eea Electricity Engineers' Association

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Engineering Innovations For Climate Change

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Solar PV Grid Integration : The Challenges and Opportunities

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Agenda

- Basic Principles Of Harvesting Solar Energy
- Challenges Of Integration :
  - Distribution Level
  - Bulk Power System Level

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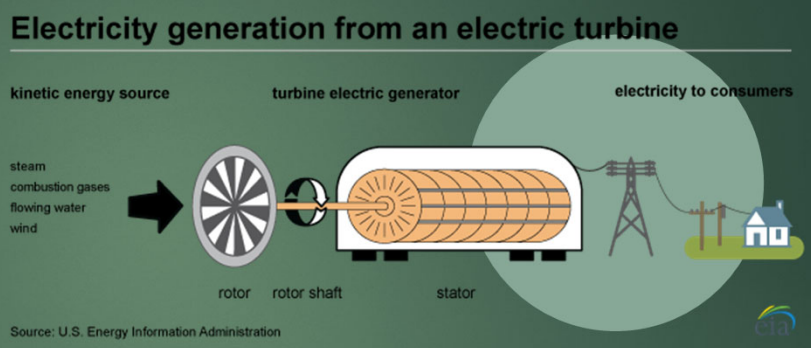
Solar energy conversion

Traditional means of energy conversion: kinetic → electrical



Solar cell: Light → Electricity conversion

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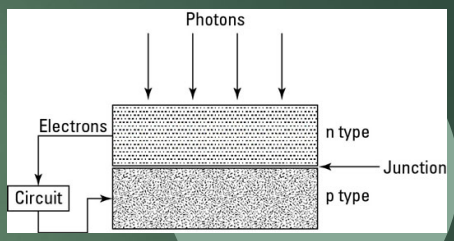
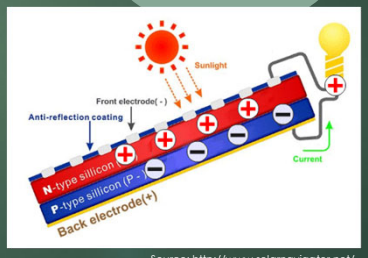
Solar to Electricity

Use light (Photons) from sun to be absorbed by solar cells made of semi conductor with P-N junction.



Photovoltaic (PV)

Photon ⟶ Voltage



Source: http://www.solarnavigator.net/

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Challenges in grid integration

Concentrated and Dispersed Solar PV integration at:

- Distribution Level
- Bulk Grid Level
- With/without storage

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Local Network Model

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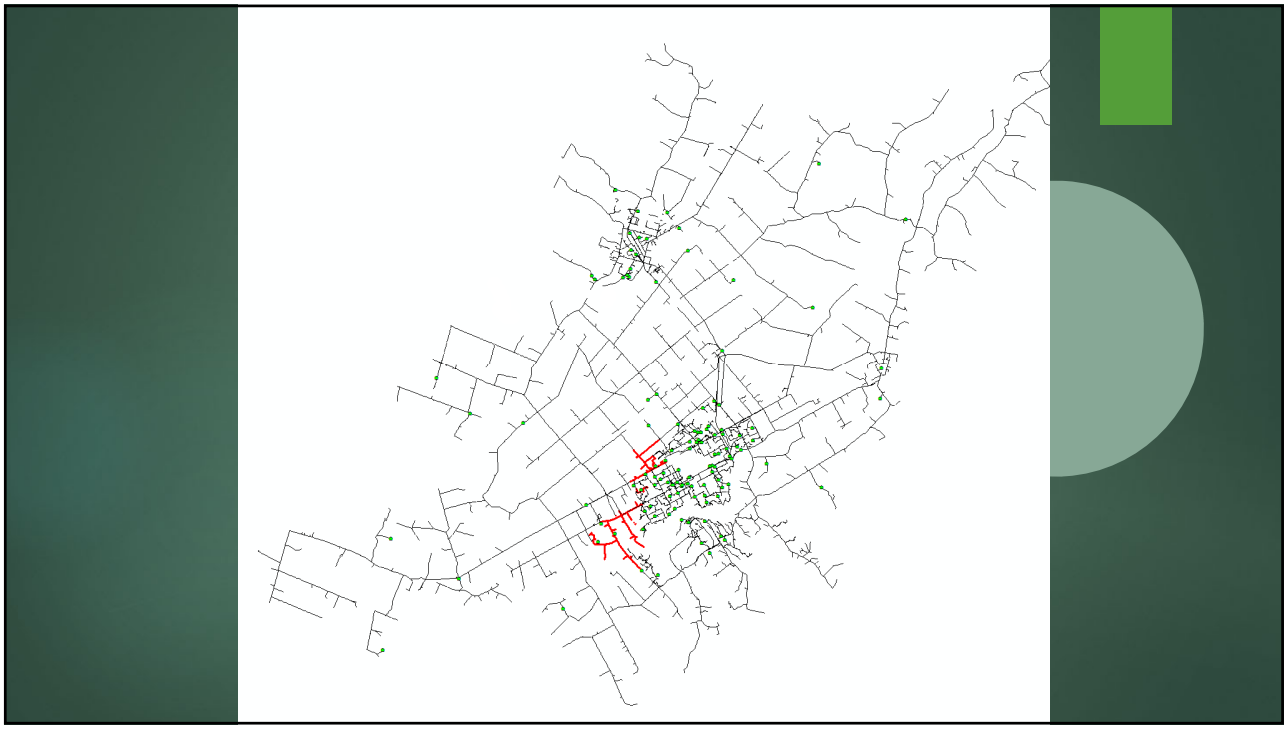

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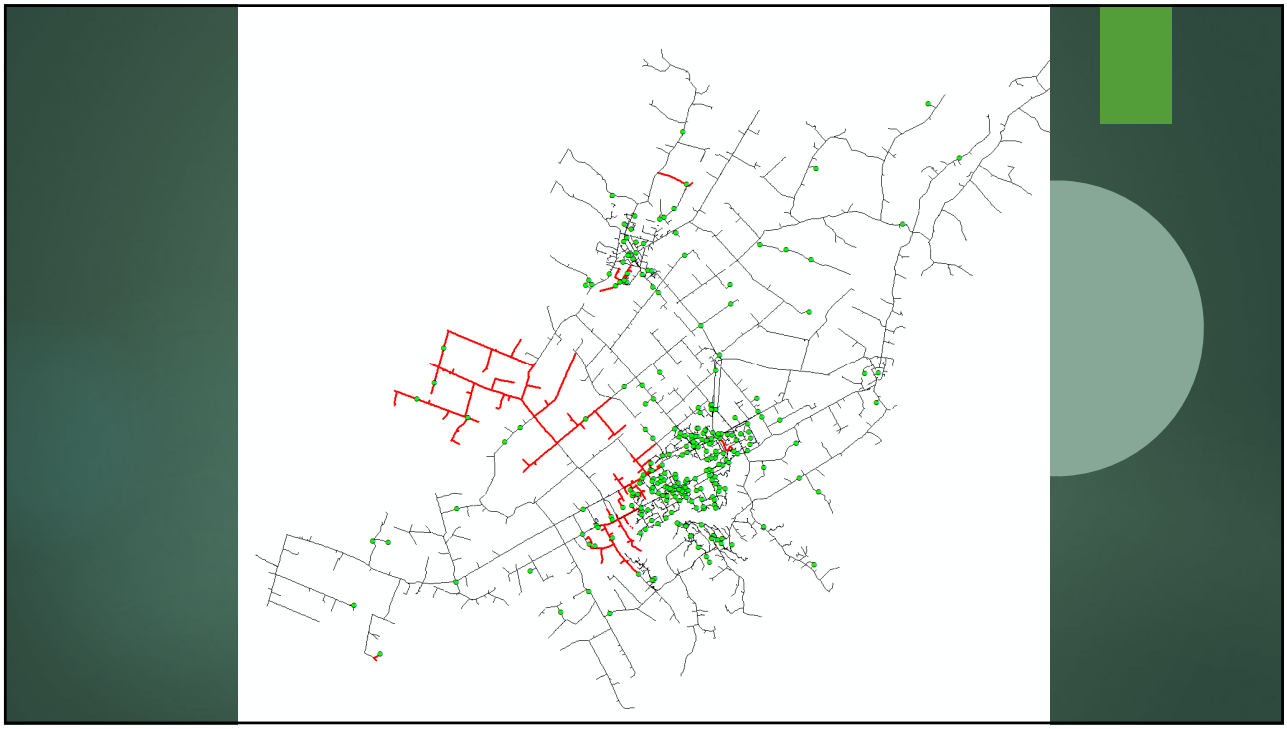

