NREL
NATIONAL RENEWABLE ENERGY LABORATORY

MIDAS

Multi-timescale Integrated Dynamics and Scheduling (MIDAS)

-Maui Study Cases

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ESIG Fall Technical Workshop 2020

Contents

MIDAS Solar Project

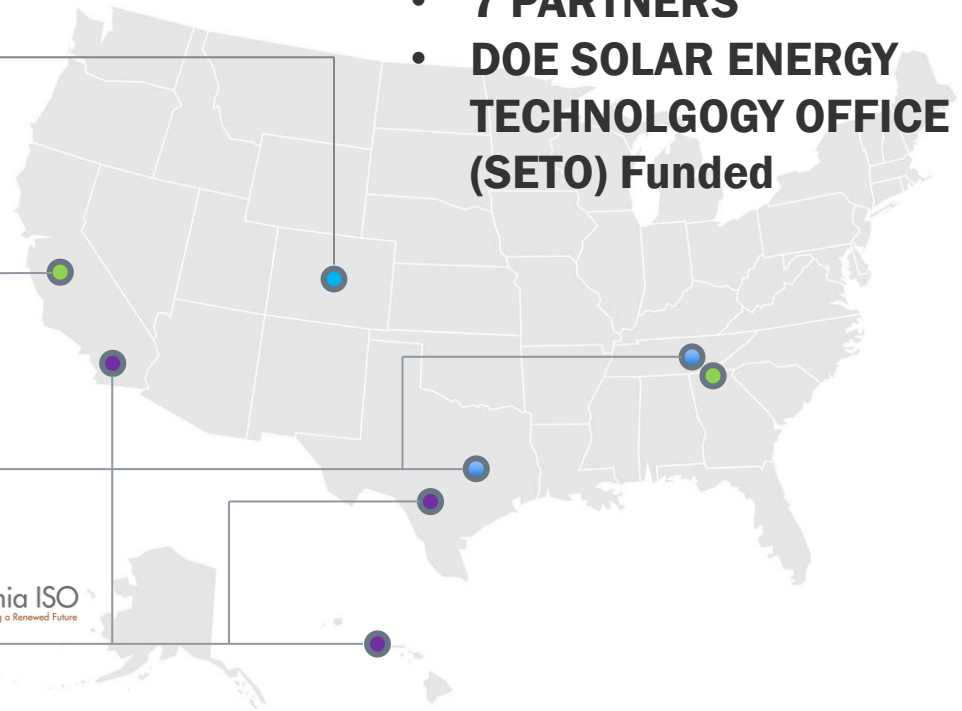
- 3 YEARS
- 7 PARTNERS
- DOE SOLAR ENERGY TECHNOLGOGY OFFICE (SETO) Funded

National Lab — NREL Transforming ENERGY

Research Institute — EPRI ELECTRIC POWER RESEARCH INSTITUTE

University — THE UNIVERSITY OF TENNESSEE KNOXVILLE; SMU

ISOs — Hawaiian Electric; ercot; California ISO Shaping a Renewed Future



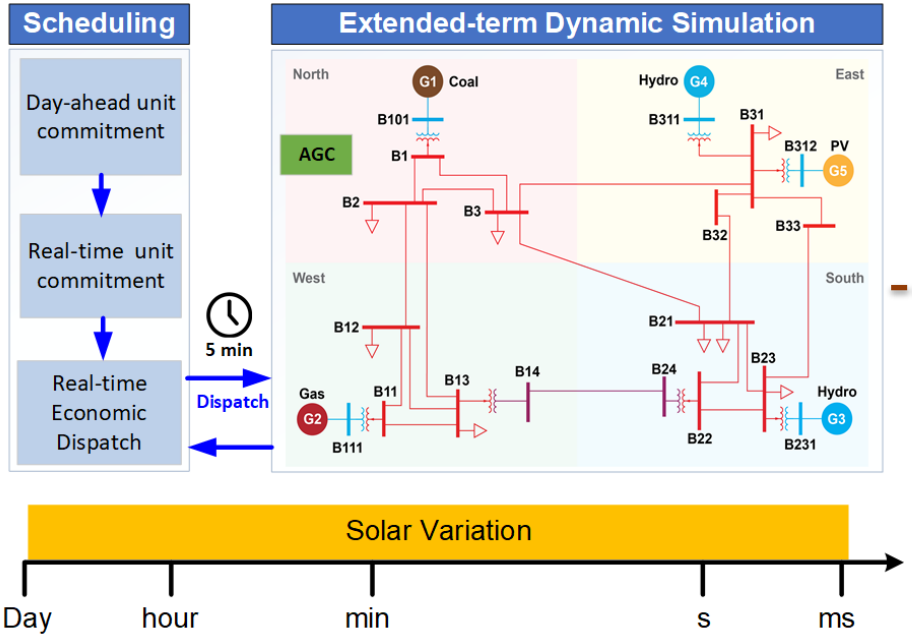
What is MIDAS Solar?

