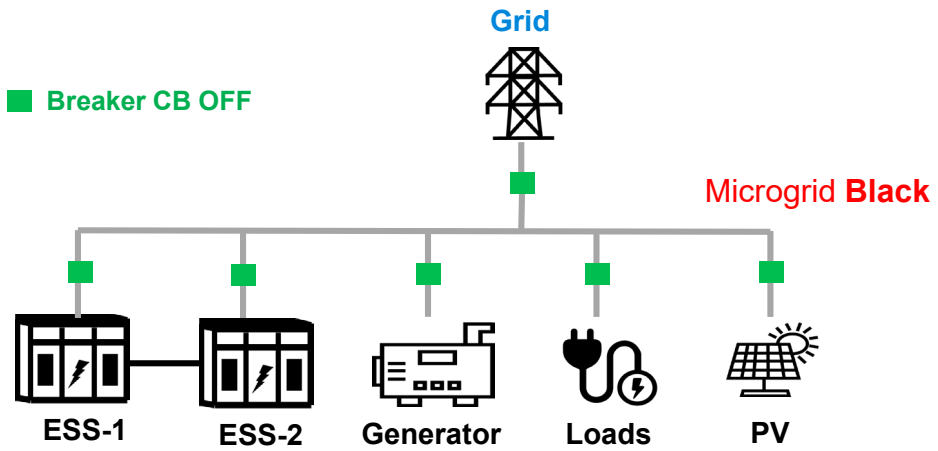
Scenario #4. On-Grid to Off-Grid (PCS1,PCS2 Parallel)

Scenario Description: PCS1, PCS2 parallel seamless (un-planning)

Unexpected power failures happen in the Grid, posing a risk of power loss to our microgrid.

Without Seamless Solution

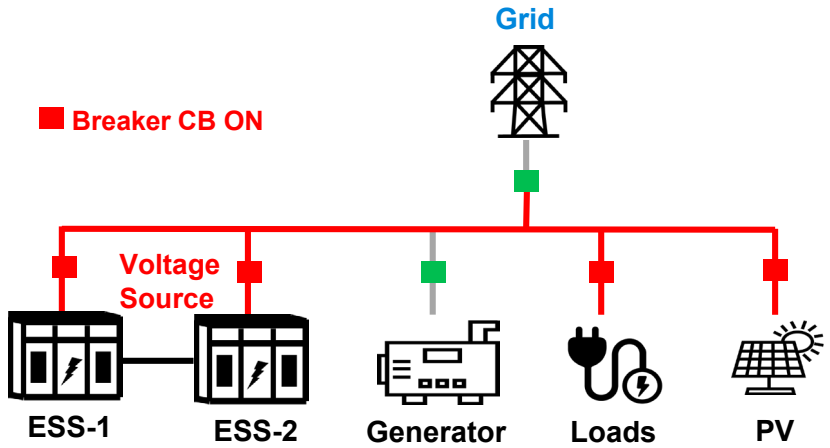
- Without any contingency measures, the Microgrid will immediately black out due to power loss.



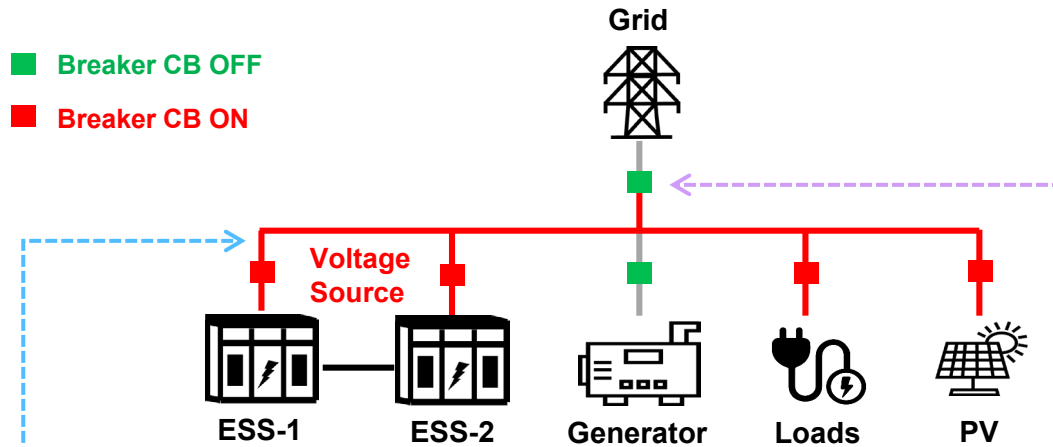
(Auto) With Seamless Solution

2024/Q1 Verified

- Make the **PCS1,PCS2 parallel transform to Stand-Alone mode seamlessly**, prevent our microgrid from losing power.



