



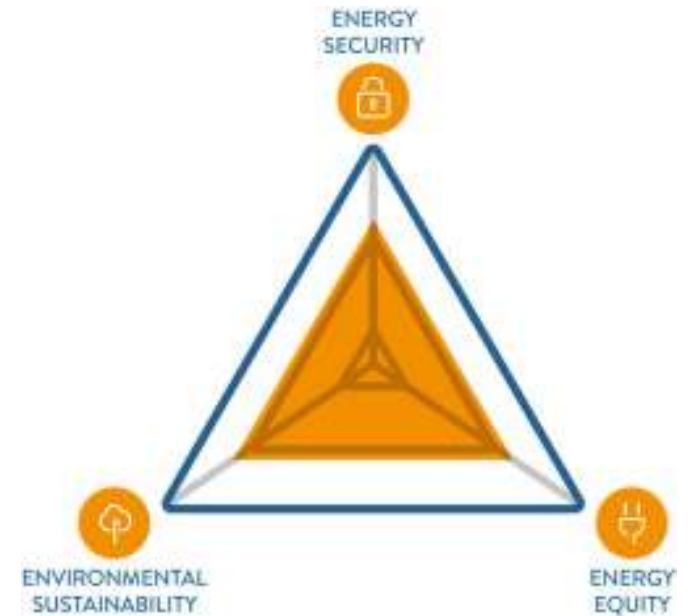
# Towards Multiscale Analysis of Energy Systems with Microgrids

Presenter: Zainab Rizvi

Supervisory Team: Engr. Con Lu, Prof. Cameron Walker, Assoc. Prof. Michael O'Sullivan

# Energy Trilemma

- The energy system in Aotearoa needs to be **resilient** and have greater **capacity** and provide electricity **affordably**.
- The bid for zero net-carbon footprint by 2050 has led to accelerated electrification of the transport and industrial sector.
- This increased demand has is **taxing a complex, centralized power distribution system** that does not have the capacity to transmit said power.





## Tairāwhiti

*“Gisborne is **cut off by road and air, power and communications networks** are out to most of the region and residents are being asked to **conserve water.**”\**

\*[Cyclone Gabrielle: Flooding, evacuations, power outages across multiple regions | RNZ News](#)

- In February 2023, the lack of resilience in the electricity infrastructure was laid bare by Cyclone Gabrielle.
- Tairāwhiti and Hawke’s Bay were the worst hit regions in Aotearoa | New Zealand.
- According to Transpower the Redclyffe Substation was damaged resulting in the loss of electricity supply to Hawke’s Bay and Tairāwhiti.
- It took FirstLight (regional lines company) more than 2 weeks to restore power to the more isolated households.

# Partnerships in Tairāwhiti

“This project is not just research out of Auckland, but an economic development project for the entire region.”\*

- Gisborne District Council,
- Te Weu Tairāwhiti,
- Local iwi,
- East Coast Exchange,
- Community Energy Network,
- Trust Tairāwhiti.

\* Tairāwhiti Regional Leadership group Rau Tipu Rau Ora



# Energy Autonomy

“Autonomy is often cited as a key aspect of energy systems. Previous academic literature on energy autonomy has predominantly approached it from a technological perspective, and conceptualized it as self-sufficiency of energy production.”

Jouni K. Juntunen, Mari Martiskainen, “Improving understanding of energy autonomy: A systematic review”, *Renewable and Sustainable Energy Reviews*, Volume 141, 2021

# Research Question & Approach

Are Microgrids of value to Aotearoa | Zealand? How can we determine their value?

Model energy autonomy through Microgrids in the Aotearoa | New Zealand energy system.

Analyse the effects of energy autonomy on the national, regional and nodal level.

Give recommendations about Microgrid design and adoption strategies to partners in Tairawhiti.

