Dynamic Solar Hosting Capacity Calculations in Microgrids

Zohreh S. Hosseini & Amin Khodaei
University of Denver
USA

E. A. Paaso, M. S. Hossan & D. Lelic
ComEd
USA

Presented by: Alireza Majzoobi
University of Denver
USA

Outline

- Introduction
- Hosting capacity
- System definition
- Illustrative example
- Conclusion

Introduction

- **Microgrids** are particularly of interest in integration of renewable energy resources, most commonly customer-deployed solar PVs.

- **Distributed Energy Resources (DERs),** such as wind and solar PV generators, are the cornerstone of future distribution grids.
- Incorporating these technologies can:
  - Reduce greenhouse gas emissions
  - Minimize energy costs
  - Reduce dependence on fossil fuels
  - Increase distribution efficiency
  - Meet growing energy demands

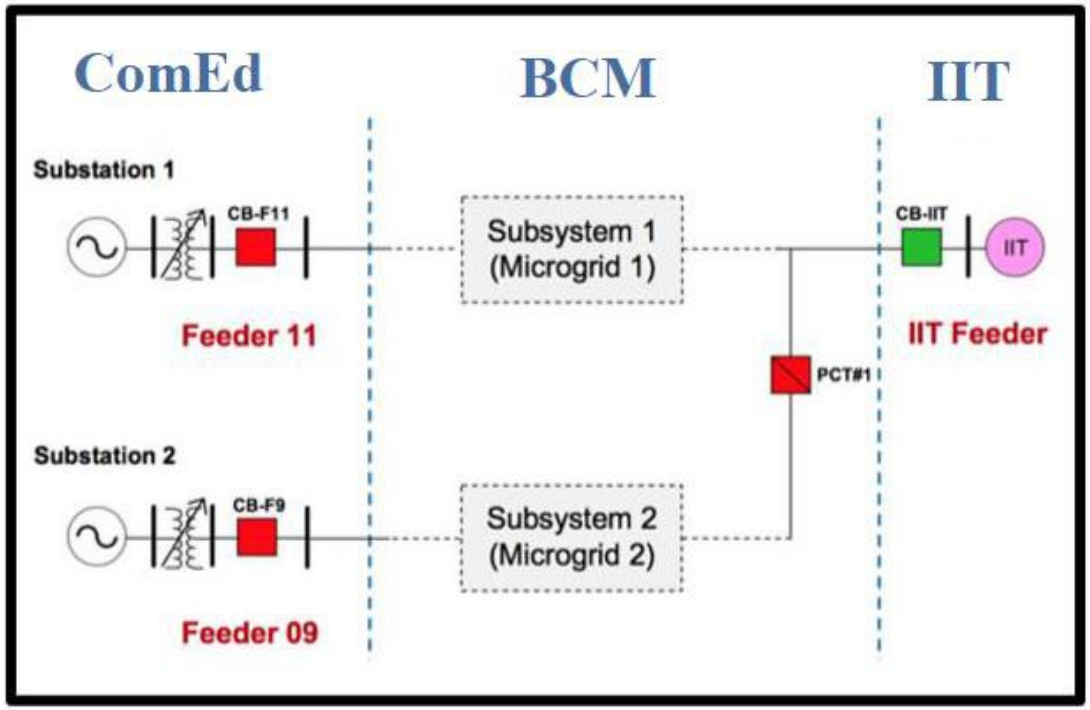
Hosting Capacity

- There is a limit to the additional amount of DG that a distribution grid can accommodate before adversely impacting the operational performance of the grid, these can appear:
  - Undesirable voltage deviations
  - Increased line losses
  - Unexpected thermal overloads
- To determine how much DGs can be added, the concept of hosting capacity is introduced.
- The grid **hosting capacity** is defined as the amount of new production or consumption that can be added to the grid without adversely impacting the reliability or voltage quality for other customers.

