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Condition Monitoring, Asset Management and Security Management for Energy Grid 2.0

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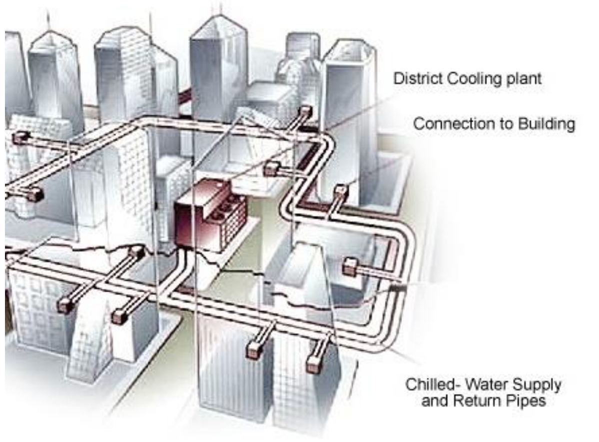
Condition Monitoring, Asset Management and Security Management for Energy Grid 2.0

- Power and energy delivery system for the future urban environment:
  - More distributed generation in terms of geographical localities
  - More diverse in fuel mix
  - More diverse and multi-disciplinary in technologies
  - More complex power flow profile in space and time
- New challenges in meeting the requirements of:
  - Condition monitoring and health prognosis
  - Asset management – tracking in space and time, replacement schedule, compatibility
  - Security management - both physical and cyber

Conventional Power Grid Assets

- Will still be significant in next 50 years
  - Transformers
  - Lines and Cables
  - Central and Distributed Generation Plants
  - Rotating Generators
  - Switchgears
- New technologies for CM, AM, SM will continue to be translated from advances in fundamental research



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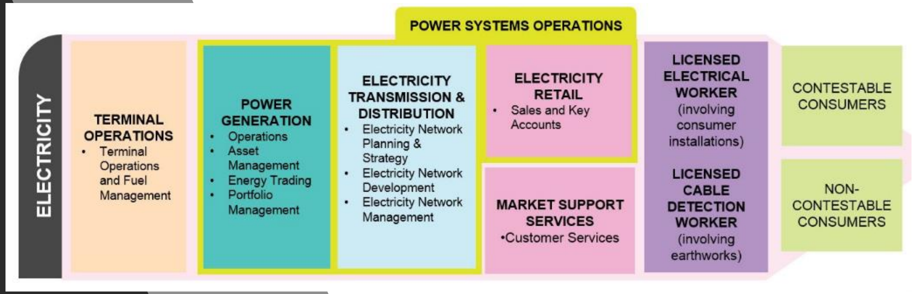
New Types of Assets in Future Energy Grid

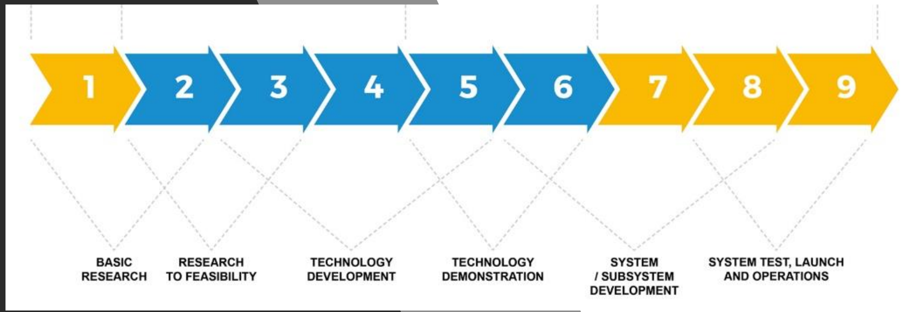
- New assets with less understood aging and failure behavior
  - Solar Photovoltaic Panels
  - Energy Storage Systems
  - NG, H2 based Solid State Generation
  - District Cooling Systems
  - Power Electronics based Distribution Network
- Tends to be more digitally connected leading to more potential security issues

Meeting the New Challenges by our IHLs

- Capability Development through Applied Education
  - Pre-Employment Training (PET)
    - Diplomas and BEng
  - Continuous Education and Training (CET)
    - Part-time coursework Masters
    - Short courses leading to certificates and professional qualifications
    - Upskilling of professionals
      - Industry Masters and Engineering Doctorates
      - Undertaking industry projects – putting IHLs inside the industries

- Translation of Upstream Research Outcomes
  - To Actual Applications through Applied Research
  - Deep Understanding of Sciences, Mathematics and Humanities
    - Semiconductor Electronics
    - Electro-Statics
    - Electro-Magnetics
    - Electro-Mechanics
    - Electro-Chemicals
    - Thermal and Fluid Dynamics
    - Economics, Finance, Accounting, Environment and Ethics
  - Close Engagement with Engineers and Technicians in the Field

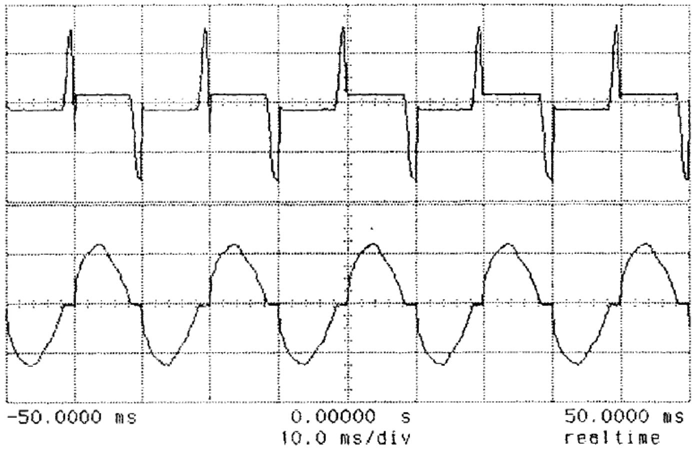




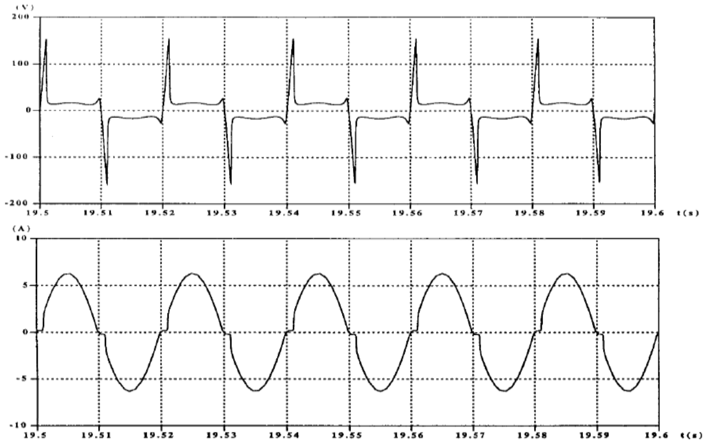
Example of Electric Arc Model Available for Translation

An experimentally verified hybrid Cassie-Mayr electric arc model for power electronics simulations

- An electric arc model that can approximately represent both the static and dynamic characteristics of an arc load controlled by a power electronic circuit.
- The proposed model was developed from the combination and modifications of the classical Cassie and Mayr equations.
- The model equations have been expressed in a form suitable for incorporation into circuit simulators employing the nodal analysis method of equation solving.



