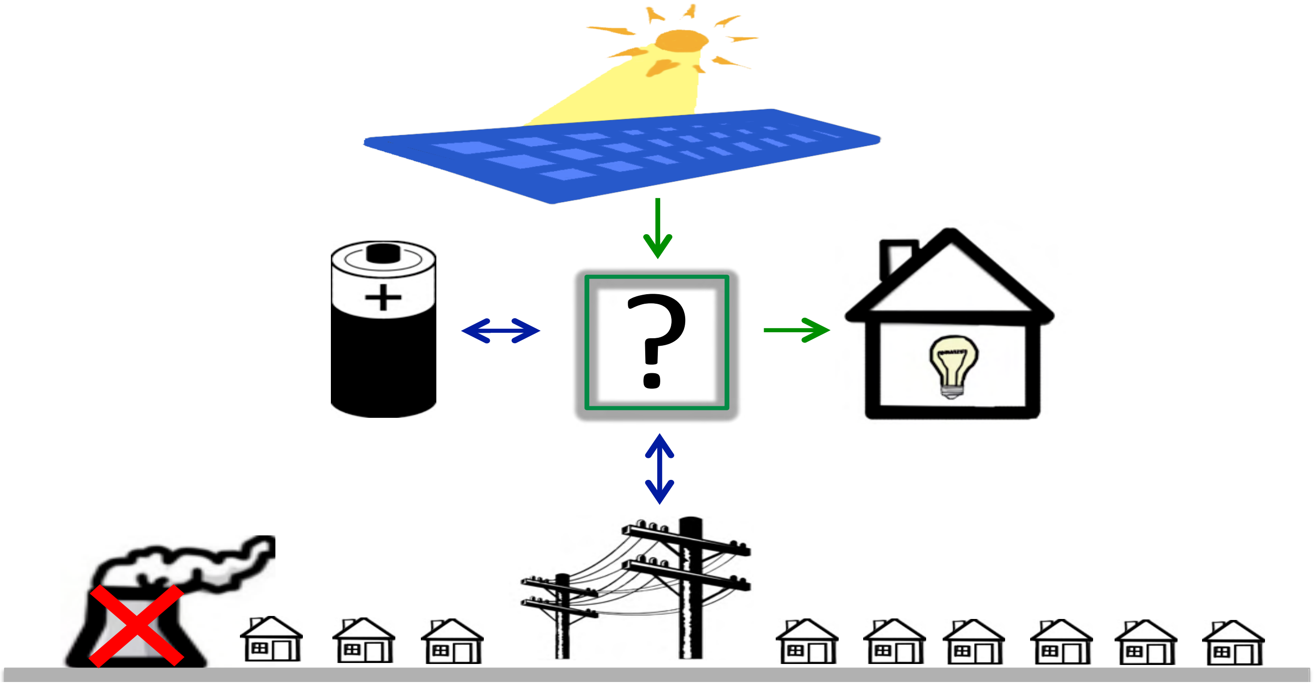
Controlling Power Systems in the Transition to Net-Zero