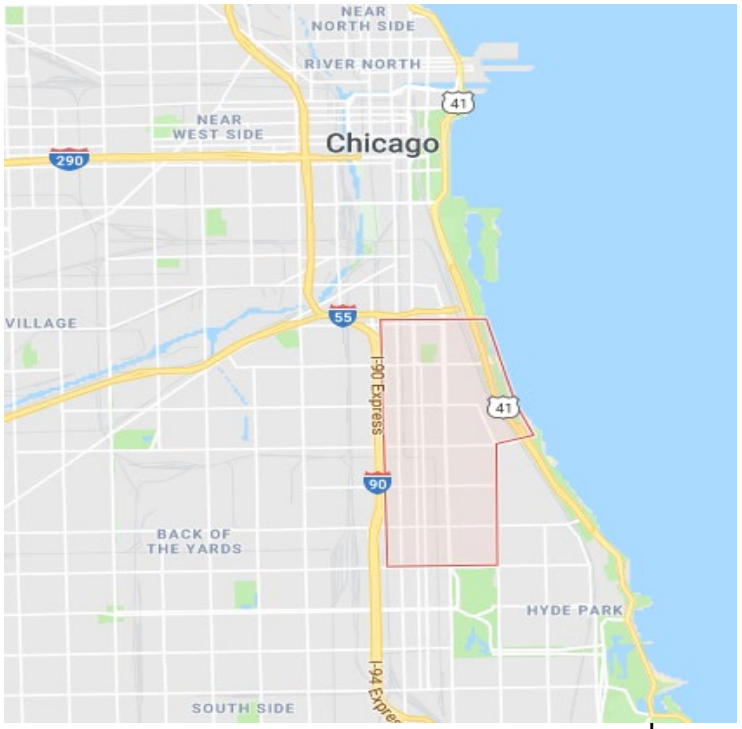
Dynamic Solar Hosting Capacity Calculations

- Stability analysis for **different levels** of PV penetration to find the hosting capacity for the transition from the **grid-connected** mode to the **islanded mode**

- Test System: **Bronzeville Community Microgrid** (BCM)