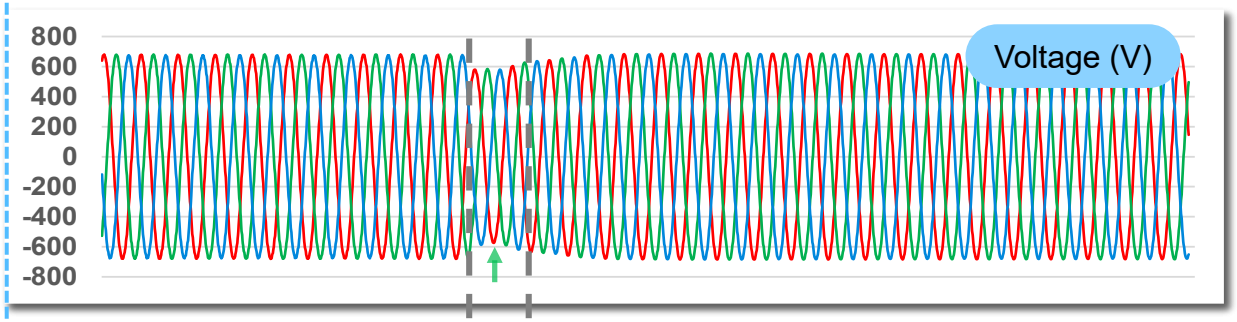
Scenario #4. On-Grid to Off-Grid (PCS1, PCS2 Parallel)