(a)



(b)

Example of Thermal Model Available for Translation

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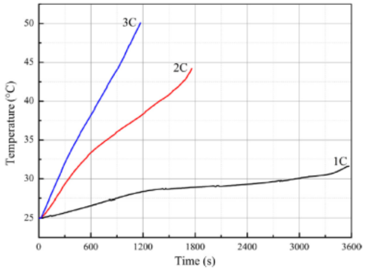
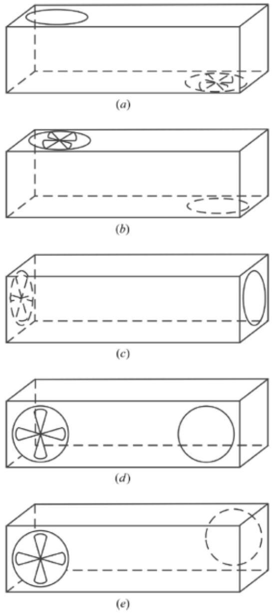
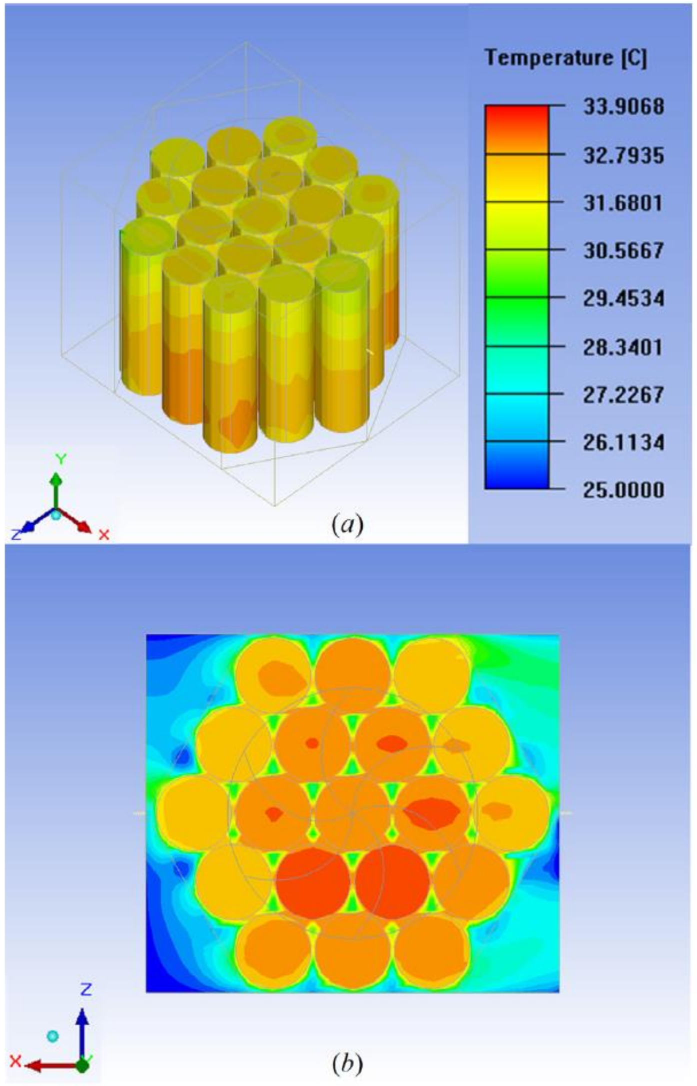
Thermal investigation of lithium-ion battery module with different cell arrangement structures and forced air-cooling strategies

- Three-dimensional CFD model with forced air cooling are developed for battery modules.
- Impact of different air-cooling strategies on module thermal characteristics are investigated.
- Impact of different model structures on module thermal responses are investigated.
- Effect of inter-cell spacing on cell thermal characteristics are also studied.
- The optimal battery module structure and air-cooling strategy is recommended.