- Bronzeville neighborhood on the South side of Chicago, IL



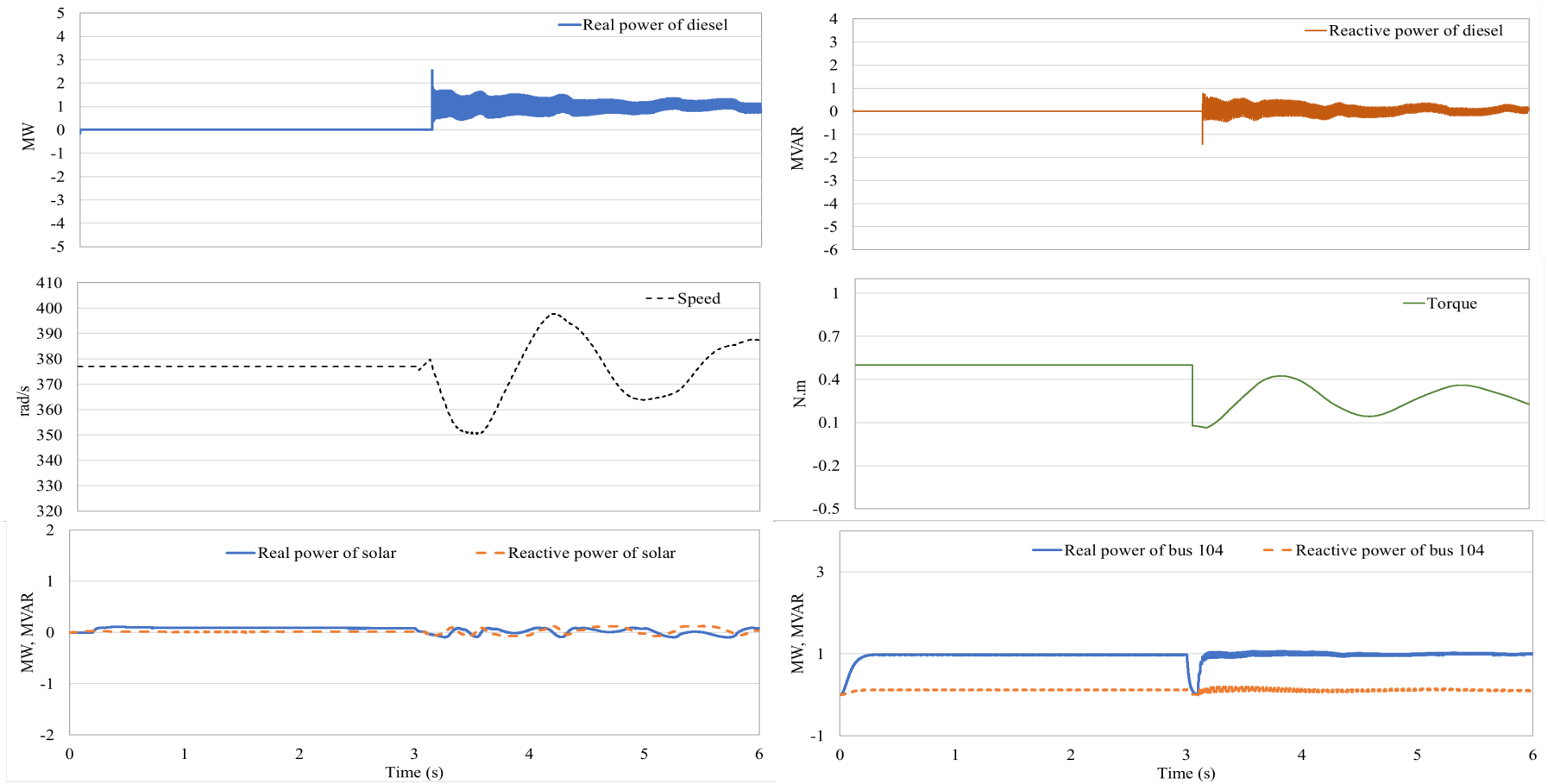
Source: https://www.google.com/maps

Simulation

- Detailed BCM distribution model in **PSCAD** simulation tool
  - 1) a voltage source for the main grid,
  - 2) a diesel generator,
  - 3) detailed solar PV model (PV array, DC-DC Boost convertor, and voltage source converter),
  - 4) loads and feeder impedances.
- Stability analysis
  - Transition from grid-connected to islanded mode at t=3 s,
  - levels of PV penetration from 0% to 60% of the load, with steps of 10%.
- Four scenarios: Low/High load condition and diesel status ON/OFF.