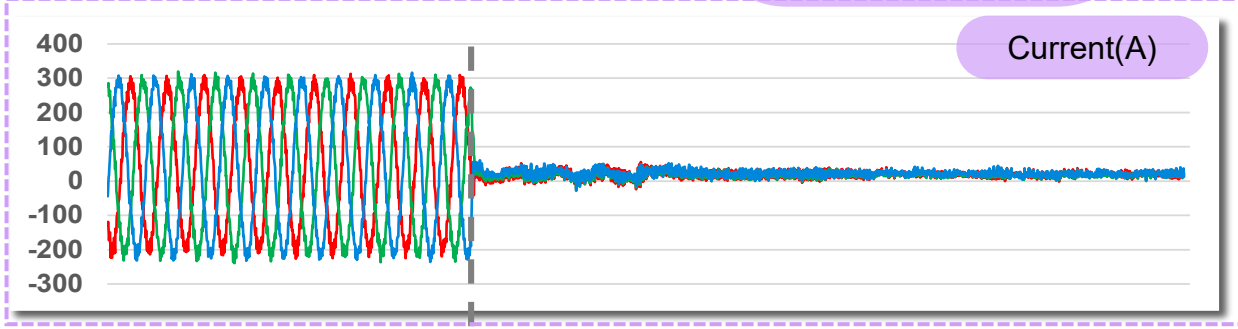


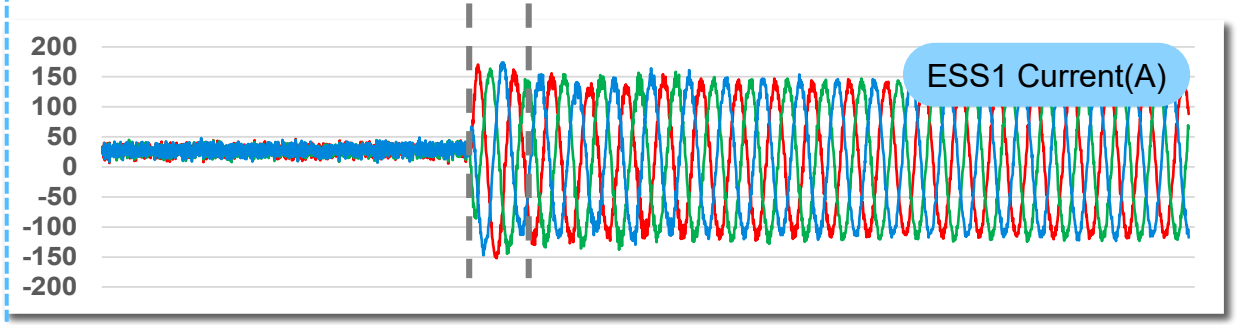
Verified

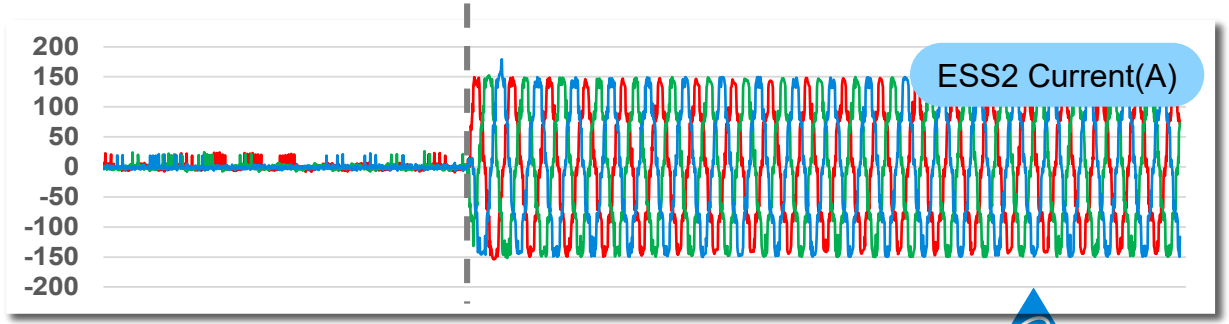
PCS side

Grid side









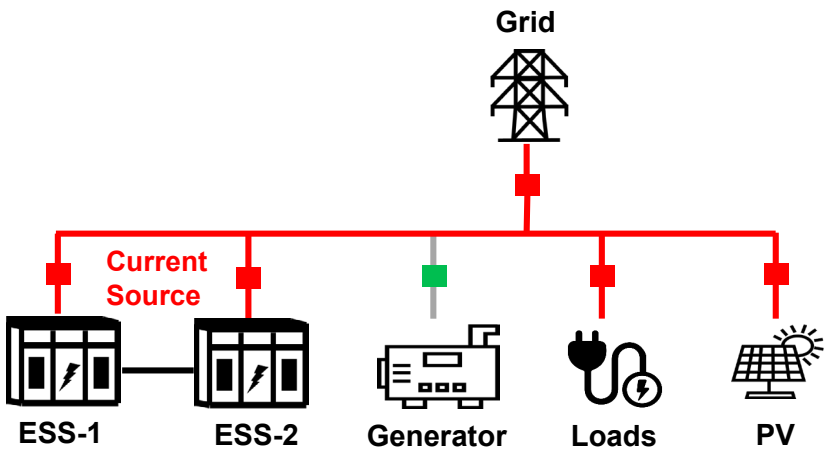
Scenario #5. Off-Grid to On-Grid (PCS1,PCS2 Parallel)

Scenario Description: PCS1, PCS2 parallel PLL Seamless
As grid returns to normal, the microgrid is going to re-connect with the grid to avoid power load lose again.

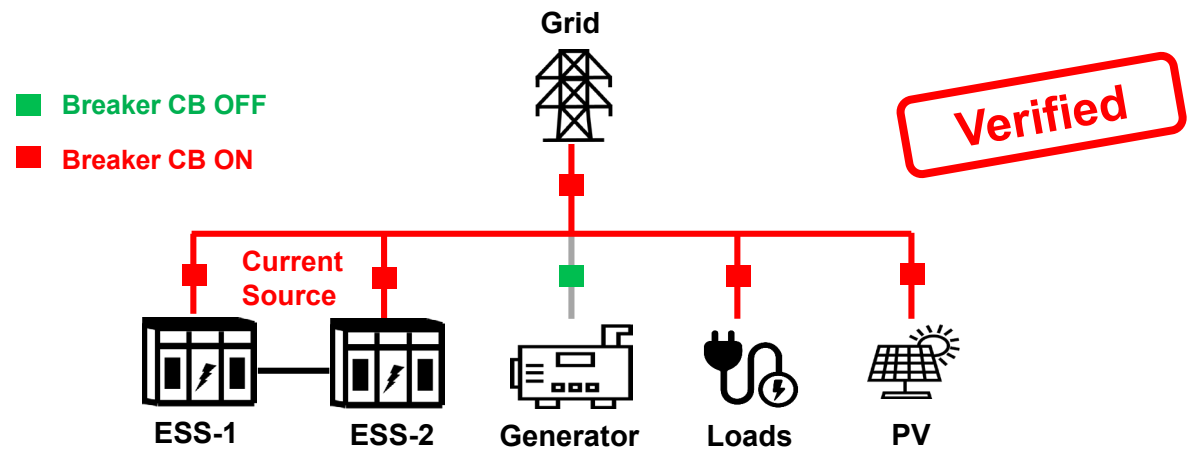
With Seamless Solution (Auto)

