Department of Electrical and Electronic Engineering
University of Peradeniya
Deep Vision, Bright Future

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THE UNIVERSITY OF MELBOURNE

Workshop on Smart Grid Technologies and Implications for Inclusive Development in Sri Lanka

3-4 April 2018 • Galle, Sri Lanka

FLEXIBILITY services in the future smart grid

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Transformative changes in power sector

Causes

Decentralisation: more roof top PV, DGs, EVs

Democratisation: community power,
empowering consumers

Decarbonisation: climate change

Enablers

Digitisation: one of the key enabler of smart grid

Distributed ledger: blockchain

Demanding FLEXIBILITY services for system planning and operation

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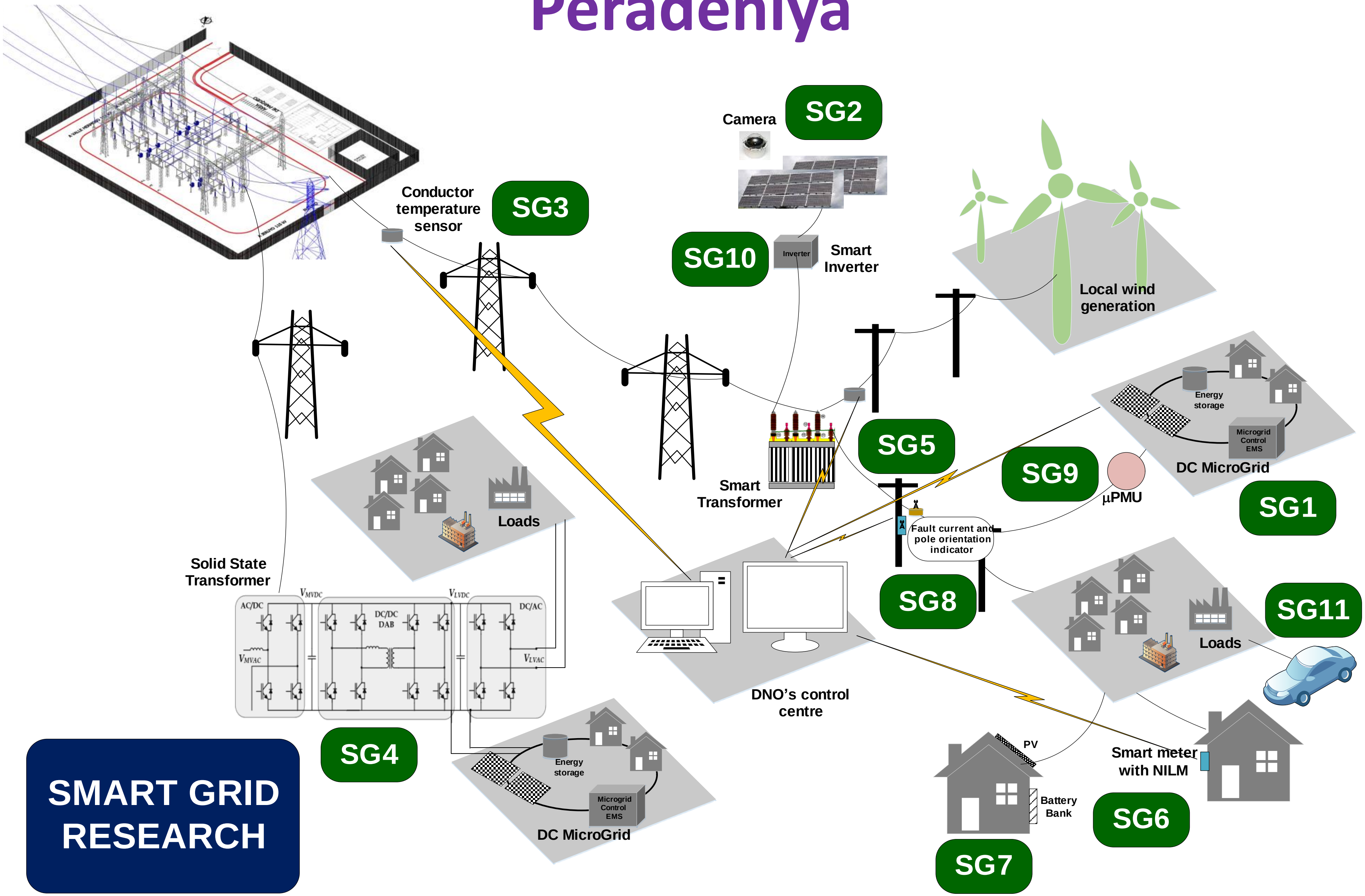
Smart Grid research at the University of Peradeniya