Scenario 1: Low load condition – Diesel is OFF

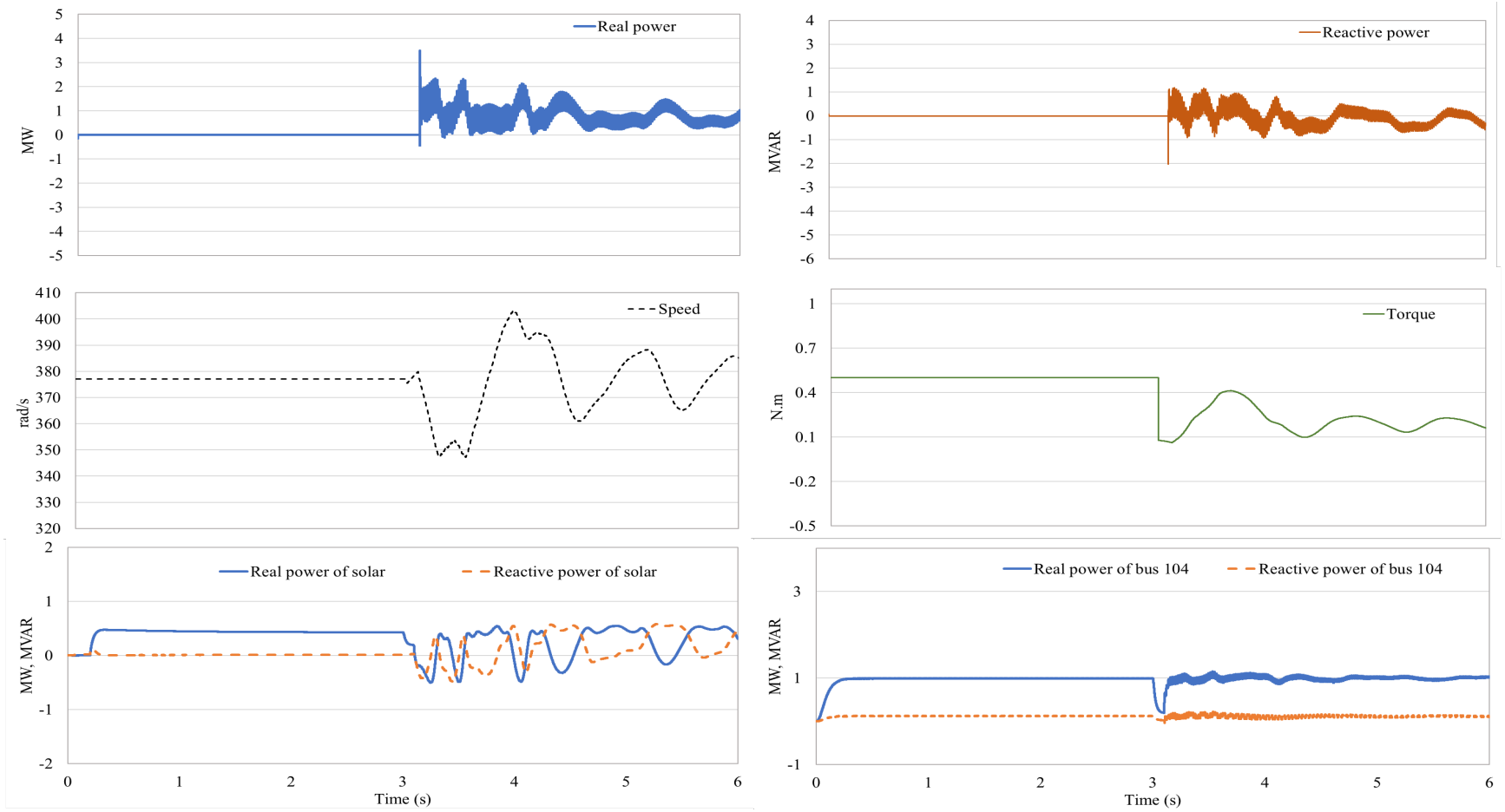
PV Penetration = 10% of load level (Stable)



- DG experiences oscillations, however these oscillations are slightly damped.
- Damping oscillations of DG lead to damping oscillations on PV.
- DG and PV unit are able to pick up the load and microgrid remains stable.