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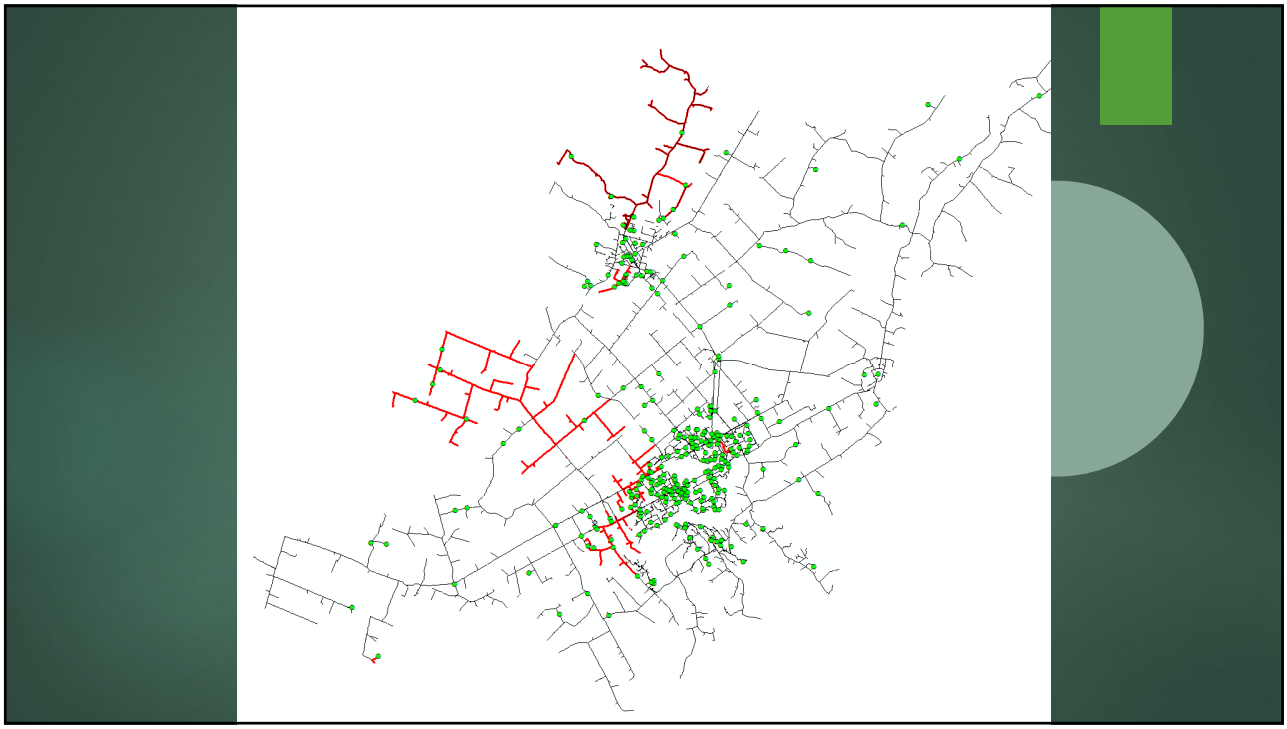