# What are Microgrids

A microgrid typically consists of distributed generation (fossil-based and/or renewable), energy storage, load control, and distribution system management.\*

- Definition: *Microgrids are electricity distribution systems containing loads and distributed energy resources. They consist of distributed generators, storage devices and controllable loads that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded.\*\**



\*Ref: [Surveillance-Defining-Microgrids-November-2019.pdf \(cooperative.com\)](#)

\*\*Ref: CIGRÉ. Working Group C6.22 Microgrids Evolution Roadmap, Microgrids 1: Engineering, Economics, & Experience, forthcoming.

# Vectorised Scheduling Pricing and Dispatch (vSPD)

vSPD is maintained by New Zealand Electricity Authority.

It is a Linear Programming model used to clear the market, i.e., assign generator offer bids to demand load bids at each of the 500+ grid exit points (GXP) in the national grid.

The objective of vSPD is to maximise 'Net Benefit' to the system given inputs and its constraints like redundancy for n-1 events, island reserves, etc.

vSPD inputs are:

- Half-hourly demand at each node/GXP,
- Half-hourly offer bids by generators at each node.
- Static network description including line capacities and estimated losses.

Its outputs are:

- Offer bids selected.
- Revenue earned by a generator at a node
- Cost paid to fulfill demand at a node
- Net benefit to the system





# Demand and Generation Changes at Tuai

Results	Original Simulation	Modified Simulation (90% reduction in Tuai demand)	Change
<b>Demand</b>	1533.028 MW	153.3 MW	-1,379.728 MW
<b>Generation</b>	1,869.83 MW	1,668.05 MW	-201.78 MW
<b>Surplus</b>	336.80 MW	1,515.2 MW	+1,178.4 MW
<b>Revenue</b>	\$10,387.61	\$28,522.27	+\$18,134.66

## National level analysis

- The national grid consists of 523 nodes or points of contact.
- At every node for every trading period, 'Revenue' is earned by generators and 'Cost' paid by the consumer changes.
- All 523 nodes of the system participated in price change due to the decrease in load at Tuai. Change in 'Revenue' and 'Cost' is due to change in 3 factors:
  - Demand,
  - Generation, and
  - Pricing, i.e. offer stacks selected based on the demand and available generation.
- With the decrease in demand for electricity at Tuai, the overall price of electricity being traded throughout the network decreased.
- The table on the left shows the impact of reduced demand on the price of electricity on one node, Huntly.

## Huntly Power Generation and Revenue

	Original Simulation	Modified Simulation	Difference
<b>Generation (MW)</b>	8,595.56	8,432.41	163.15
<b>Revenue (\$)</b>	243,185.00	198,226.27	44,958.73
<b>Average Price (\$/MW)</b>	28.29	23.50	4.79