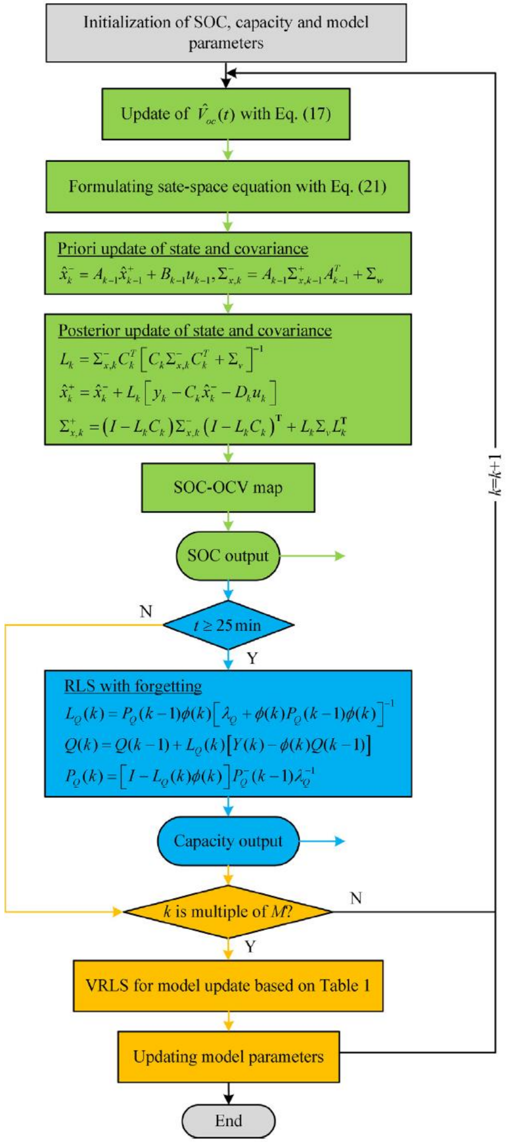


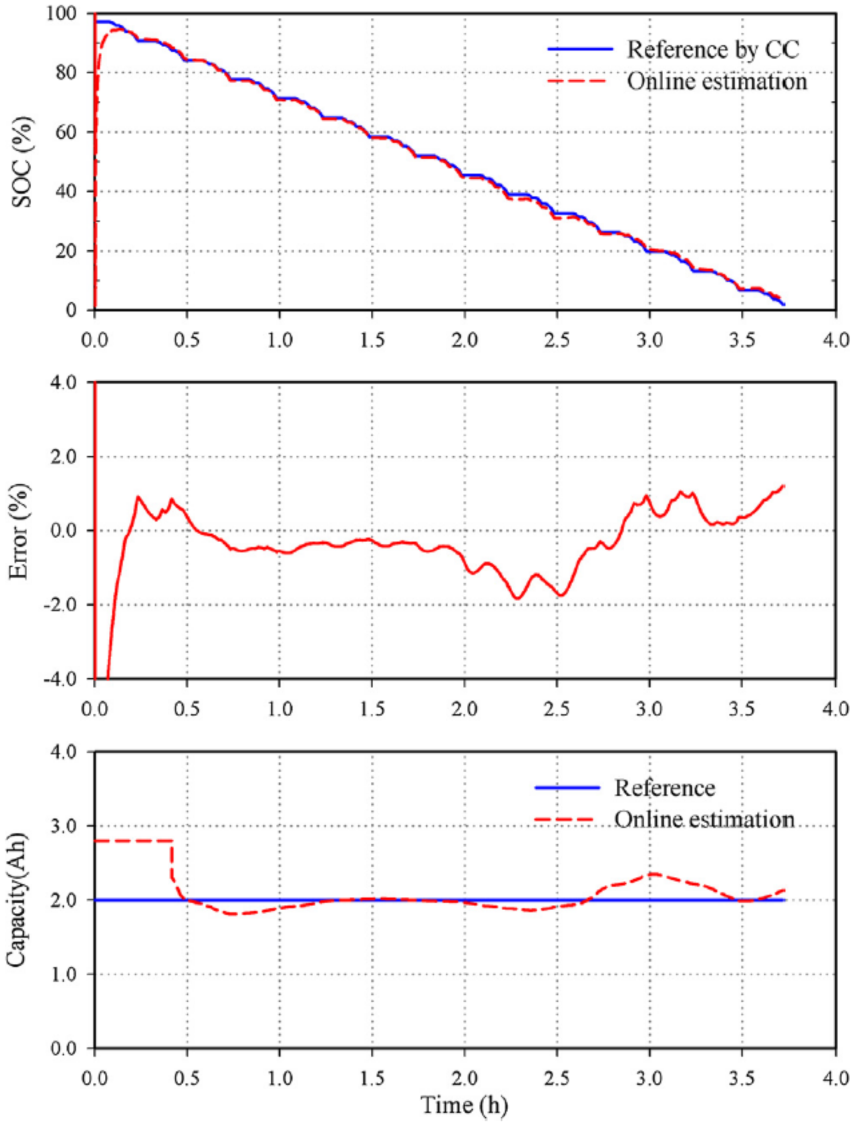


Example of Battery Model Available for Translation

A multi-timescale estimator for battery state of charge and capacity dual estimation based on an online identified model

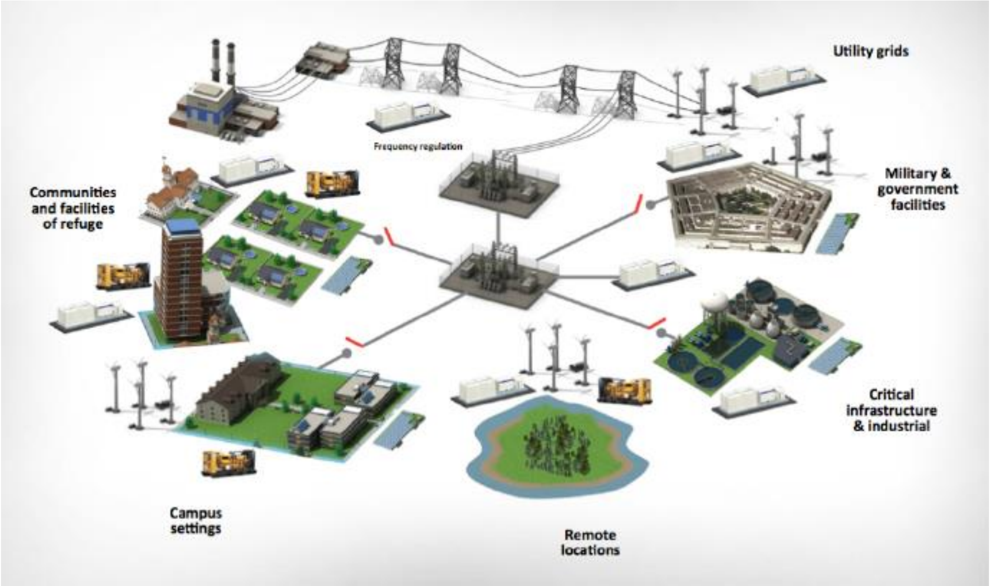
- SOC and capacity are dually estimated with online adapted battery model.
- Model identification and state dual estimate are fully decoupled.
- Multiple timescales are used to improve estimation accuracy and stability.
- The proposed method is verified with lab-scale experiments.
- The proposed method is applicable to different battery chemistries.