Multi-timescale Integrated Dynamics and Scheduling

- **Economics, reliability and stability** of grid with **high PV penetration**

- Cost
- Forecasting
- Etc.

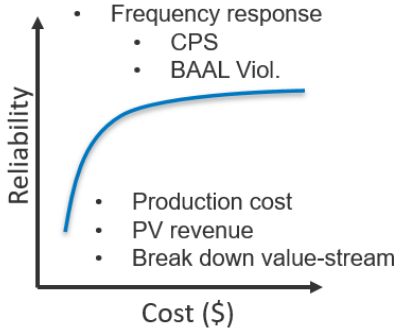
- PSS/E files
- Time-series solar and load data
- Etc.



(selected snapshot) EMT Simulation

Output

(1) Cost-reliability analysis

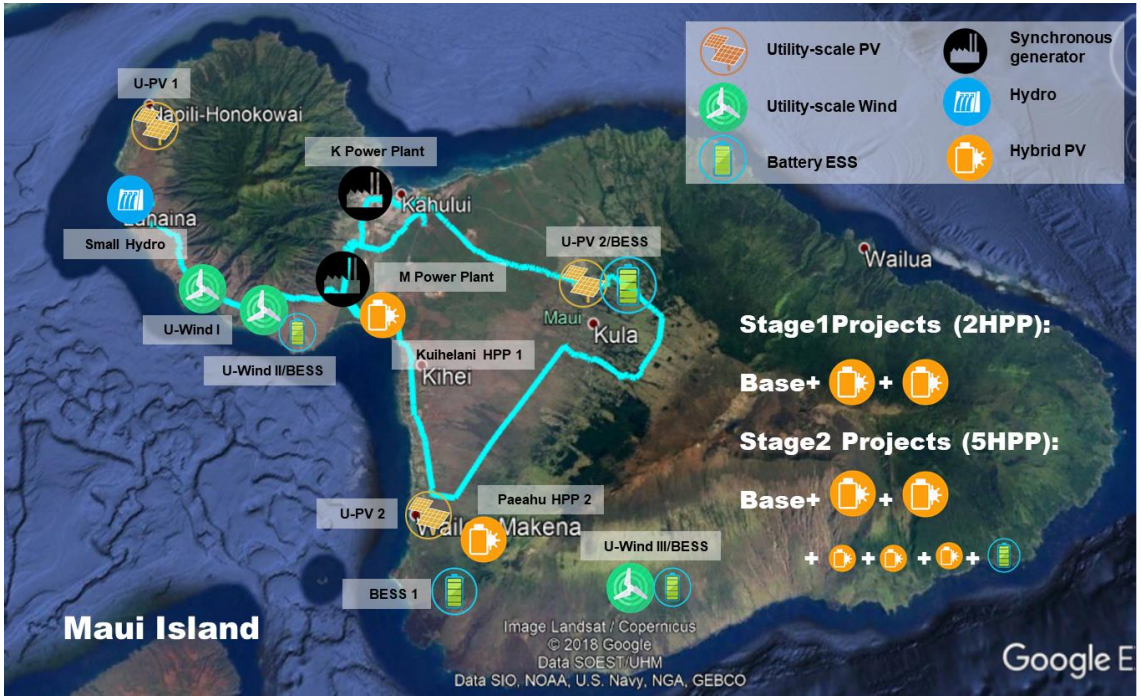


(2) Stability analysis

Electro-mechanical simulation → Dispatch-based dynamic security assessment

EMT Simulation → Detailed RE EMT modeling

Overview – Maui Grid



Hawaii's Renewable Portfolio Standard

30% by 2020 → 40% by 2030 → 70% by 2040 → 100% by 2045

Three Stages

- Base case
- 2HPP case (Stage1)
  - Add two hybrid power plants (PV + BESS).
- 5HPP case (Stage 2)
  - Add additional three new hybrid power plants and one BESS.