Energy Efficient Utilization of PV through a dc MicroGrid

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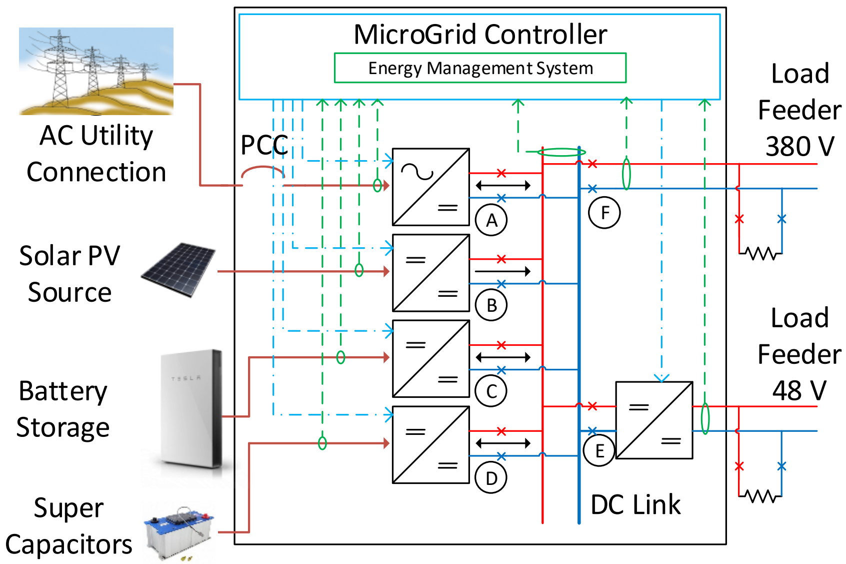
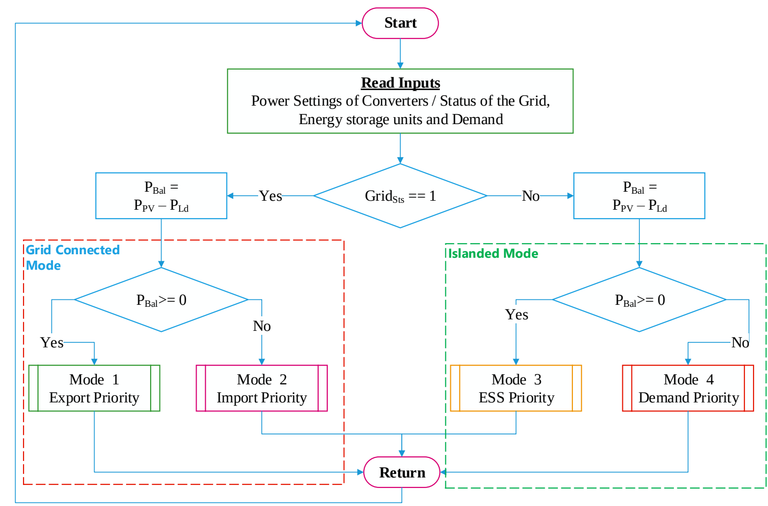
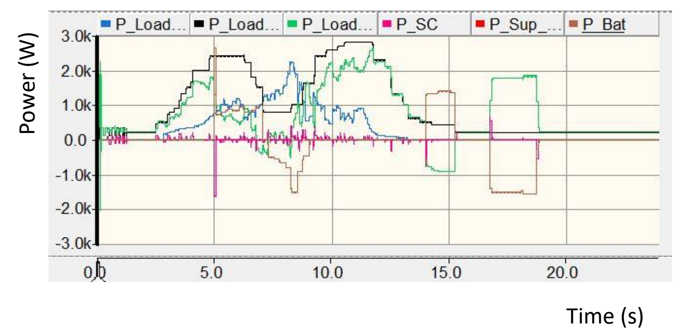
இலங்கை நிலைபெறுதகு வலு அதிகாரசபை
Sri Lanka Sustainable Energy Authority