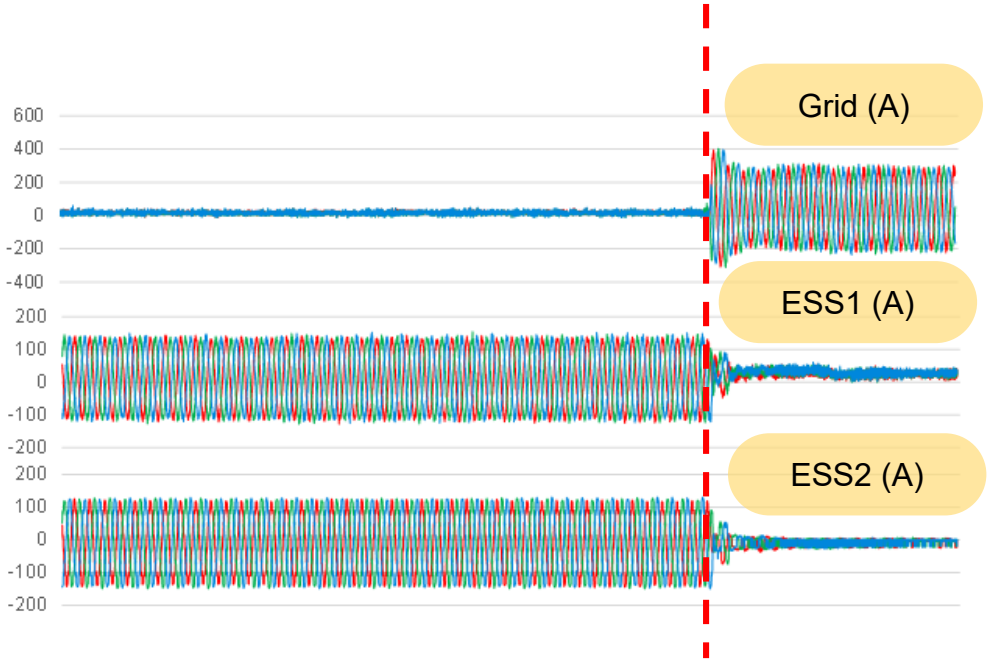
Verified

- After making sure the power in the grid has recovered, and Make the **PCS1,PCS2 parallel transform to Grid-tied mode seamlessly**.
- With such procedure, the load will not lose power during the transition.
- Automagically transfer to ON-Grid after Synchronous



Scenario #5. Off-Grid to On-Grid (PCS1,PCS2 Parallel)
(Grid Power Recovery to Auto Transfer to On Grid after Synchronous)