Key questions about inertia requirement

- Why do we need minimum inertia requirement in scheduling stage? Is that necessary?
- How much inertia from SGs does Maui grid need?
- Is there any risk or disadvantage of using fixed inertia method?

Definition:
Power system inertia is defined as the ability of a power system to oppose changes in system frequency due to resistance provided by rotating masses.


Source: google

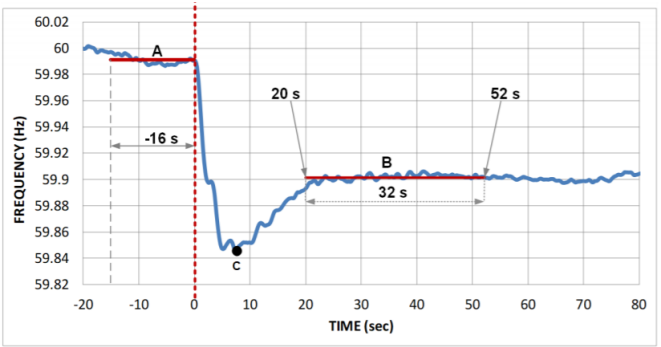
Minimum inertia requirement methods

- Traditional scheduling model:
  - Minimize the production cost and fulfill all the ancillary services constraints.
  - No minimum inertia requirement

- Fixed minimum inertia requirement:

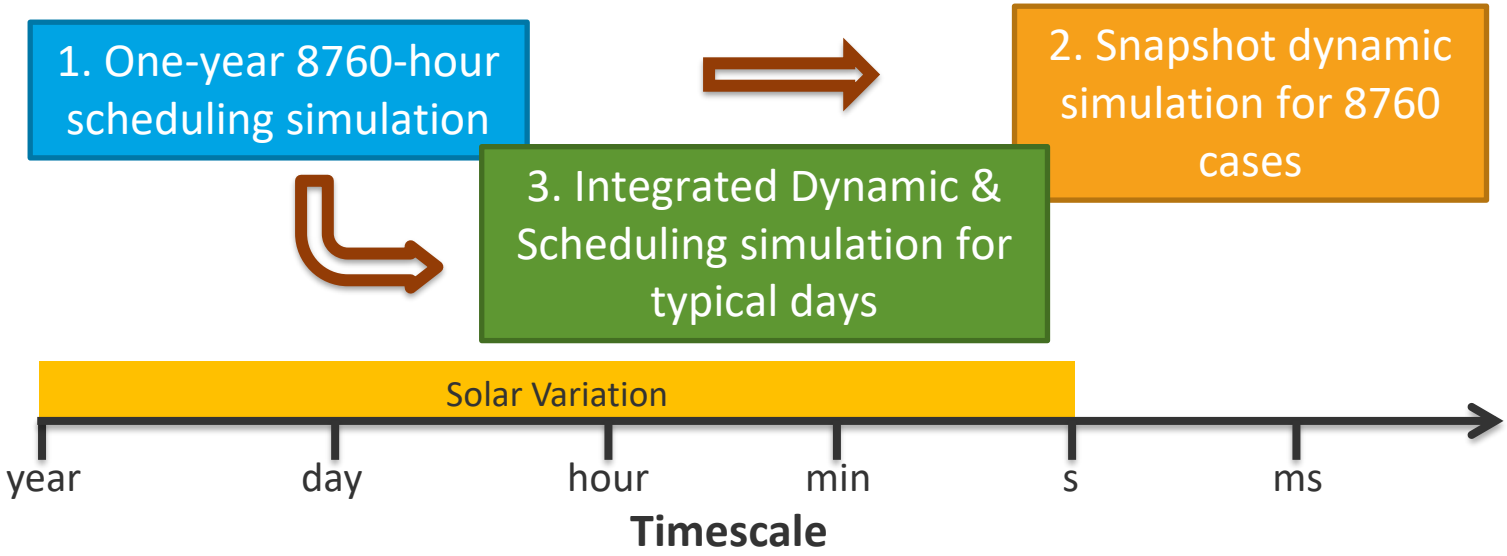
Goal: meet the target ROCOF=3Hz/s

$$E = 30 \times \frac{\Delta P}{ROCOF} = 30 \times \frac{35.4(MW)}{3Hz/s} = \mathbf{354}\ (\boldsymbol{MWs})$$