Variation of output power of all the power converters

DC MicroGrid

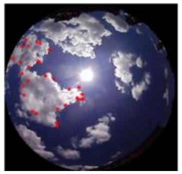
- DC Link voltage 380V; Capacity 5 kW
- Four Sources and two load feeders

A. Controlled Rectifier – AC utility interface (3 kW)
B. DC-DC Boost converter – PV interface (2 kW)
C. DC-DC isolated bi-directional converter – Battery storage interface (3 kW)
D. DC-DC isolated bi-directional converter – super-capacitor interface (1 kW)
E. DC-DC isolated forward converter – 48 V Load interface (1.5 kW)
F. 380 V Load interface (1.5 kW)

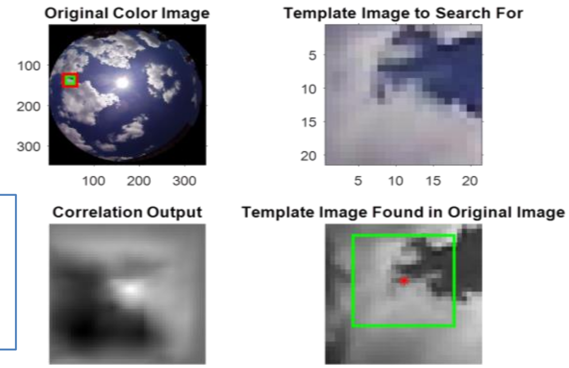
Security of Supply with the Large Scale Deployment of PV

(A)

(B)



(C)

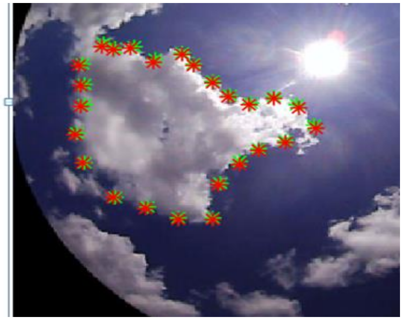


1st image → Cloud Segmentation → For each cloud, Find the cloud's boundary segment

2nd image → For each boundary segment, apply Fast cross-correlation and find the corresponding areas in 2nd image

3rd image → Apply fast cross-correlation and find the corresponding area in 3rd image

(D)



6th image → apply Fast cross-correlation and find the corresponding area in 6th image

Find the boundary segment moving velocity → Predict future cloud location

- Cloud tracking
- Solar prediction
- Reserve requirements

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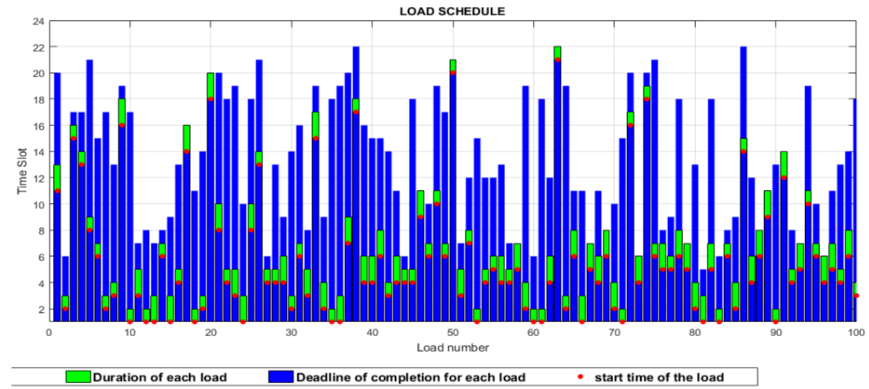
Optimum utilization of power network assets for maximum renewable absorption