Dr. Elizabeth Ratnam, ANU FERL Fellow & Senior Lecturer

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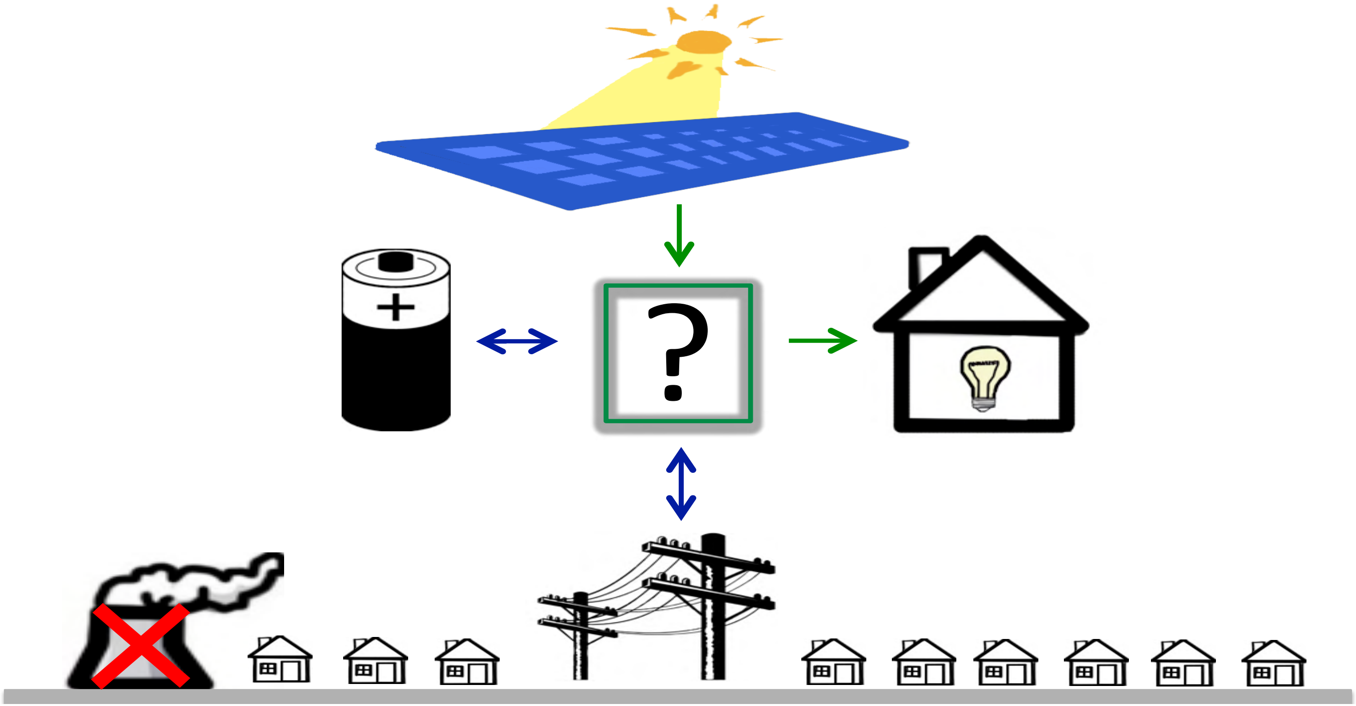
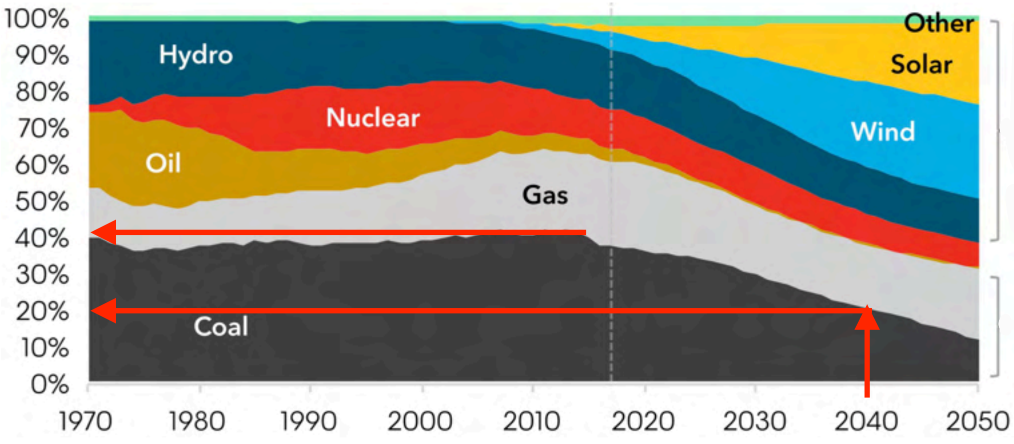
ANU Energy Update 2023

Short Overview



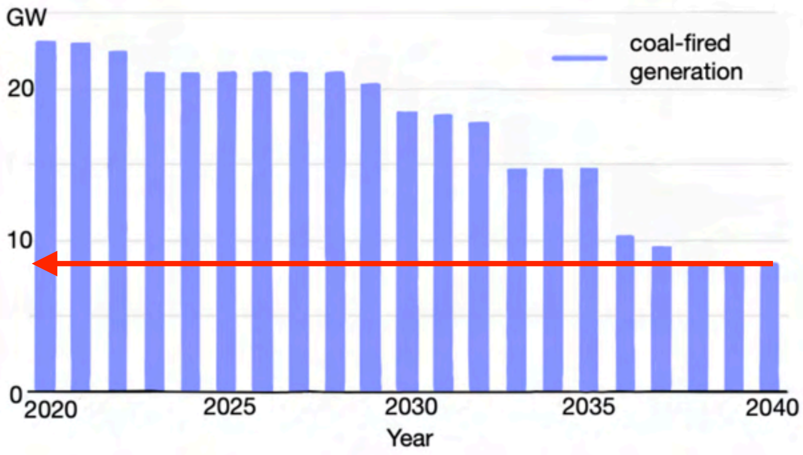
Future: Coal-Fired Generation in Australia and Globally