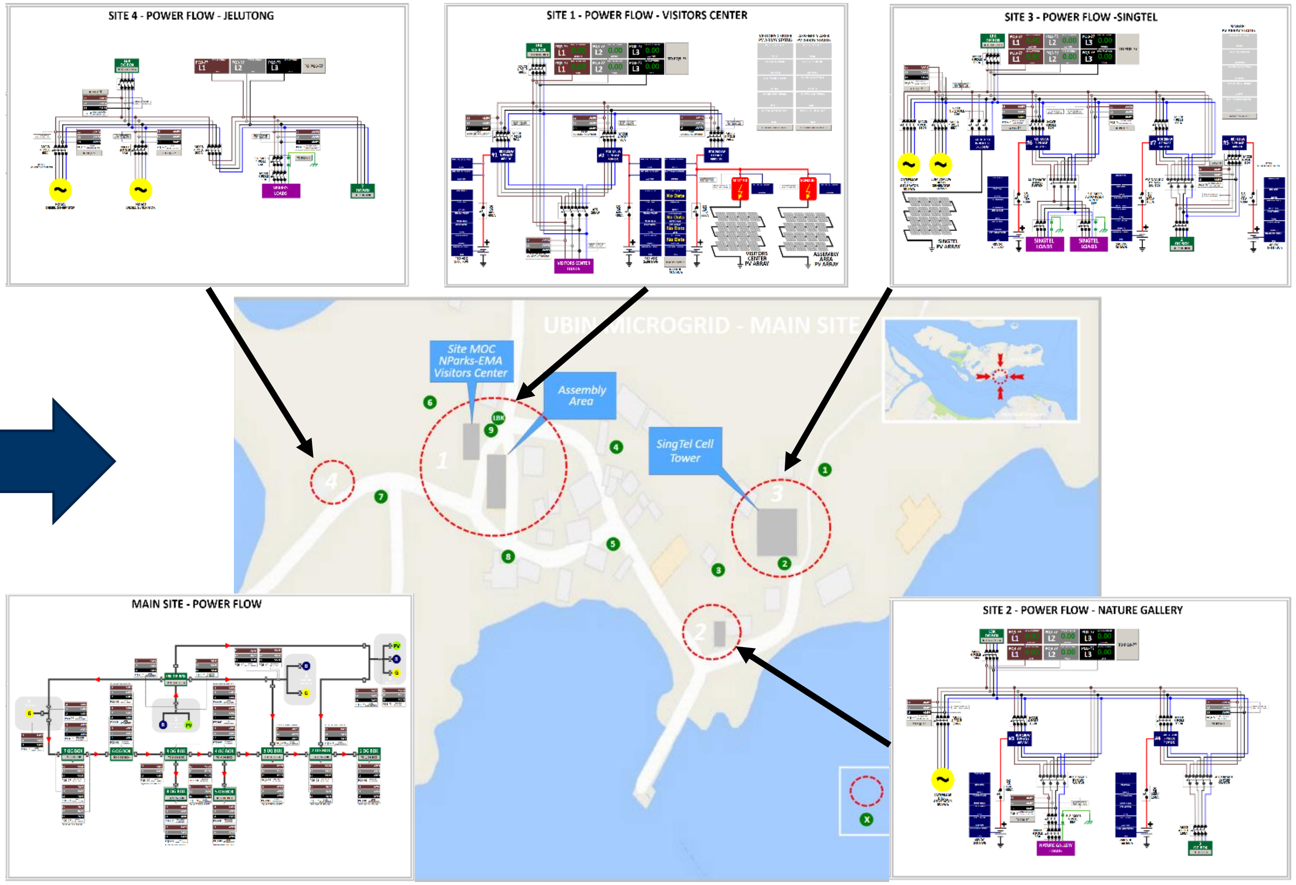




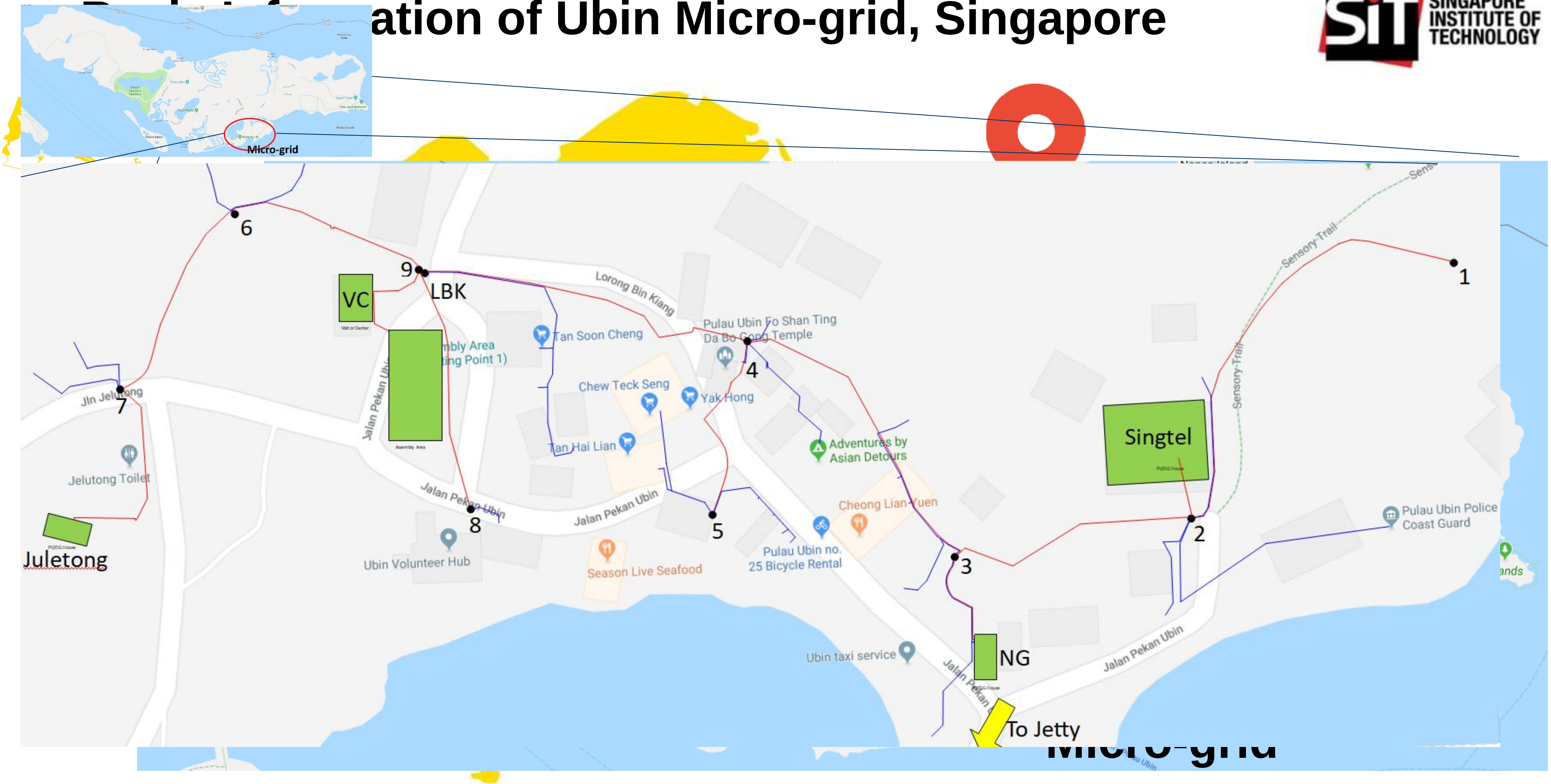
Using Real Power Systems as 'Live' Training Lab
Data Analytics, Visualization, Condition Monitoring