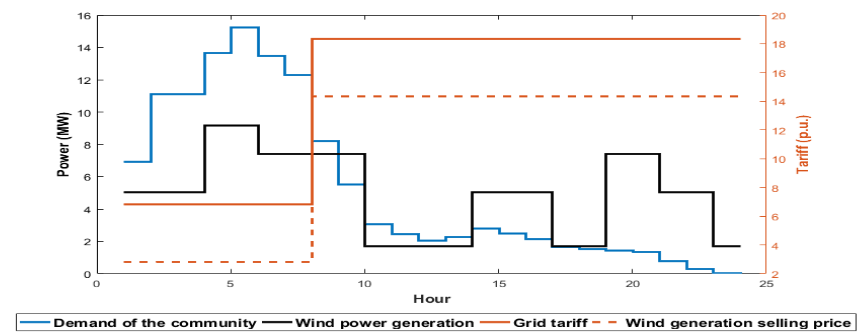
Coordinate dynamic line rating (DLR) and demand management (DSM)

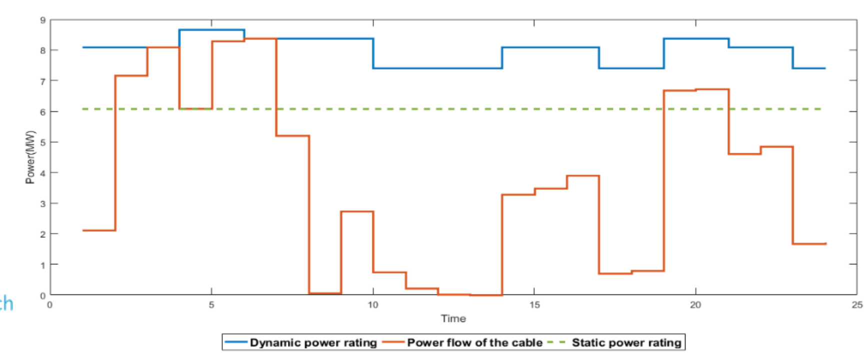
Increase network asset utilization

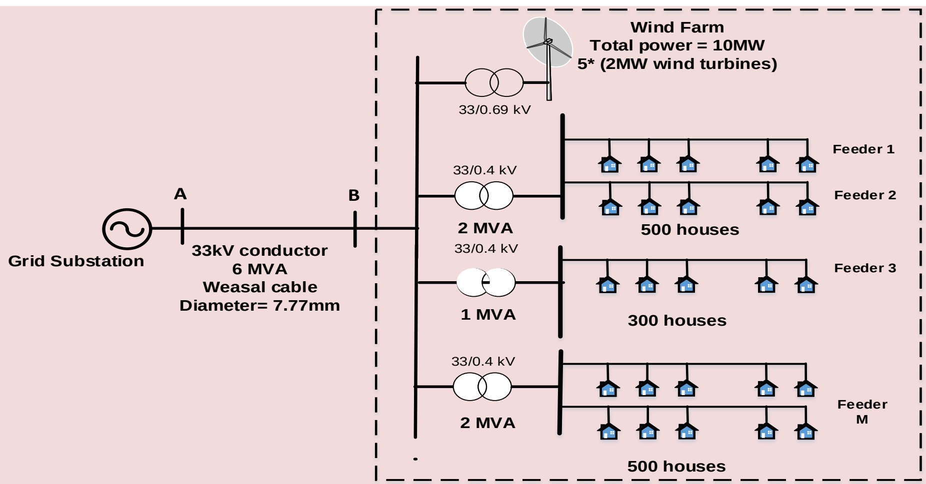
Relive distribution network bottlenecks

Connect more renewable energy sources and cater for increasing demand