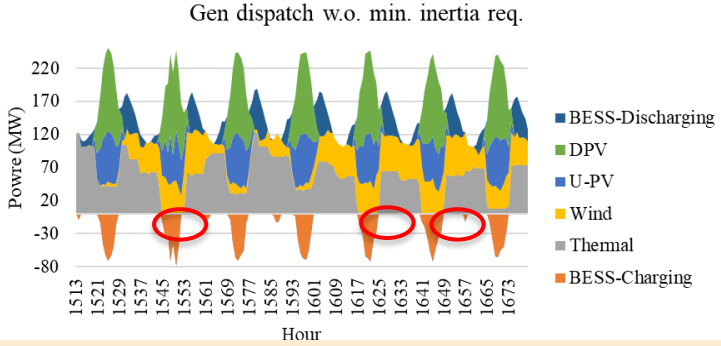


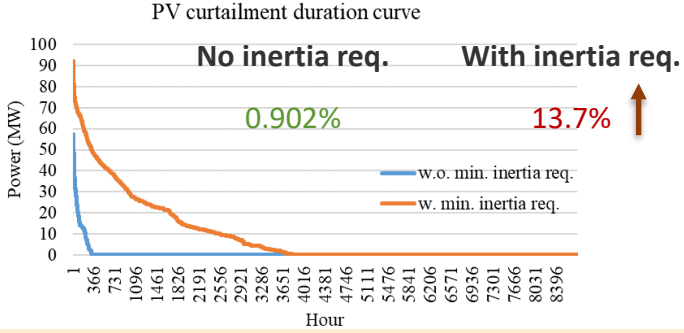
Multi-timescale Approach

Goal: Understand the potential risk of fixed minimum inertia requirement.
Approach: Multi-timescale study by using MIDAS