# Typical generator energy offer in wholesale spot electricity market\*

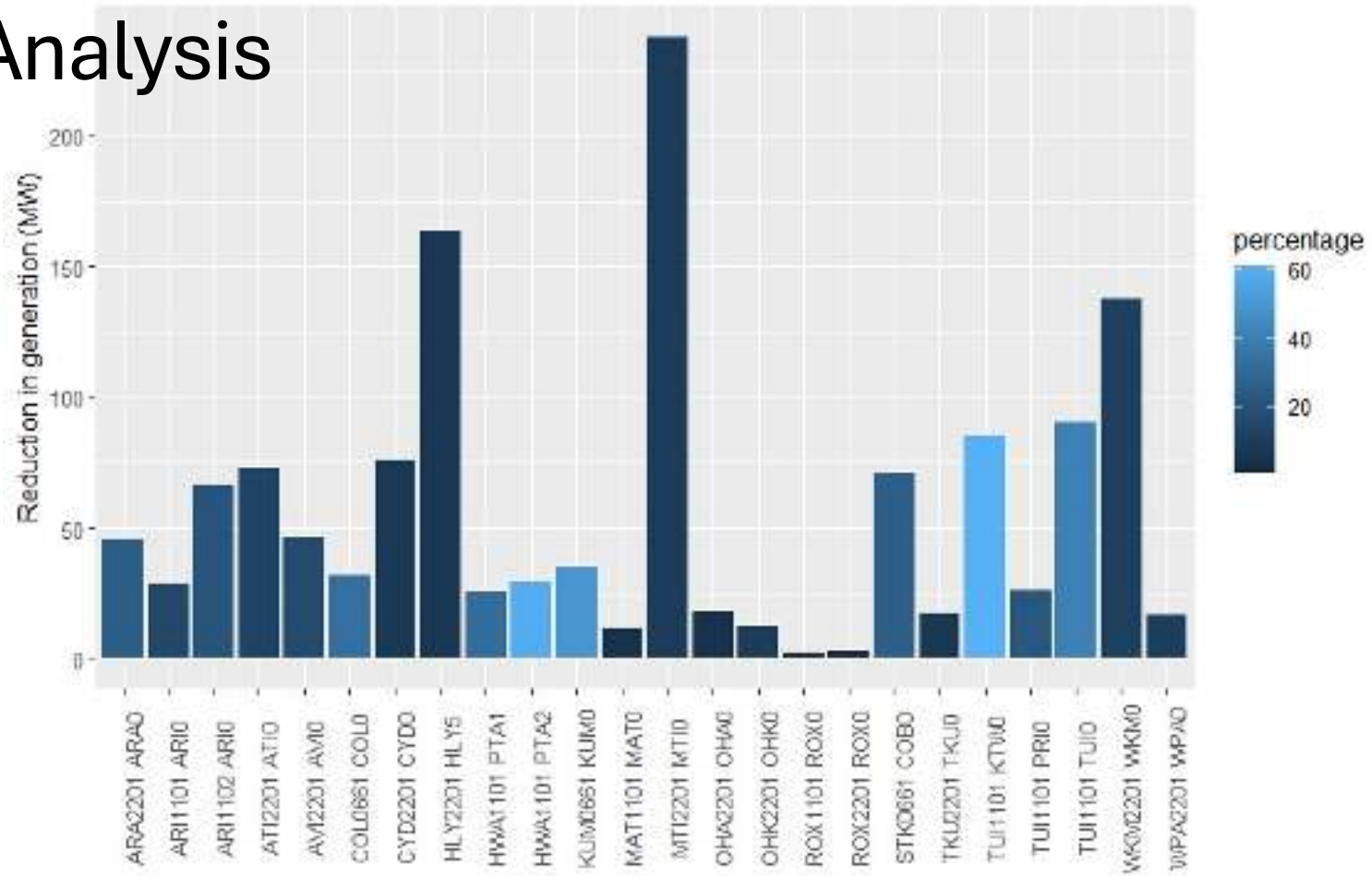


\*<https://environment.govt.nz/publications/electricity-allocation-factor-estimates-for-201617/>



# Nodal Power Generation

# Nodal Analysis



<b>Results</b>	<b>Original Simulation</b>	<b>Modified Simulation (90% demand reduction at TUAI)</b>	<b>Reduction</b>	<b>Reduction Percentage</b>
Cumulative Generation	215,313.19 MW	213,945.91 MW	1367.28 MW	0.64%
Cumulative Load	207,962.77 MW	206,583.05 MW	1379.728 MW	0.66%
Average Cost	\$38.64 /MWh	\$31.36 /MWh	\$7.28 /MWh	18.84%
Cumulative Cost	\$4,478,797.58	\$3,613,009.59	\$86,5787.99	19.33%
Cumulative Revenue	\$4,280,756.53	\$3,447,999.38	\$83,2757.15	19.45%
Cost – Revenue	\$198,041.05	\$165,010.21	\$33,030.84	16.67%
Net Benefit	\$209,500.51	\$150,833.61	\$58,666.90	28.00%

Thank you.  
Any questions?