Scenario 1: Low load condition – Diesel is OFF

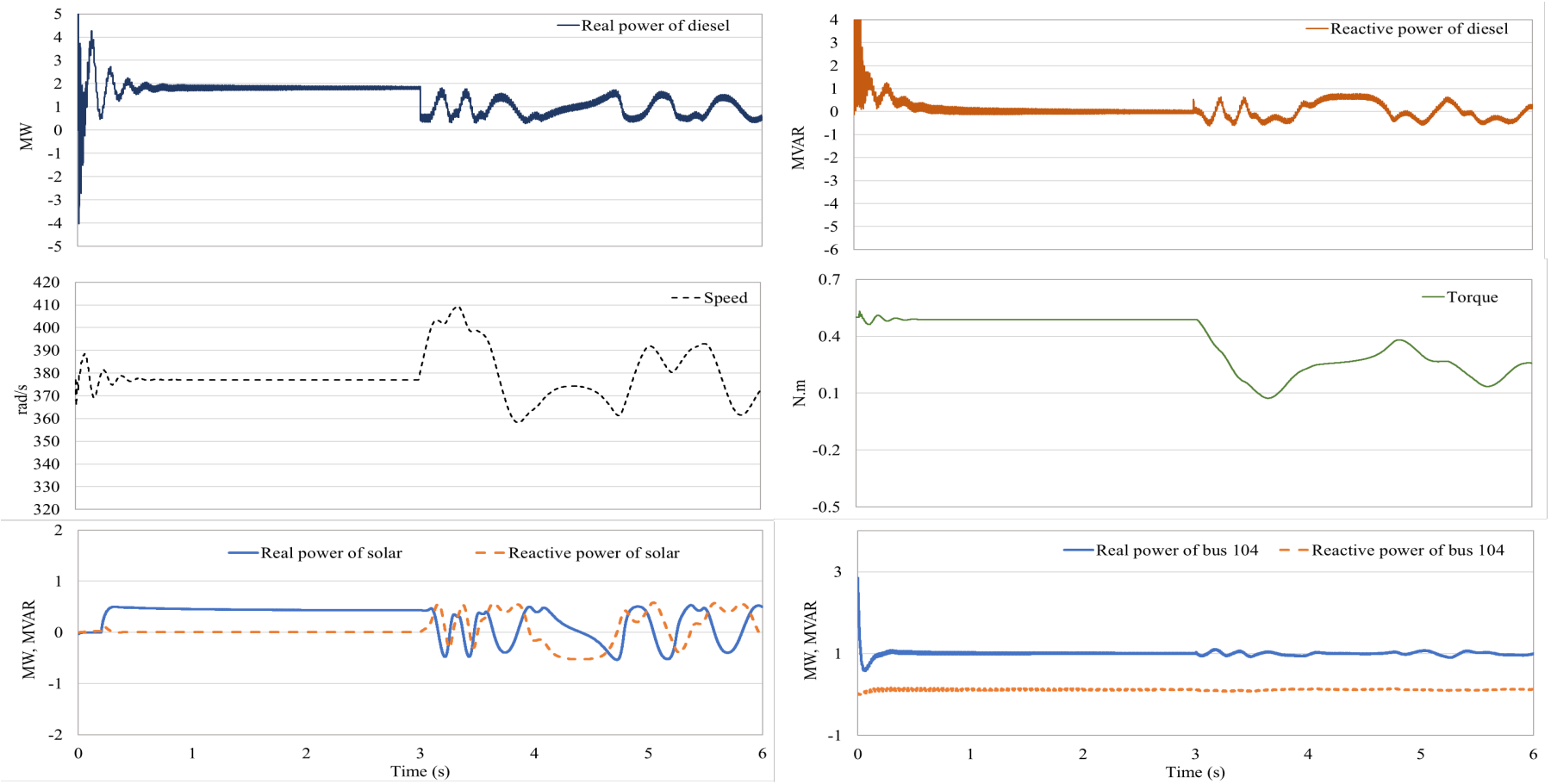
PV Penetration = 50% of load level (Unstable)



- After islanding DG experiences oscillations, which stay undamped.
- PV unit tracks DG as its voltage source, experiences different levels of oscillations.
- These oscillations may cause tripping in the system and lead to the instability.

Scenario 2: Low load condition – Diesel is ON

PV Penetration = 60% of load level (Unstable)