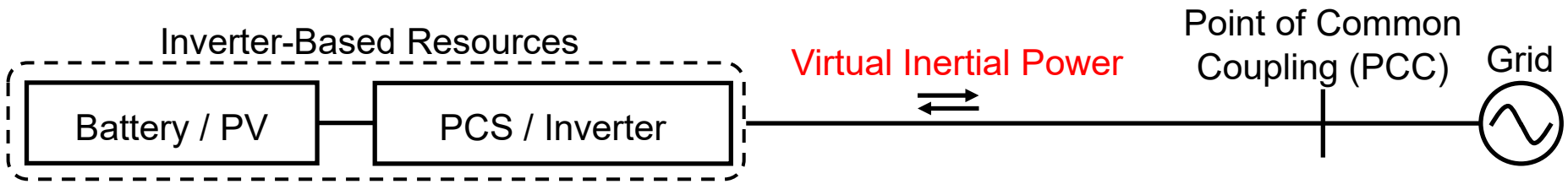




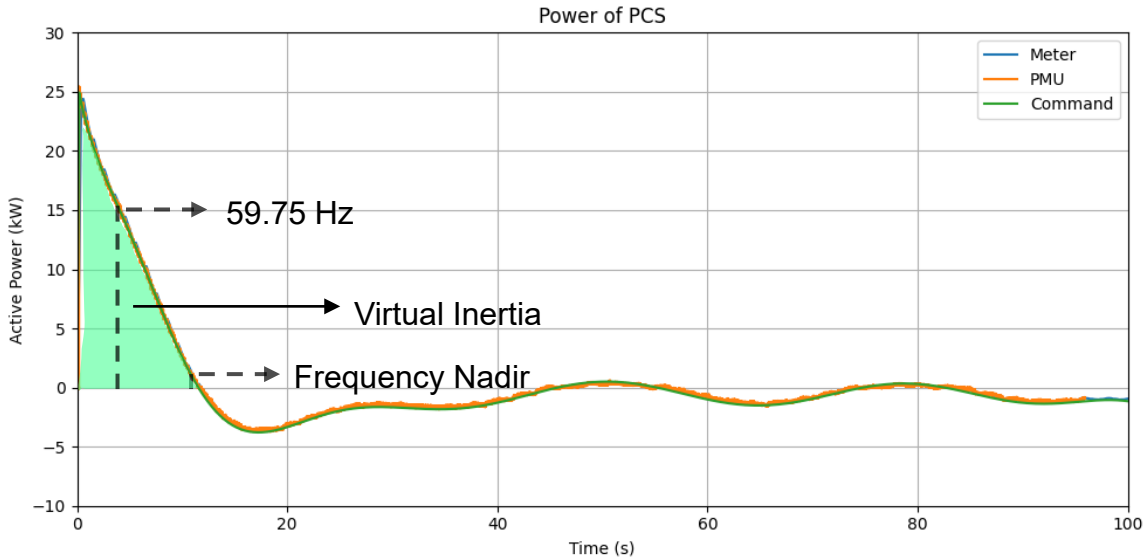
Scenario #6. Virtual Inertia (GFL)

Scenario Description: PCS Virtual Inertia by Software-In-the-Loop

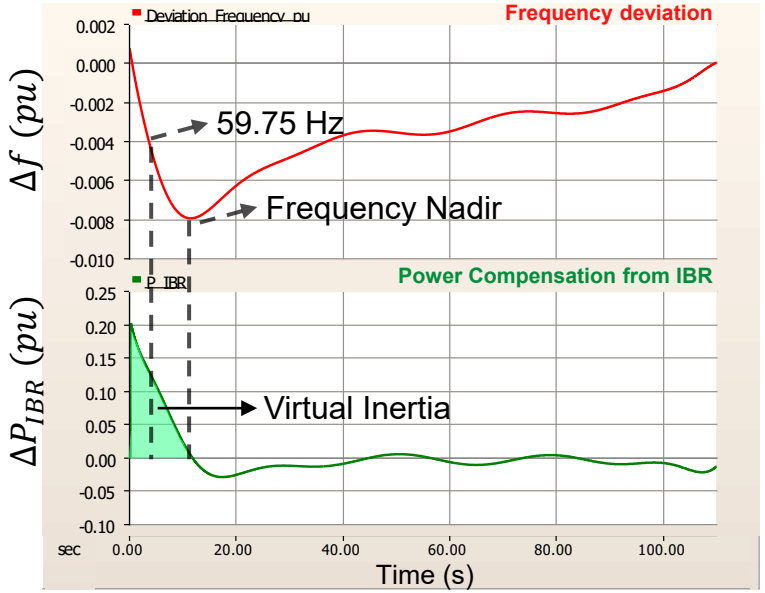
- Inverter-Based Resources with Virtual Inertia Control



➢ Delta PJ Microgrid Site Experiment Results:



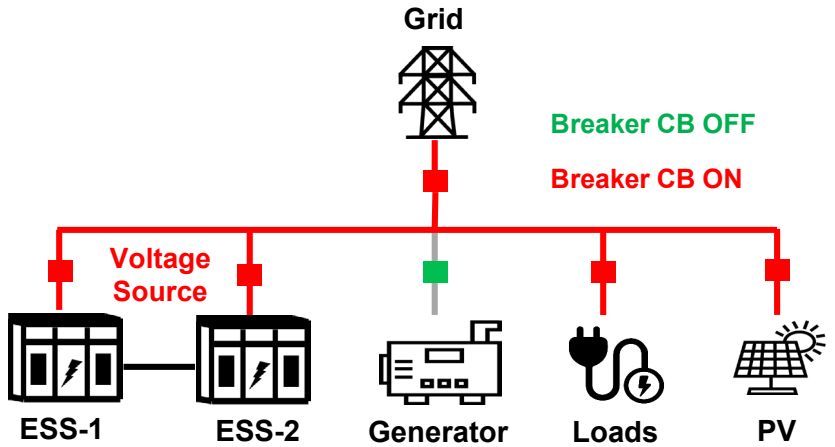
➢ Simulation Results:

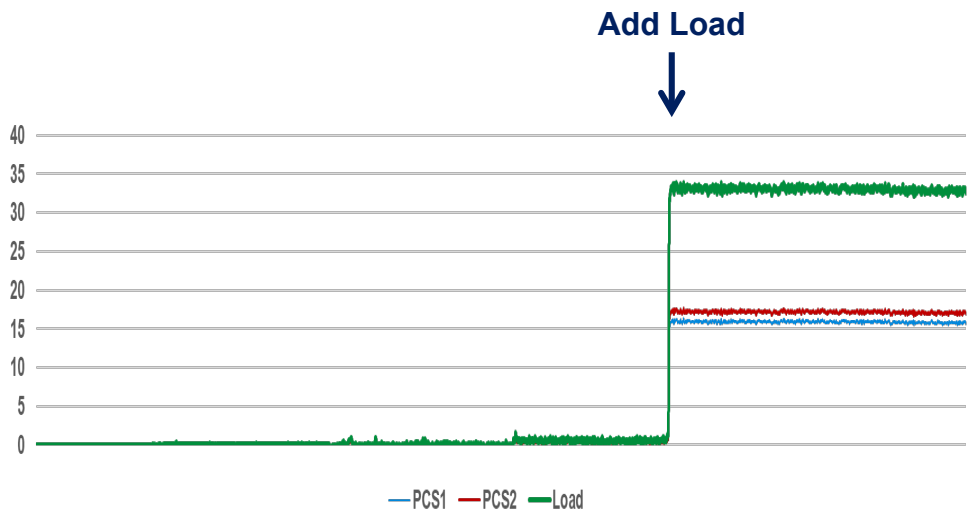


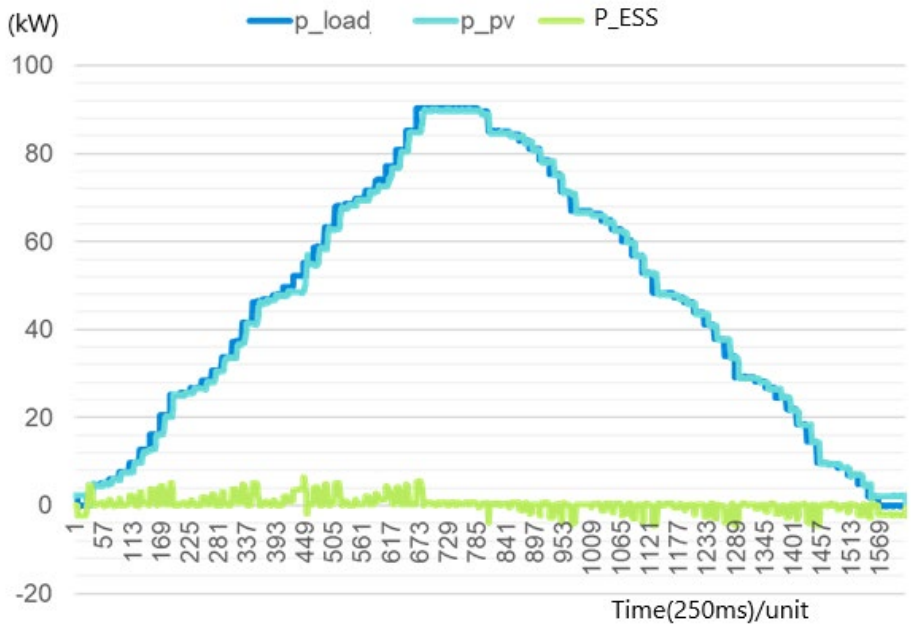
Scenario #7. Black Start (GFM)

Scenario Description:

PCS1, PCS2 parallel for Black Start







Conclusion

- Microgrid for Grid-Tie and Stand-Alone Topology
- Inverter Base Resource Technology in Micro Grid
- Reduction Carbon in Power Generation with Microgrid Technology
- Microgrid Clusters enhance Grid Resilience

Smarter. Greener. Together.