A key teaching/learning paradigm in SIT's BEng EPE and MEngTech EPE programs





ation of Ubin Micro-grid, Singapore



Users of Ubin Micro-grid

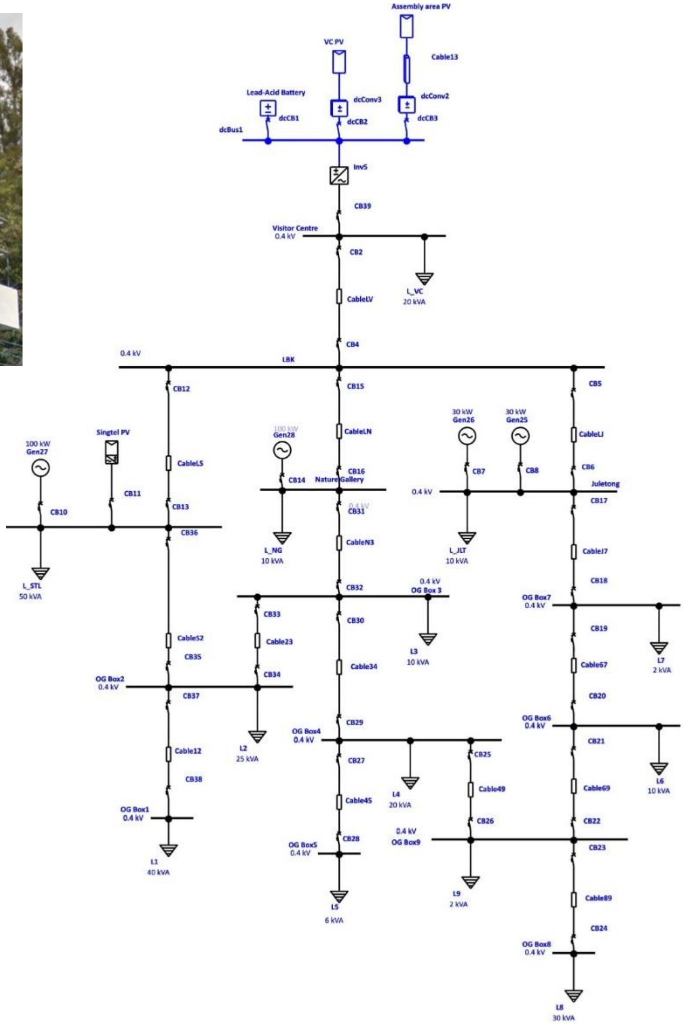
Infrastructure of Ubin Micro-grid

- PV

- BESS

Lead-acid *Hybrid ion* *Zinc air*

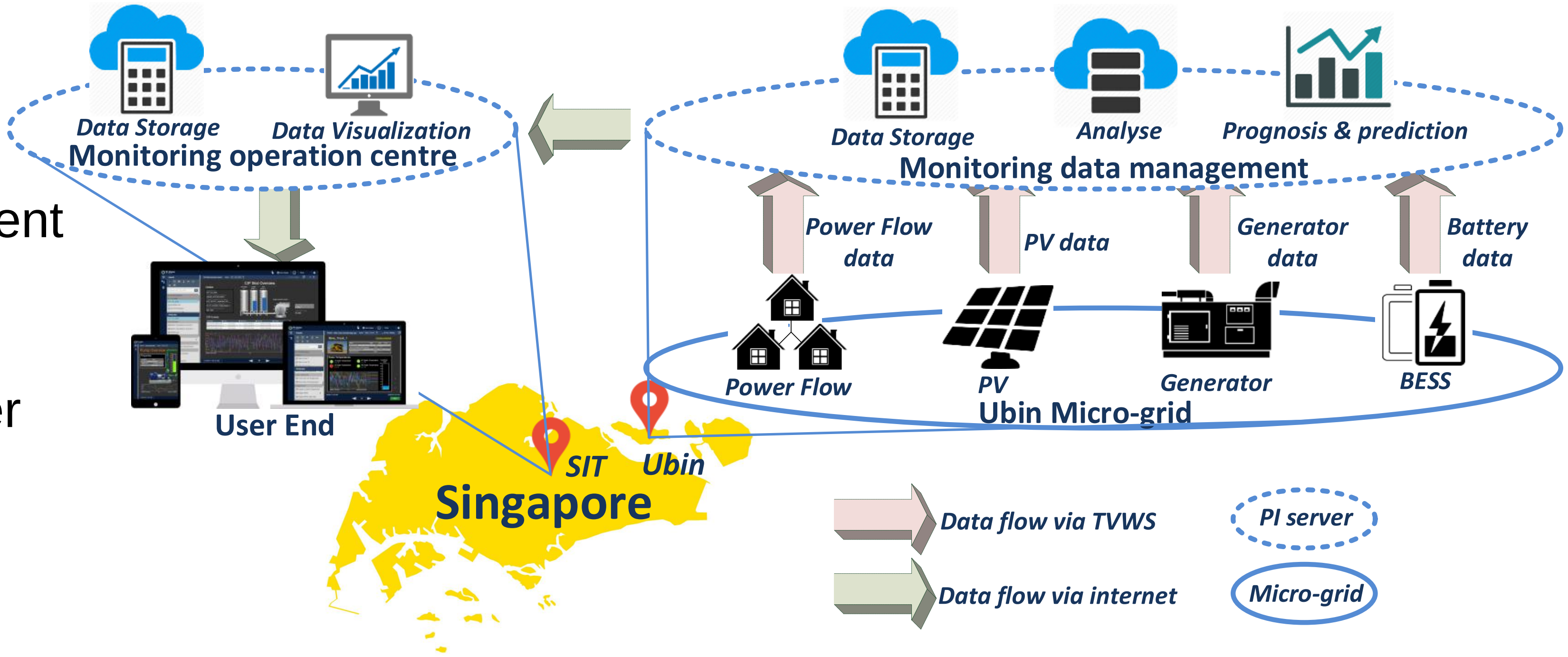
- Hybrid generators



- Single line diagram

Monitoring system of Ubin Micro-grid

- Sensors\meters & data acquisition
- Monitoring data management (local data storage and processing) @ Ubin
- Monitoring operation center (remote data storage and visualization) @ SIT