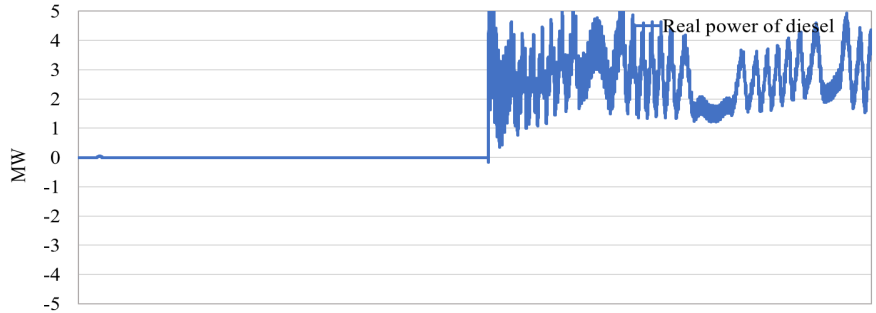


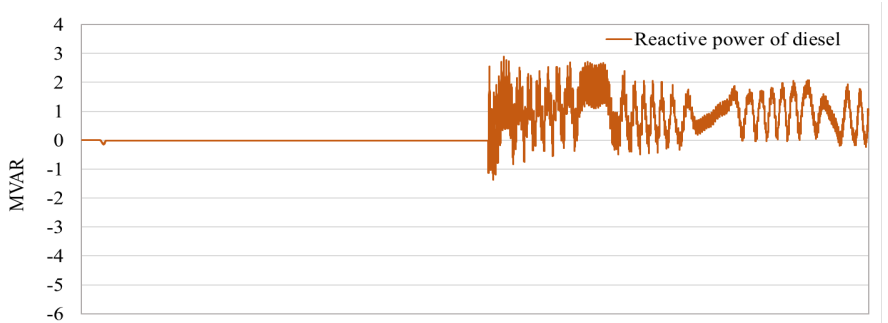
- After islanding DG experiences severe increasing speed and torque oscillations.

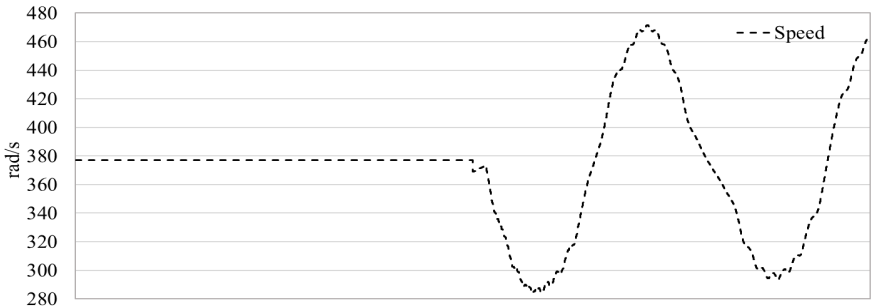
Undamped oscillations → Not able to pick up the load → Tripping in the system and the microgrid becomes unstable.

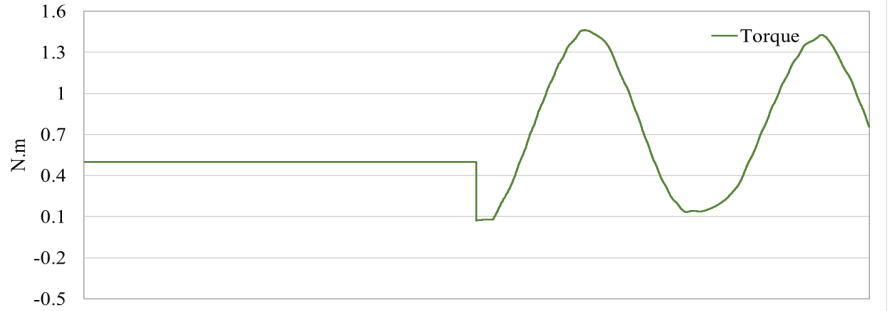
Scenario 3: High load condition – Diesel is OFF

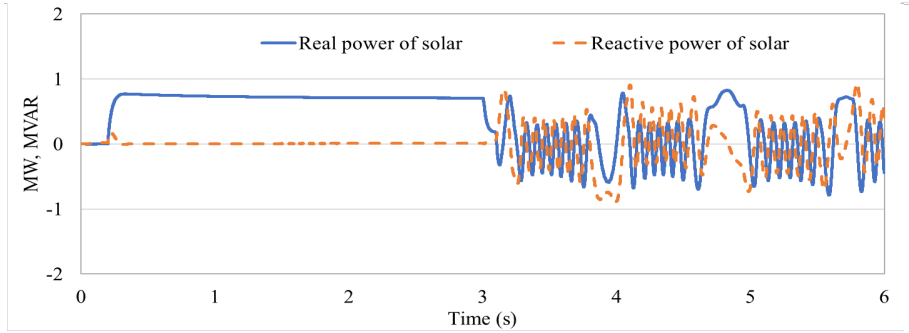
PV Penetration = 30% of load level (Unstable)