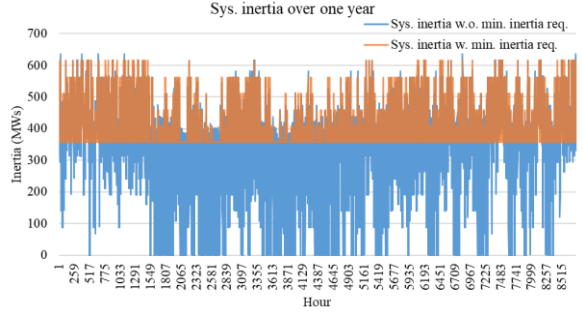
One-year Scheduling Simulation



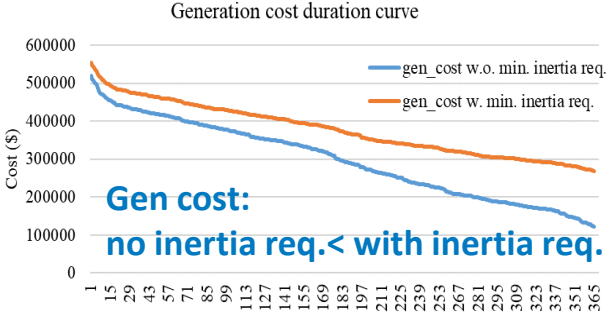


Without inertia req., thermal can reduce to zero

With inertia req., PV curtailment will increase



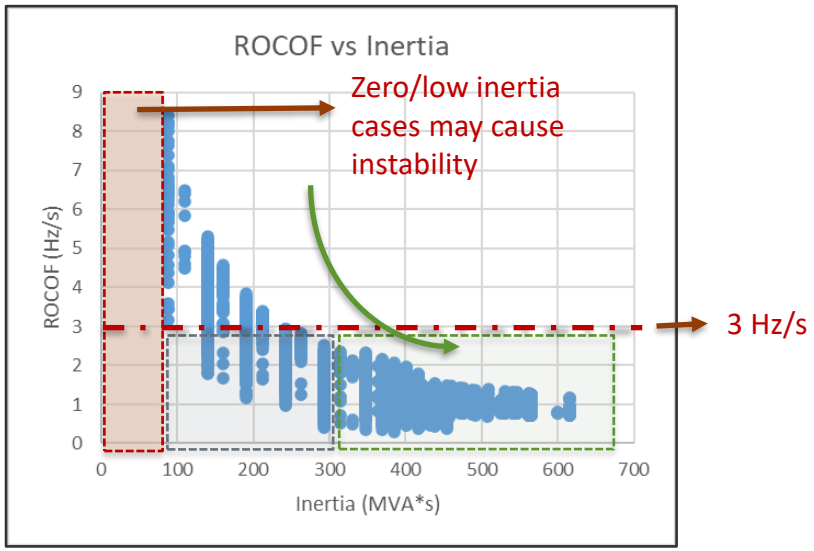
Inertia=0s for 10% of the time

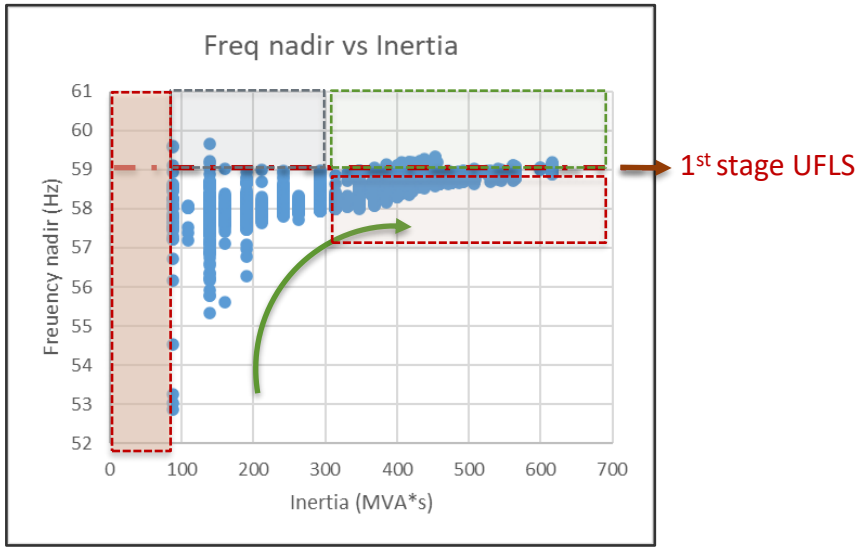


☺ Minimum inertia requirement can maintain system inertia

☹ Minimum inertia requirement brings more SGs back to grid and it will increase the generation cost and the renewables will eventually hit the penetration ceiling.

Largest N-1 contingency analysis for 8760 snapshots





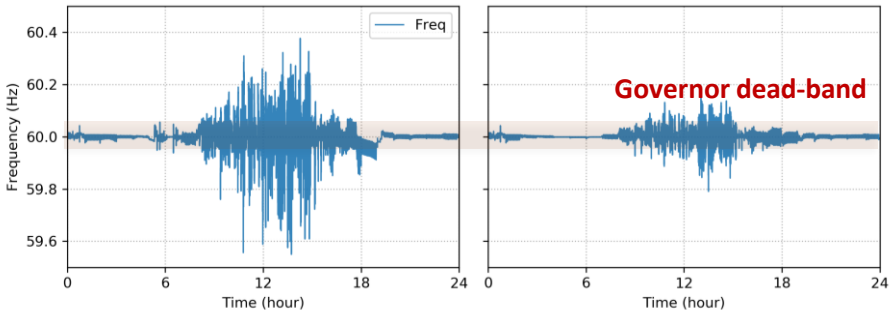
- Minimum inertia req. can guarantee ROCOF Req., but not guarantee frequency nadir above UFLS setting.
- There are system conditions where less inertia can still achieve ROCOF Req. and frequency nadirs above UFLS.