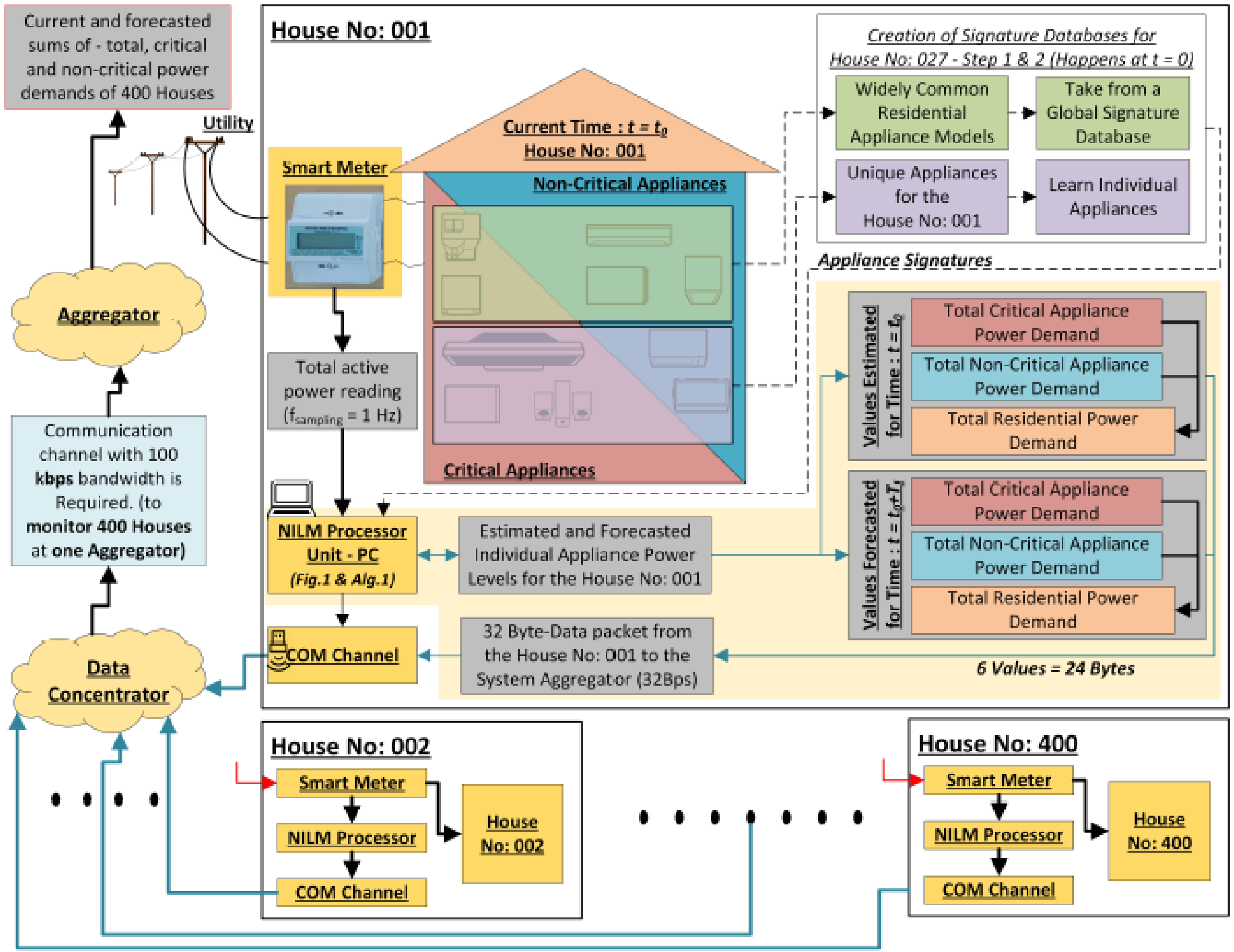








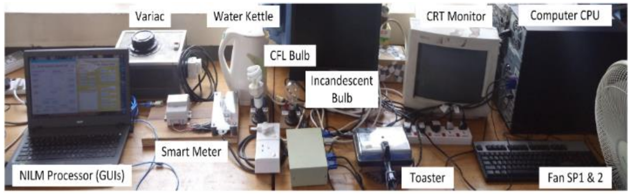
Non-Intrusive Load Monitoring (NILM) for Flexible Demand Estimation and Management



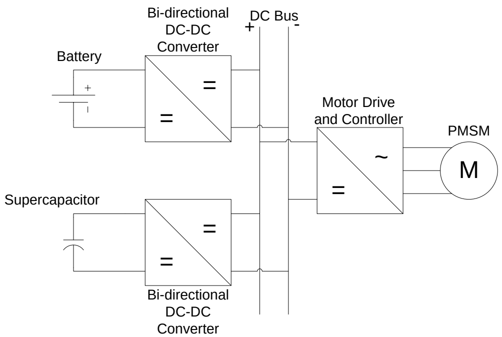
Demand response through load estimation and predictions