The Energy Mix: Global Energy Systems



Source: Bloomberg New Energy Finance 2019

Australian Coal-Fired Electricity Generation

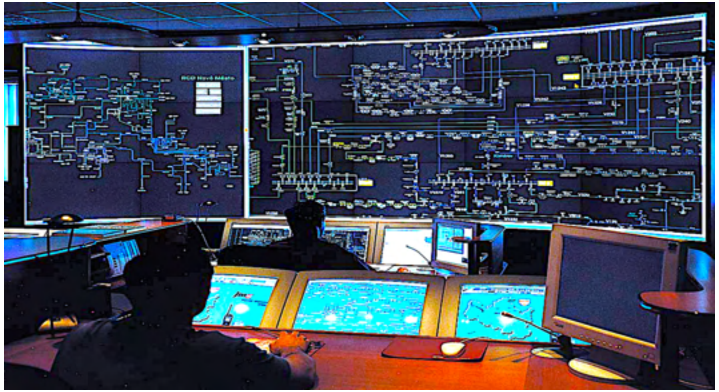


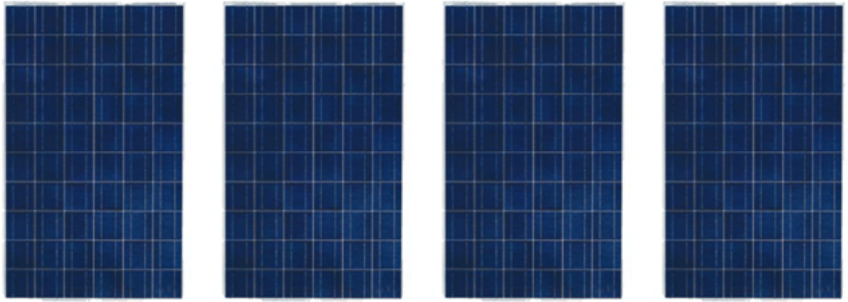
Source: AEMO Integrated System Plan 2019

More than half of the worlds coal-fired power plants will be retired in the next 15-20 years

More than 50% of Australia's Electricity Generation comes from Coal

Solar Generation - Australia is leading the world





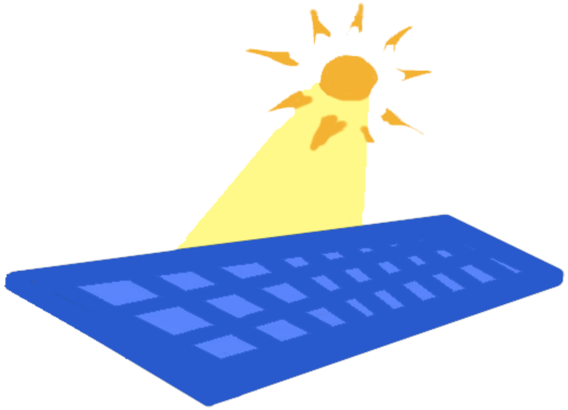
YINGLI SOLAR
Yingli YL250P-29b

6.6 m^2

Installed PV Generation				kW/person
	2010	2023	Population	
Australia	~1GW	~30GW	~25 million	1.2
Germany	~18GW	~66GW	~83 million	0.79
USA	~1GW	~142GW	~332 million	0.43
Japan	~3.62GW	~ 90GW	~125 million	0.72
China	~0.8GW	~392GW	~1,436 million	0.27

An Australian PV + Battery Customer

+



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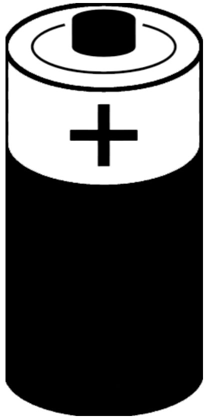

Residential Load
≈ 20kWh/day
≈ $5/day

1.5kW PV unit produces
≈ 5kWh/day
≈ $3/day ($2)

10kWh battery
LP ≈ -$1/day ($4)
QP ≈ $1/day ($2)

What about Electric Vehicle customers?