Monitoring system of Ubin Micro-grid

- Sensors\meters & data acquisition

PV voltage sensor

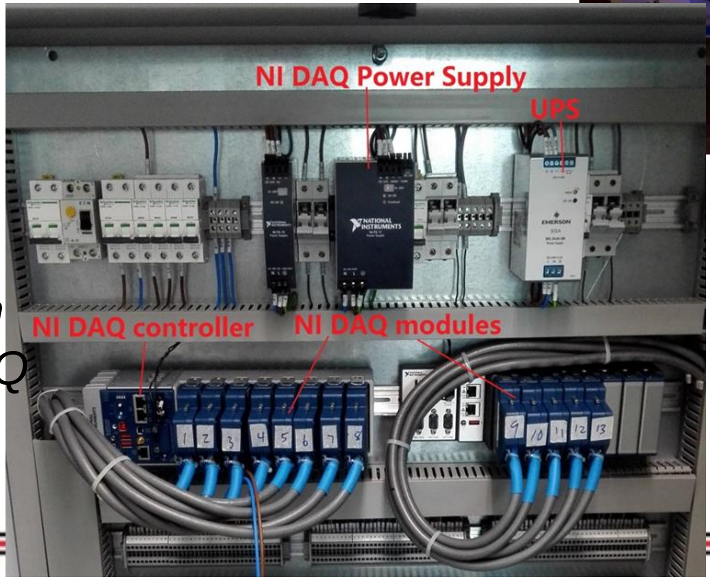
Air temperature
r

Irradiance sensor

Power flow & generator monitoring meter: PQube 3

PV temperature sensor

PV current sensor

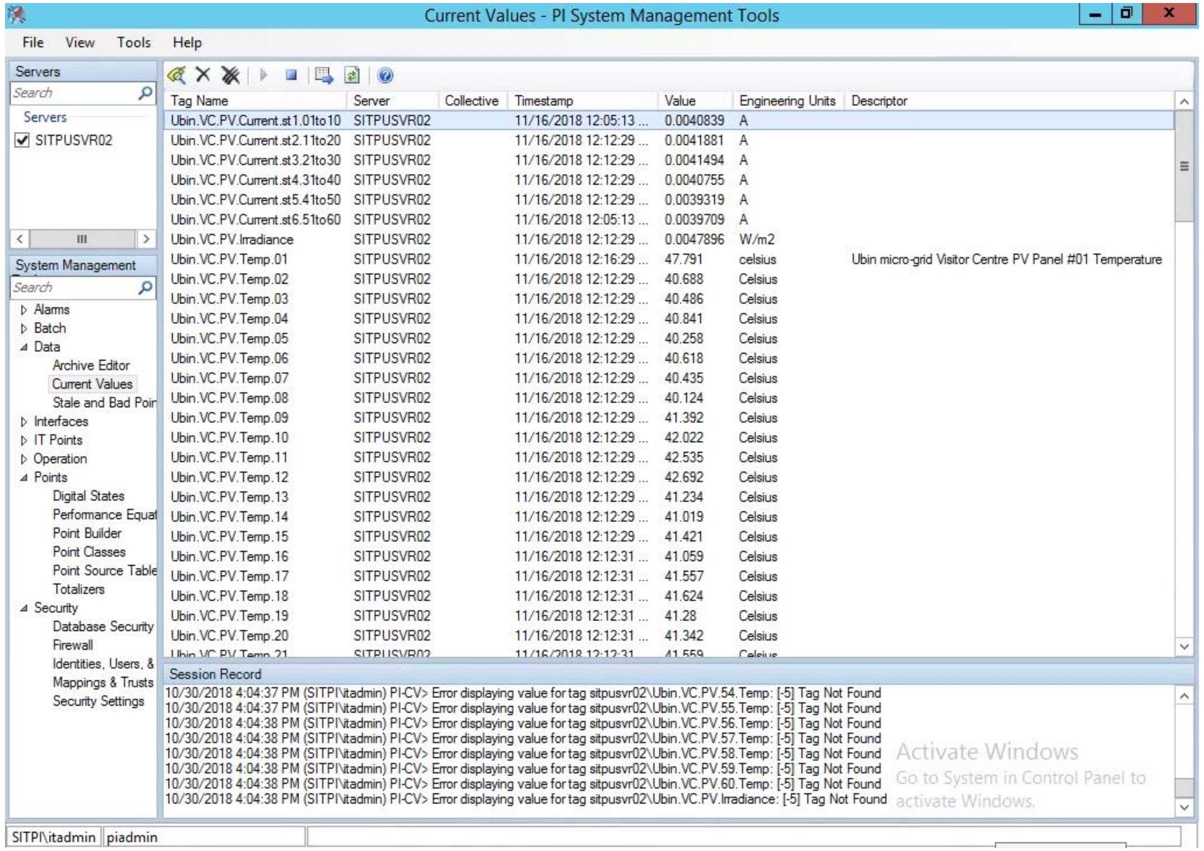


Data acquisition platform: NI DAQ & LabView

Monitoring system of Ubin Micro-grid

- Monitoring data management (local data storage and processing) @ Ubin

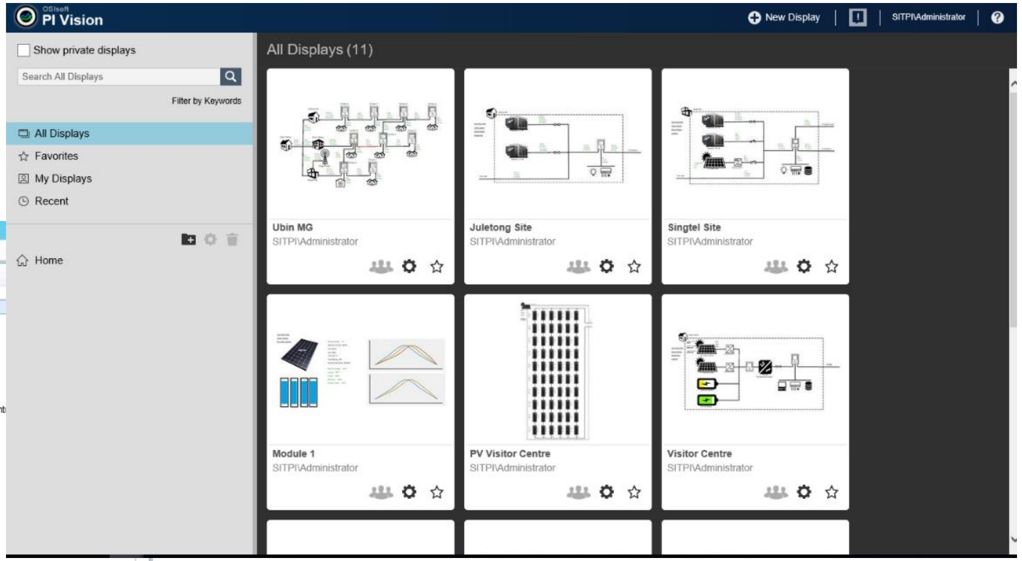
Servers and UPS



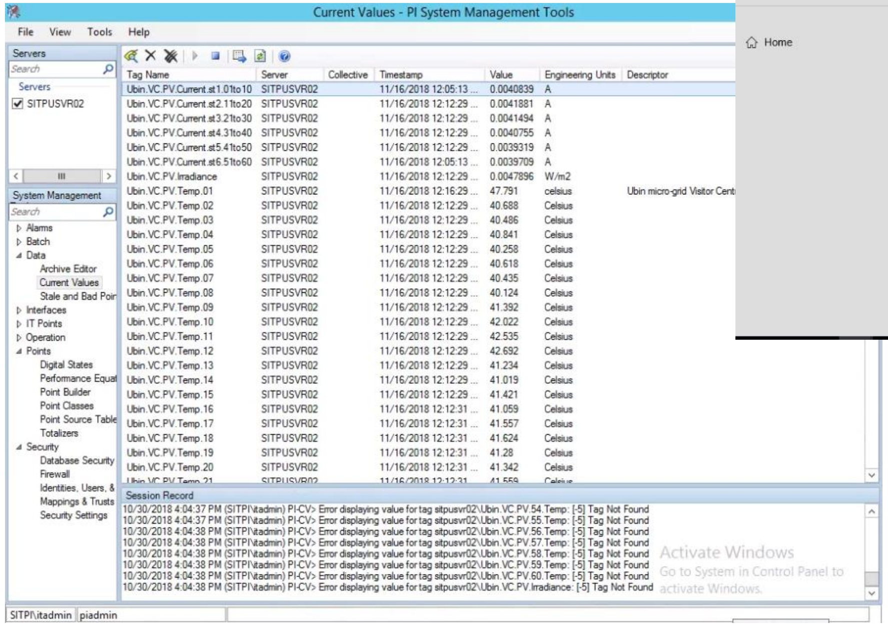
PI system based data storage and processing