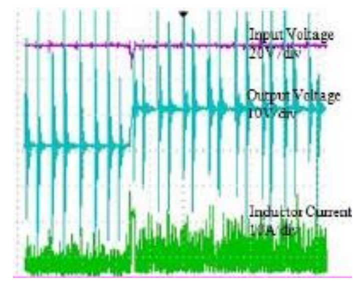
TABLE II: Real-time Appliance Identification Accuracies Comparison

Combination	A_{CV}%	A_{VV}%	Combination	A_{CV}%	A_{VV}%
B1	52.1	93.2	F1	33.2	80.2
B1+B2	51.0	91.2	Dr	60.1	98.7
B1+B2+To	48.8	86.4	PC+Mo	60.2	77.5
To	62.3	93.5	To+PC	66.2	78.5
B2+To+PC	55.8	79.2	PC+Mo+F1+B2	32.0	72.0
VC	40.2	98.5	VC+WK+F1+B1	45.7	70.5
WK+B2	45.2	80.2	PC+Mo+VC	40.5	78.3
B1+VC+WK	30.2	73.0	B2+F1+Dr	57.8	86.5

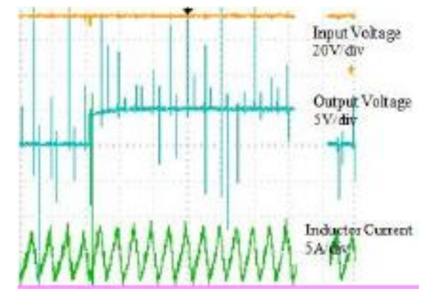


Design of a Dual Energy Source for a Small Electric Vehicle



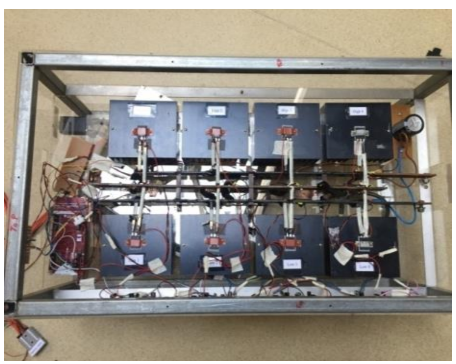


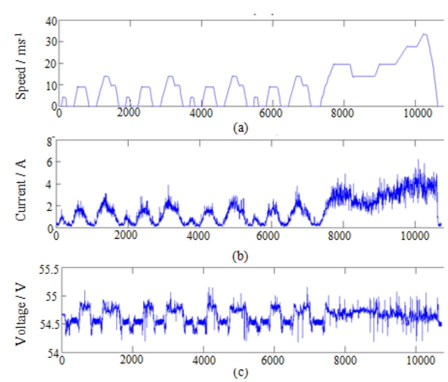
Battery converter: Output ref. changed (10V)



Supercapacitor converter: Output ref. changed (5V)