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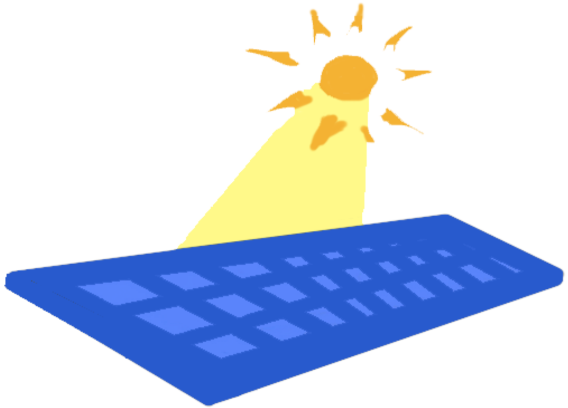

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Residential Load

≈ 20 kWh/day

$\approx \$5$/day

1.5 kW PV unit produces ≈ 5 kWh/day

$\approx \$2$/day

1.5 kW PV unit exports ≈ 2 kWh/day

≈ 14 kWh/day

≈ 110 km

≈ $9.0/day

LP ≈ $0.7/day ($8.3)

Take-away: V2G savings of $8.3/day are possible, can we leverage V2G more?

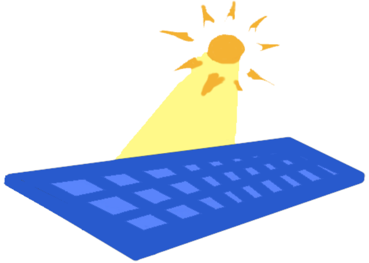
https://www.energymadeeasy.gov.au/

https://www.tesla.com/en_AU/support/range-calculator

Energy Transformation: Can we interconnect renewable energy zones faster?

Do we need 10,000 km of new transmission network (cost $12.7 billion)?

Can we build less transmission lines and maintain grid stability?



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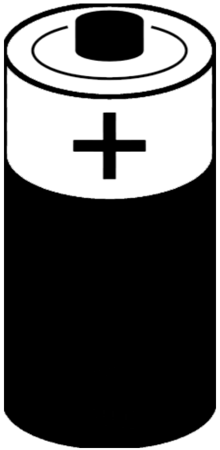
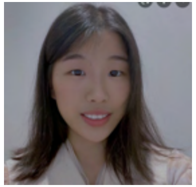


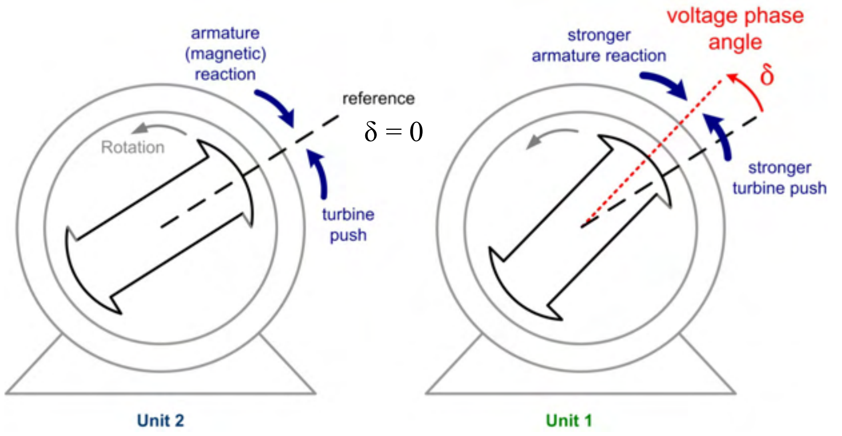
Solution: Use Giant Batteries and Electric Vehicles

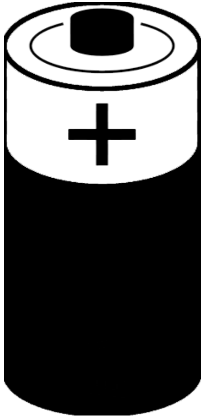
Can we build less transmission lines and maintain grid stability?