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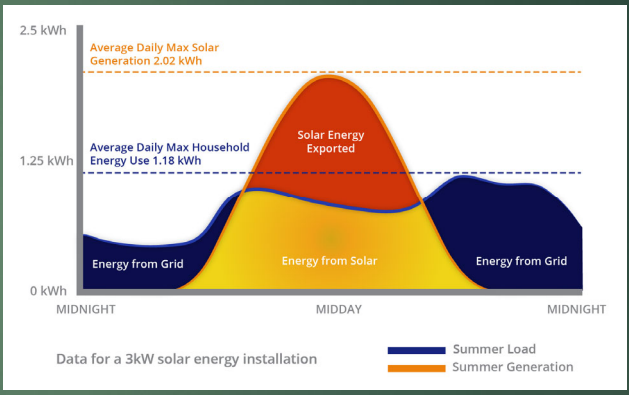
Distribution Level Challenges

- Minimum electricity demand coincidental with maximum solar irradiation.
- Traditional unidirectional power flow becomes bidirectional.
- Higher grid voltage due to reverse power flows.
- Voltage ranges in excess of 1.05 P.U.

Reactive power compensation required to regulate voltage



Source: www.unison.co.nz/solar-technology/

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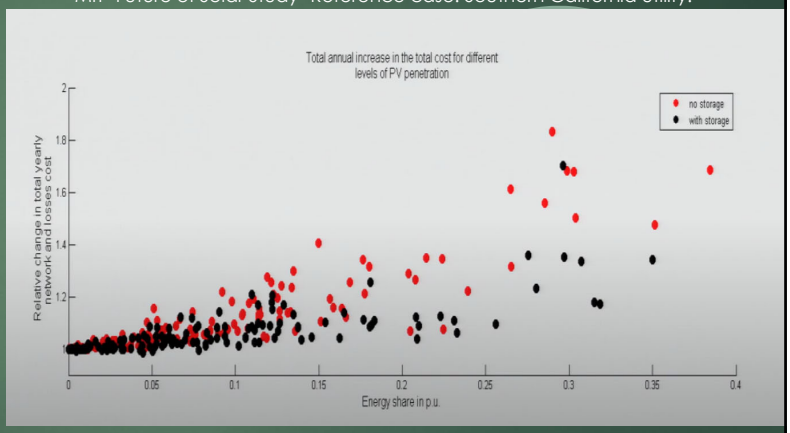
Impact of distributed storage

- Stand alone system Vs battery storage system.
- Relative network costs with increasing PV penetration.
- Presence of distributed storage in strategic place throughout network.

MIT 'Future of Solar Study' Reference case: Southern California utility:



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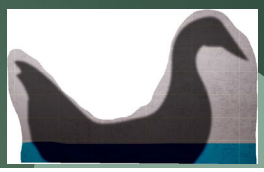
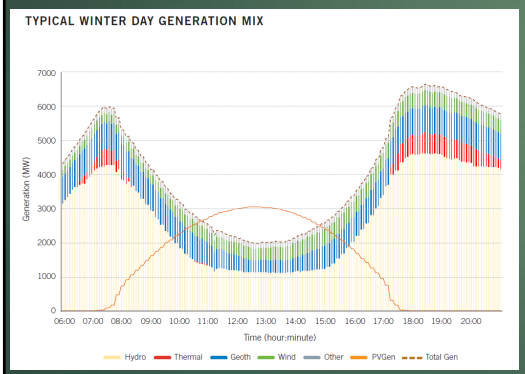
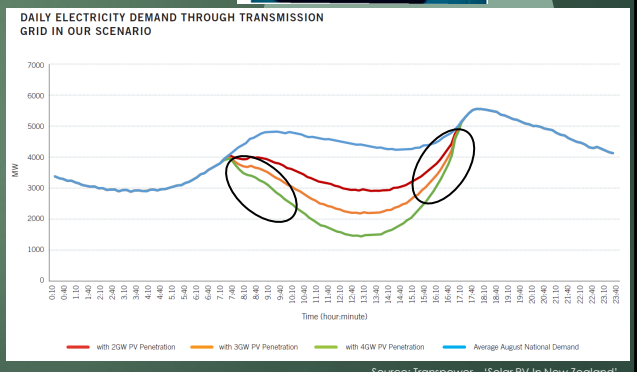
Grid Level Challenges