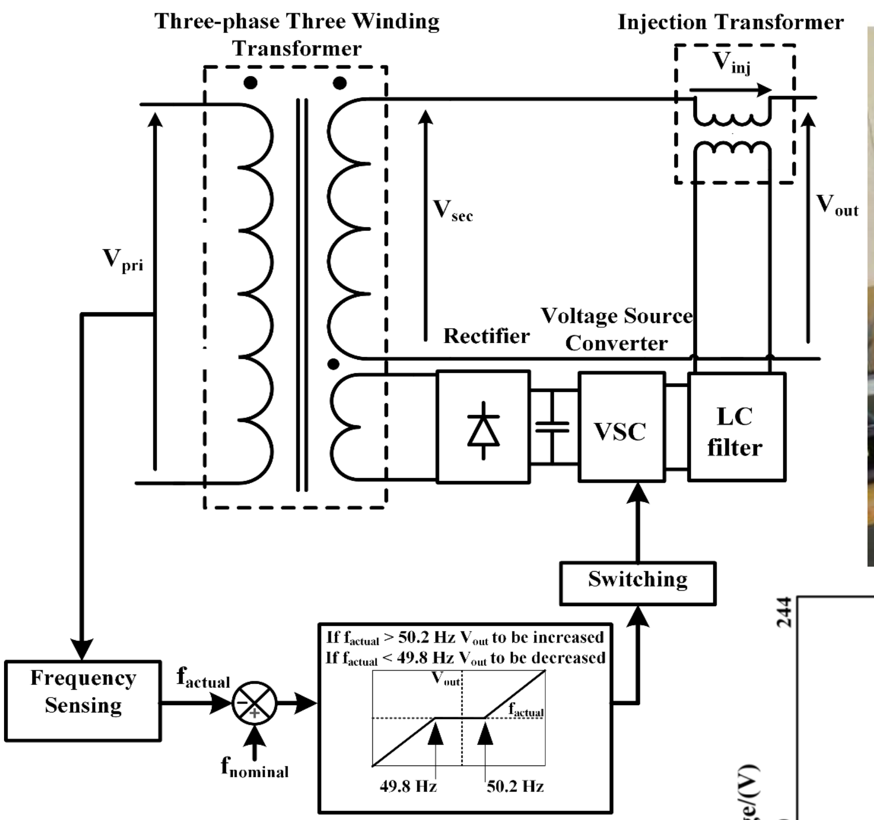
Experimental results

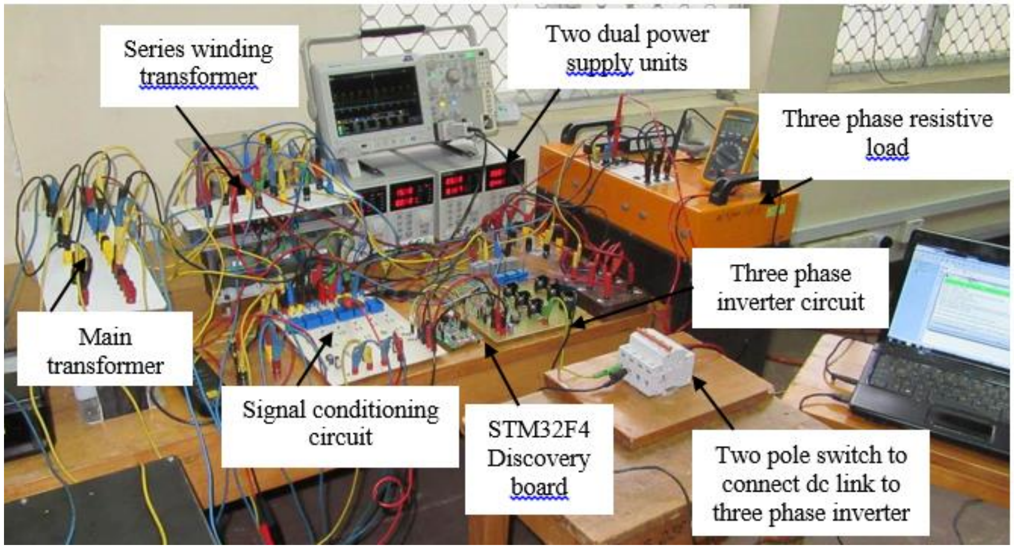


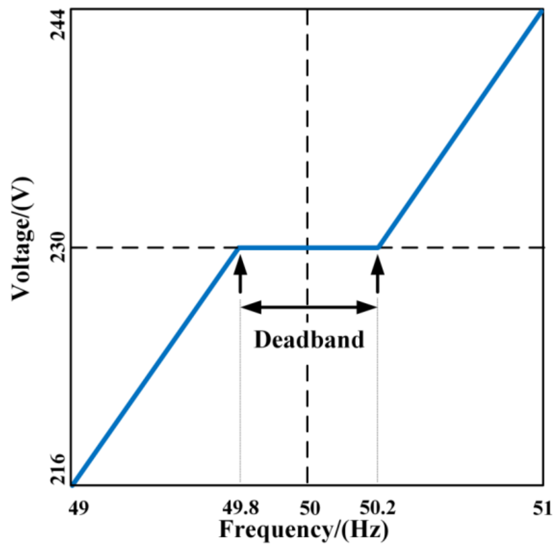


NEDC testing (a) speed ref. (b) motor current, (c) terminal voltage

Frequency following smart distribution transformer

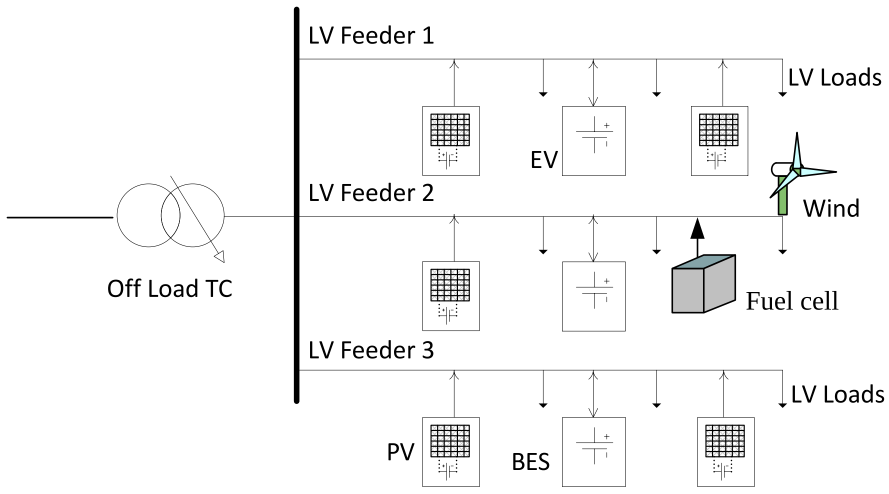






DISTRIBUTED RENEWABLE ENERGY RESOURCES TO SUPPORT THE FUTURE LAST-MILE POWER UTILITY NETWORKS (DER2LEN)

DER2LEN – Background

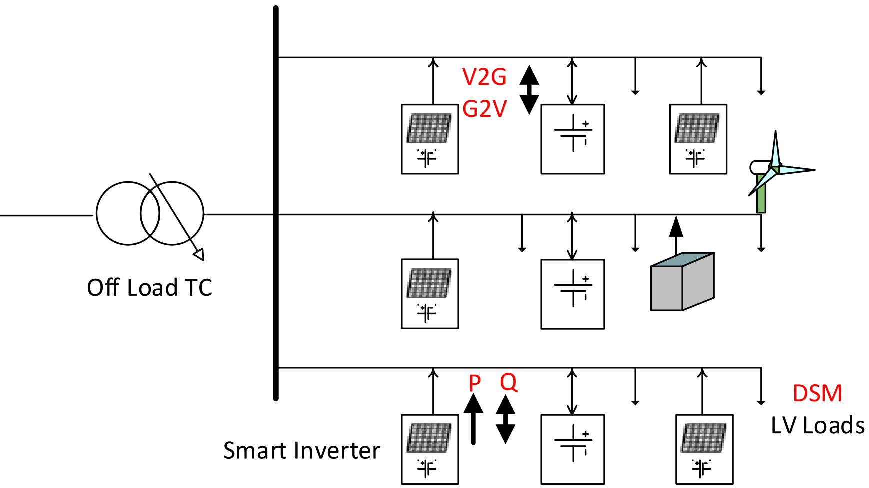


Utilities might look at DERs as entities of negative impact

Anticipated Challengers:

- The penetration of DERs such as renewable energy sources such as roof top PV schemes, Wind plants, etc. are increasing
- Increase of dynamic load and charging of electrical vehicles can create low voltage issues
- Increase of the proportion of PV connection can create over-voltage issues
- EV charging might overload network asserts thus increasing line tripping
- All DERs create harmonic and unbalance issues

DER2LEN – Proposed Solution



Opportunities:

- Electrical vehicles can operate as a load as well as an energy store
- P and Q output of the PV inverters can be manipulated through a smart inverter
- Smart metering with data analytics and intelligent control algorithm enables DSM of Loads and DER
- New business models can help to incentivize some of the grid supportive services provided by DERs

- How the above opportunities could be best utilised to support connection of more renewables while acting as good citizens?

- What are the regulation and/or suitable commercial arrangements and incentives required to obtain privately owned DER resource for network support?

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