Min. inertia req. increases the reliability and the cost

- 24-hour continual simulation of a cloudy day with high wind and high solar
- Closed-loop scheduling and dynamic simulation for the normal operation

No Inertia req. **With Inertia Req.**

One-day simulated frequency of Maui Grid



	w.o. inertia requirement	With min. inertia requirement	
Daily generation cost	$227,626	$424,104	↑
PV curtailment (MWh)	7.7	60.3	↑
Wind curtailment (MWh)	45.4	234	↑
CPS score	96%	181%	↑
Frequency std (Hz)	0.046	0.019	↓

☺ With min. inertia req., the system frequency performance has been improved, in terms of CPS score and frequency STD score.

☹ However, the generation cost increases with min. inertia req.

- Trade off between the economics and reliability.

Revisit the key questions

- Why do we need minimum inertia requirement in scheduling stage? Is that necessary?

  - Yes, if we don't consider grid forming inverters. The low inertia grid will face the stability issues.

- How much inertia from SGs does Maui grid need?

  - It will depend on the system operational points.
    - The loss of max gen.
    - The provision of PFR reserve (how much, how fast, from who)

- Is there any risk or disadvantage of using current HECO inertia method?

  - Fixed inertia requirement will cause more renewable curtailment and high generation cost. Ensure the 3Hz/s response but cannot ensure frequency nadir above 59 Hz.

Summary

- Without minimum inertia requirement in scheduling stage, in Maui grid, system inertia can reach zero about 10% of the year based on scheduling results. However, low/zero inertia cases **could cause dynamic instability of the grid** during the events without additional measures.
- With the current fixed minimum inertia requirement, the Maui grid could experience a large mount of PV curtailment (13.7%). This means that as we install more hybrid PV plants, the fixed minimum inertia requirement will **become the bottleneck to further increase the penetration level of renewables**.
- The **fixed minimum inertia requirement** can ensure the ROCOF (3 Hz/s response) but cannot ensure frequency nadir above UFLS (59 Hz). Also, there are snapshots which have less inertia but still acceptable frequency response which indicates **an adaptive requirement can be more efficient**.
- When design inertia requirement constraints, trade off between the economics and reliability need to be considered.

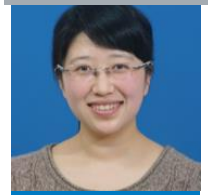
Conclusion and future work

- Enforcing an **inertia constraint will improve the frequency response** but can **take away the economic benefits** of installing new PV plants.
- **Fast frequency response** from inverter-based resources has a potential to address the low inertia challenges and will be studied in later stage of our project.
- The stakeholders need to evaluate both the **economic benefits and reliability impacts simultaneously** during policy making process, planning, and operational studies of high renewable grids.

MIDAS bridges the study of power systems dynamics and scheduling across different time-scales.

Acknowledgement

Dynamic Modeling Team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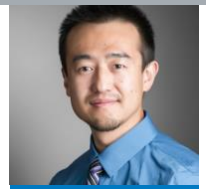
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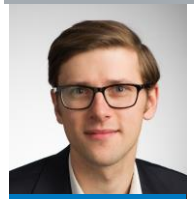
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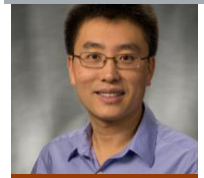
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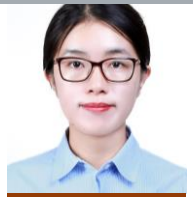
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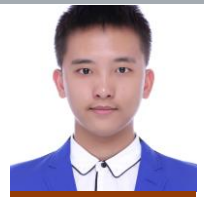
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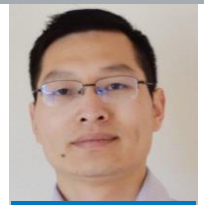
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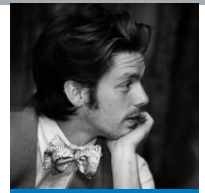
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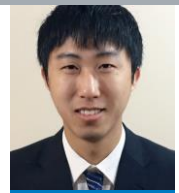
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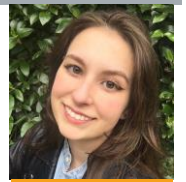
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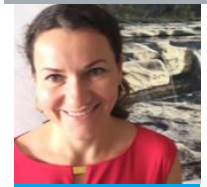
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Question?

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