Monitoring system of Ubin Micro-grid

- Monitoring operation center (remote data storage and visualization) @ SIT



PI system based visualization design (user interface)

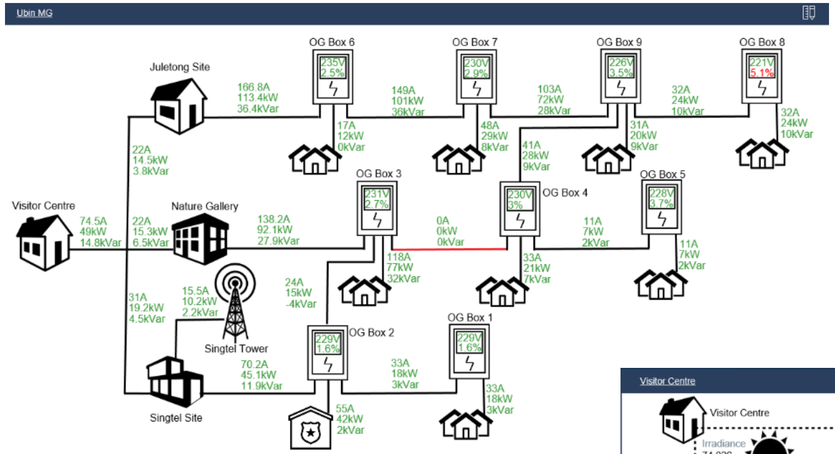


PI system based data storage

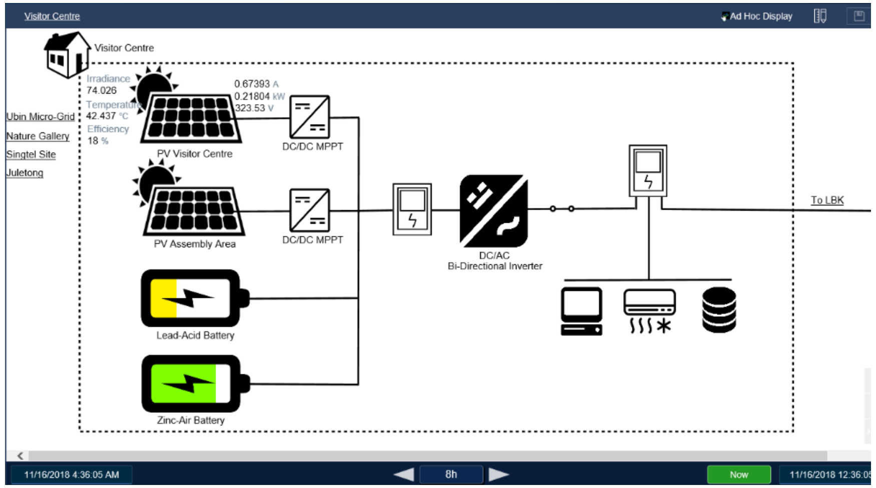
Servers and UPS

Monitoring system of Ubin Micro-grid

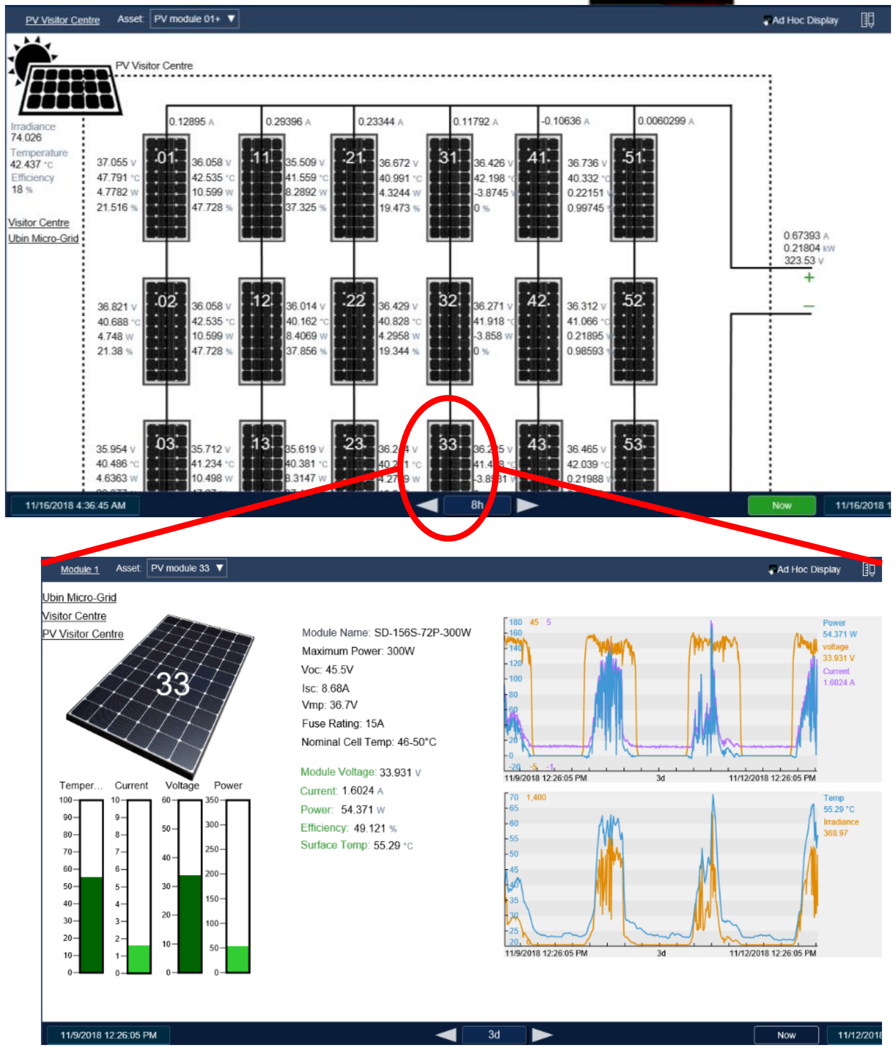
- *visualization design (user interface)*