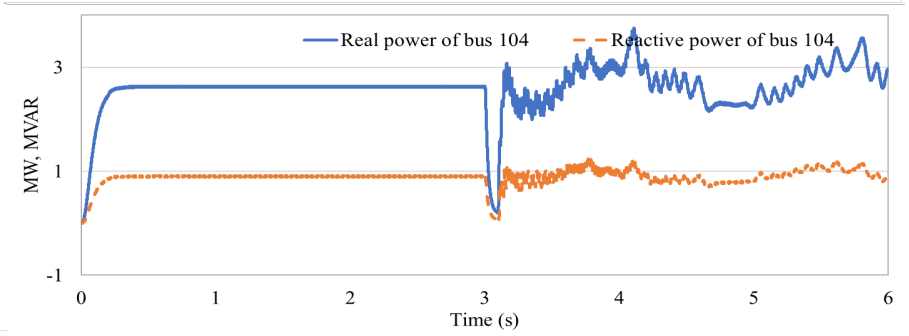








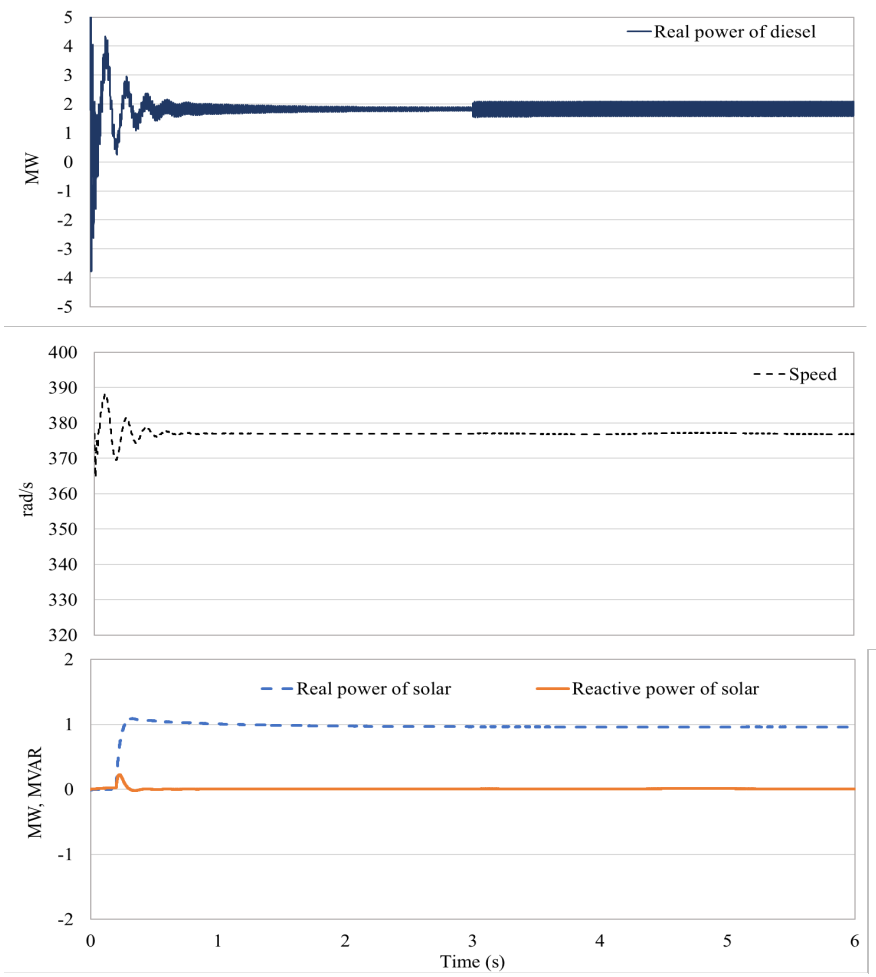


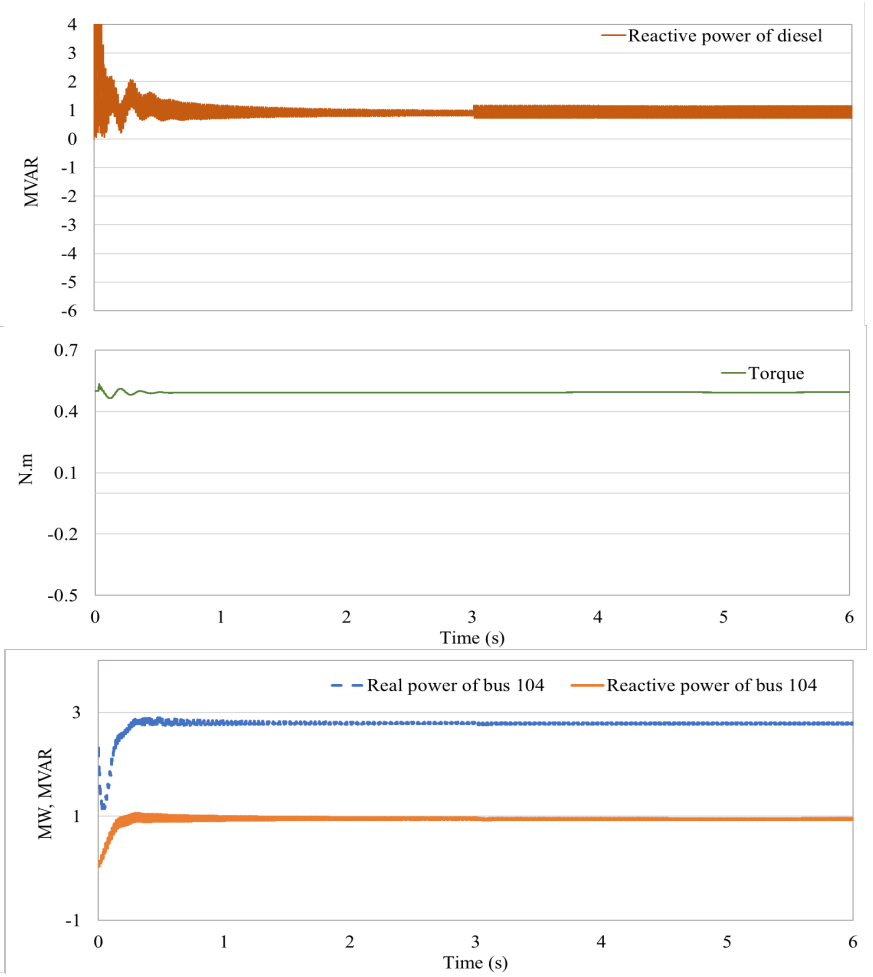


Undamped oscillations → Not able to pick up the load → Tripping in the system and the microgrid becomes unstable.

Scenario 4: High load condition – Diesel is ON

PV Penetration = 40% of load level (Stable)





- After islanding the speed and torque oscillations are significantly negligible.
- The microgrid is able to remain stable during and after the grid disconnection.

Stability Analysis Under Different Conditions

		Low load (1 MW)		High load (2.8 MW)	
Diesel status		OFF	ON	OFF	ON
PV penetration level	0%	Stable	Stable	Unstable	Stable
	10%	Stable	Stable	Unstable	Stable
	20%	Stable	Stable	Unstable	Stable
	30%	Stable	Stable	Unstable	Stable
	40%	Stable	Stable	Unstable	Stable
	50%	Unstable	Stable	Unstable	Unstable
	60%	Unstable	Unstable	Unstable	Unstable
	>60%	Unstable	Unstable	Unstable	Unstable

- When DG is ON the hosting capacity is increased especially for high load condition; means the microgrid has a grid-forming DER that can provide reserve if needed.
- If the microgrid is not equipped with adequate fast response grid-forming DERs, there is a chance of instability after islanding.

Conclusion

- A dynamic study was proposed and performed to find the PV hosting capacity of a practical microgrid in case of transition from the grid-connected mode to the islanded mode.
- The impacts of initial status of the grid-forming DER on the stability of the microgrid was also considered and proved to be a key component in the studies.
- The stability analyses demonstrated that the microgrid hosting capacity, when the load level is low, can get to approximately 50% of the load for this specific system, while for high load scenarios the hosting capacity highly depends on the availability of the grid-forming DER.
- When the grid-forming DER is initially online:
  - The microgrid is more stable after being disconnected from the grid
  - The hosting capacity is improved

Thank you

Zohreh.Hosseini@du.edu