Solution: Use Giant Batteries and Electric Vehicles

SCIENCE: Rotor Angle Control using Negative Imaginary Systems Theory







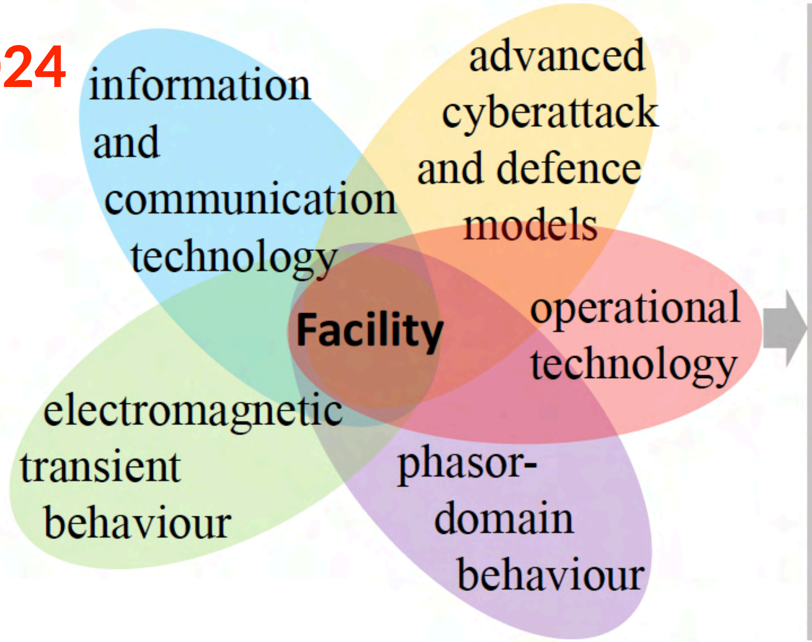
Benefit: Reduce the cost of the Energy Transition and Speed it up!

https://doi.org/10.48550/arXiv.2311.06820
https://doi.org/10.48550/arXiv.2310.01781

National Facility for Electric Grid Security and Resilience Research

IN CONSTRUCTION 2023-2024

Figure 1: OPAL-RT OP5707XG supporting the new operating system OPAL-RT Linux



Cyber-Physical Resilience

- Robust
- Secure
- Adaptive
- Trust
- Privacy
- Distributed
- Microgrids
- Learning
- Agents

ARC Funded + ANU + University of Newcastle + University of Sydney: Total $668,000

National Facility for Electric Grid Security and Resilience Research

Bringing together more than $35M in competitive funding

***Real-time Optimisation with Guaranteed Performance* DP210102454 Shames;** Manton; Manzie; Farokhi; Chapman; Man-Cho So; Said

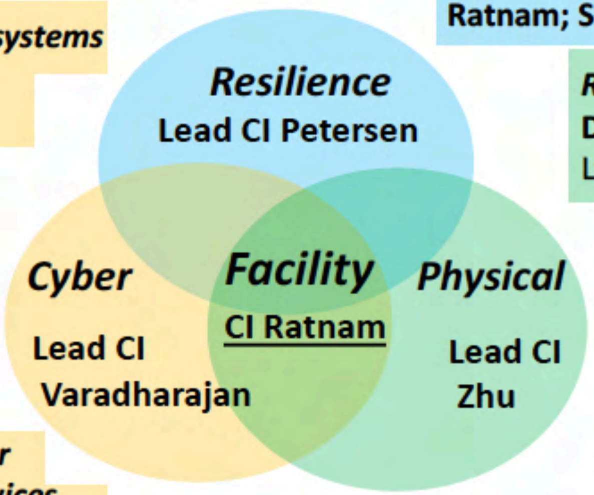
***Robust control* DP190102158 Petersen;** Moheimani; Lanzon

***Electric Vehicle Fast Charging* LP210200473 Ratnam; Shi; Petersen;** Bhardwaj; Mears

***Robust learning of dynamic systems* DP190102963 Manchester;** Schön

***Resilient electricity infrastructure* DP190103476** Lyster; **Verbic**; Farber; Verchick

***Control of network systems* DP190103615 Shi; Trumpf;** Johansson; Baras; Altafini



Controller Design Automation for Power Electronics DP220100231 Li, **Zhu,** Hui

***Democratisation of Deep Learning: Neural Architecture Search at Low Cost* DP220101035** Halgamuge; **Ratnam;** Suganthan; Hoog

***Cloud Security: Techniques for Securing Cloud Data and Services* ARC DP140100410 Varadharajan**

***Modelling, analysis and design of secure networked control systems*, DP170104099,** Nesic, **Shames**, Postoyan, Teel

***Cyber secure control for smart electricity grid:* NSW Department of Industry Varadharajan,** Chen, Hossain, Town