- 'Duck Curve'
- Typical dual peak
- Solar irradiance peaks
- PV influx changing load profile







Source: Transpower – 'Solar PV In New Zealand'

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Grid Level Challenges

- Minimum output constantly sustained for profitability.
- Cycles, ramps, shutdowns/start up reduce economic viability.
- Large amount of Time, inertia required for restarts.
- Contractual obligations

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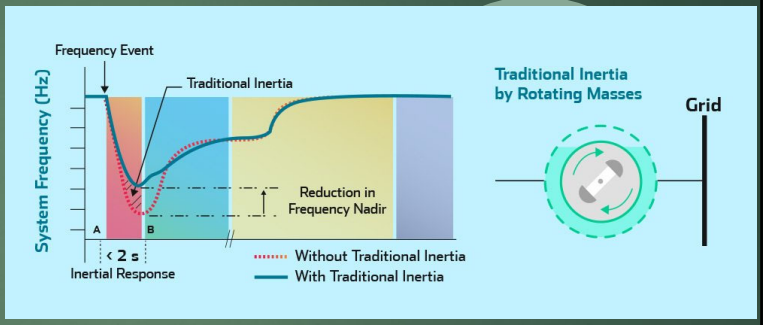
Grid Level Challenges

Inertia

- More inverter-based energy reduce overall system inertia
- Kinetic energy from spinning mass provides stabilizing force during transients



Source: www.skeletontech.com/transmission-distribution-synthetic-inertia

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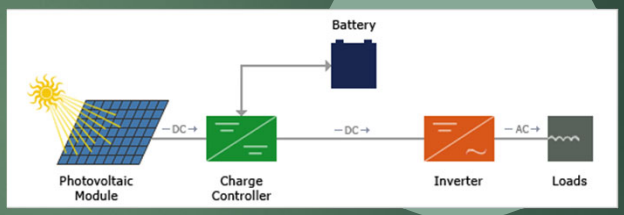
Grid Level Challenges

- No inertia in PV systems
- Sharpe frequency changes and reduction in response times.
- Reduction in overall inertia with more PV.



Source: www.synergyenviron.com/solar-photovoltaic-systems

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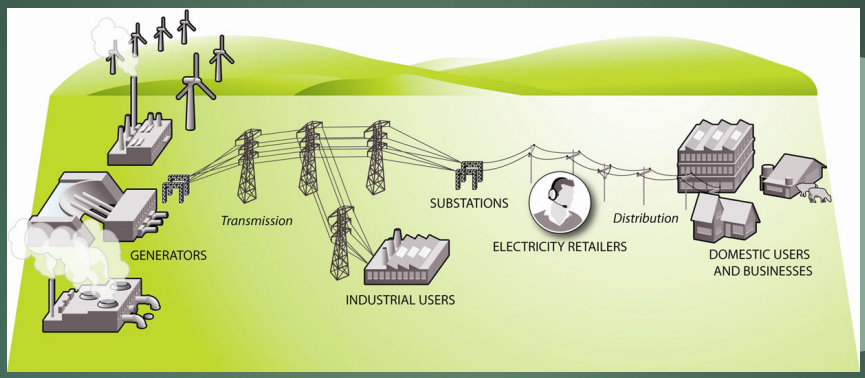

Thank you
Questions

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