Grid level monitoring

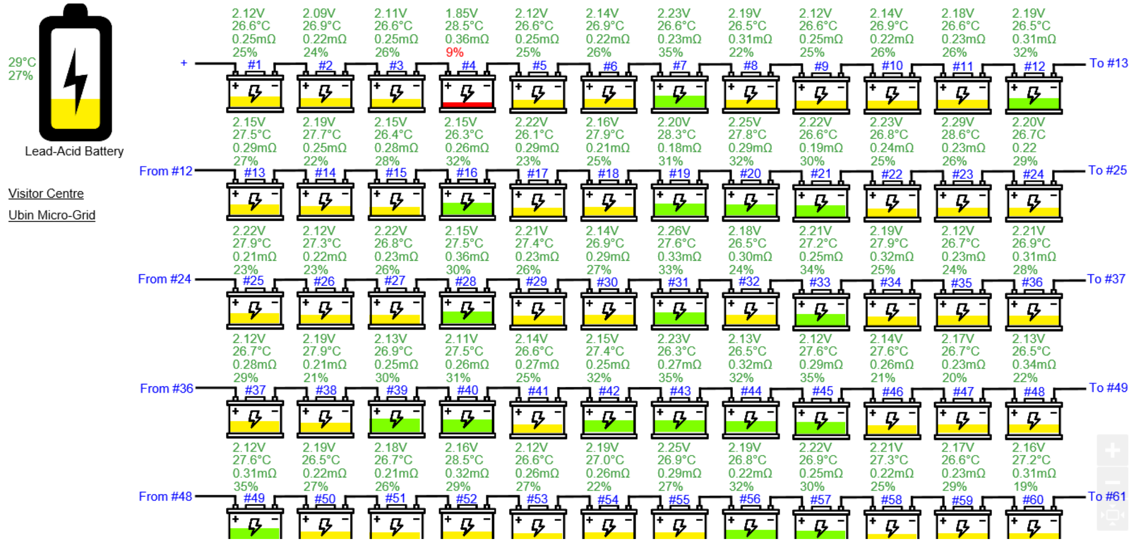


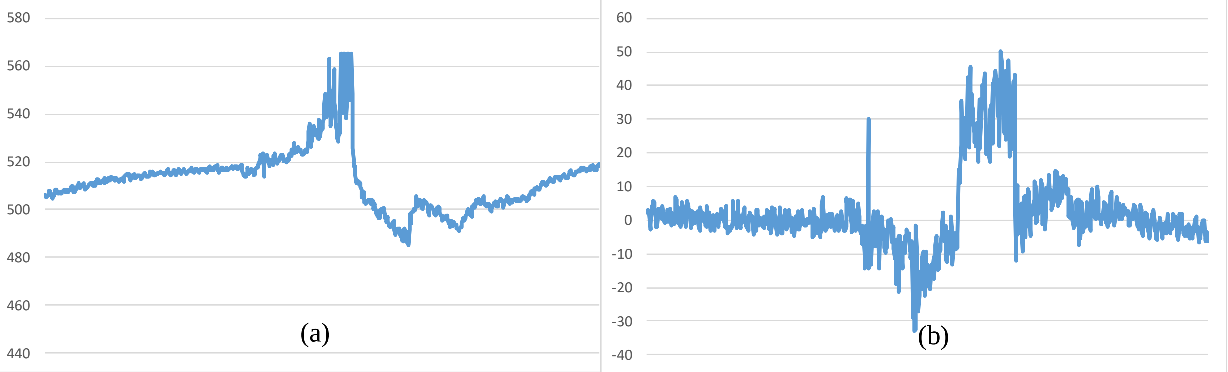
Site level monitoring



Module/cell level monitoring

Sample monitoring data

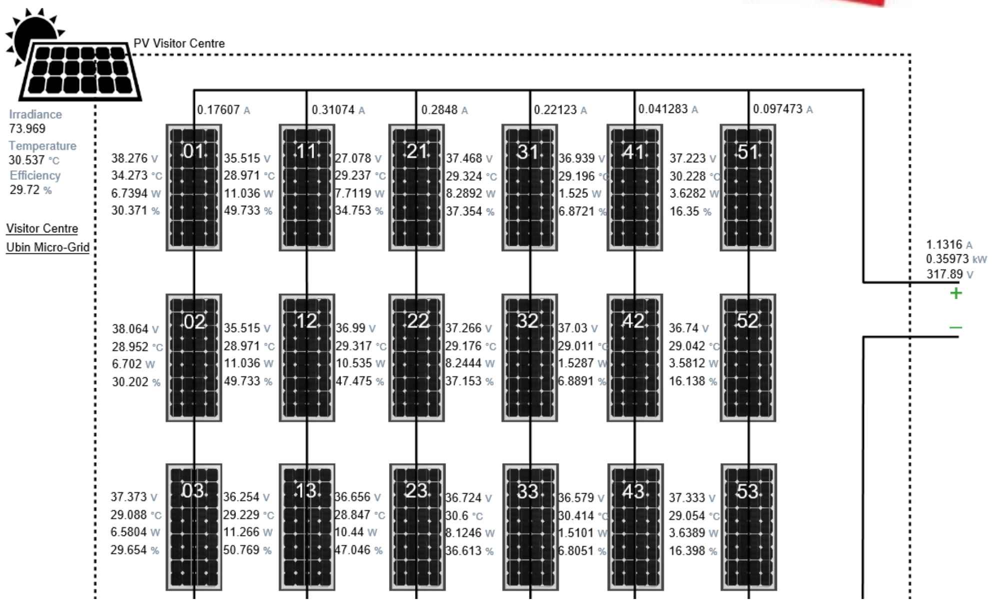


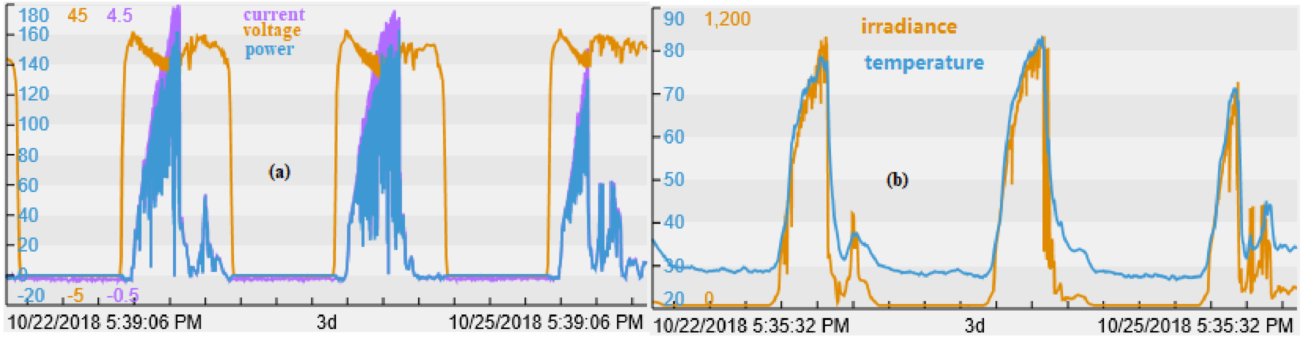


(a)
(b)

24 hour historical data for (a) voltage and (b) current waveform of battery bank

Battery monitoring and sample data





(a)
(b)

3 day historical data for (a) current, voltage and power (b) irradiance and temperature

PV monitoring and sample data

References

Thermal investigation of lithium-ion battery module with different cell arrangement structures and forced air-cooling strategies
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