Multi-Scale Analysis of Energy Systems with Microgrids

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Energy Autonomy

Evaluate	Evaluate the effect of Microgrids/Microinfrastructure on New Zealand Energy System.
Enhance	Enhance New Zealand energy system’s resilience and capacity using microgrids.
Ensure	Ensure just and fair transition to net carbon zero by 2050
Enable	Enable resilient communities by digital transforming energy management systems.

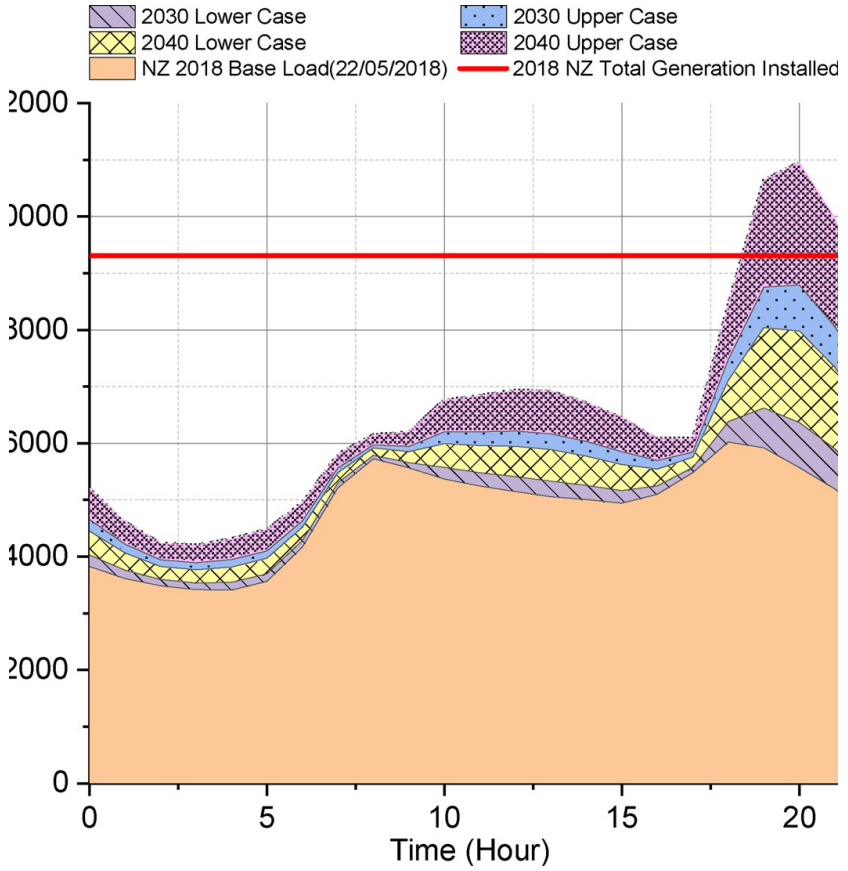
The Dual Problem

The energy system in Aotearoa needs to be more **resilient** and must have **greater capacity**.

- In Aotearoa | New Zealand, the drive to achieve net carbon zero means that it needs to accelerate the country's electrification, mainly in the transport and industrial sectors.
- This **will result in a surge in electricity demand**.
- This **increased demand could lead to increased gas and coal-based power** production in the interim **while Aotearoa increases its renewable resource-based electricity production**.
- Additionally, **increasing power production will tax a complex, centralized power distribution system** that does not have the capacity to transmit said power.
- Lastly, the increased incidence of extreme weather events is testing the resilience of the existing legacy infrastructure.

Transport Sector Electrification

- The Aotearoa | New Zealand government aims to achieve a net zero carbon footprint by 2050.
- New Zealand Climate Commission has recommended the accelerated electrification of the transport sector particularly through electric vehicle adoption.
- With said electric vehicle adoption the household demand is expected to increase by 20% to 30% .
- Without planning, increased daily demand from 6,024 MW to 10,956 MW, which would exceed Aotearoa | New Zealand's total generation capacity of 9,281 MW. *



* J. Su, T. T. Lie, and R. Zamora. Modelling of large-scale electric vehicles charging demand: A new zealand case study. Electric Power Systems Research, 167:171–182, 2 2019. ISSN 03787796. doi: 10.1016/j.epsr.2018.10.030.

NETWORK CODE	NETWORK NAME	AVERAGE % CHANGE
ALPE	Alpine Energy Ltd	10.00%
BUEL	Buller Electricity Ltd	28.80%
CHBP	Centralines	6.10%
CKHK	Wellington Electricity Lines Ltd	7.30%
COUP	Counties Power Ltd	9.20%
DUNE	Aurora Energy	7.40%
EASH	Electricity Ashburton	6.80%
EAST	Firstlight Network Ltd	9.50%
ELEC	Electra Limited	Not advised
ELIN	Electricity Invercargill	7.70%
HAWK	Unison Networks	Not advised
HEDL	Horizon Energy Distribution Ltd	5.70%
LINE	The Lines Company	Not advised
LLNW	Lakeland Network	10.00%
MARL	Marlborough Lines Limited	Not advised
MPOW	Mainpower New Zealand Ltd	Not advised
NELS	Nelson Electricity	10.00%
NPOW	NorthPower Limited	10.00%
ORON	Orion New Zealand Ltd	7.30%
OTPO	OtagoNet Joint Venture	5.88%
POCO	Powerco Ltd	7.60%
SCAN	Scanpower Ltd	5.00%
TASM	Network Tasman	6.00%
TOPE	Top Energy Ltd	8.40%
TPCO	The Power Company Ltd	6.30%
VECT & UNET	Vector Networks	8.60%

†Home - Simply Energy NZ

Increased Power Tariffs

- The electricity distribution system's transmission capacity needs to be enhanced to cater to the expected increase in electricity demand.
- **Transpower has gotten approval for spending 4.7 billion NZD on upgrading the national power grid over the next 5 years starting April 2025***. The breakdown is:
  - capital expenditure of $2.25 billion (up by 32%).
  - $1.96 billion in operating expenditure (up 20 per cent).
  - $490 million for building resilience into the system
- Earlier last year, Lines Company representative stated that capacity enhancement needed for EV adoption would require a large investment of about 22 million New Zealand dollars in the next five to ten years**.
- Now we see that as of 1st April 2024 almost all Lines companies have revised their tariffs.

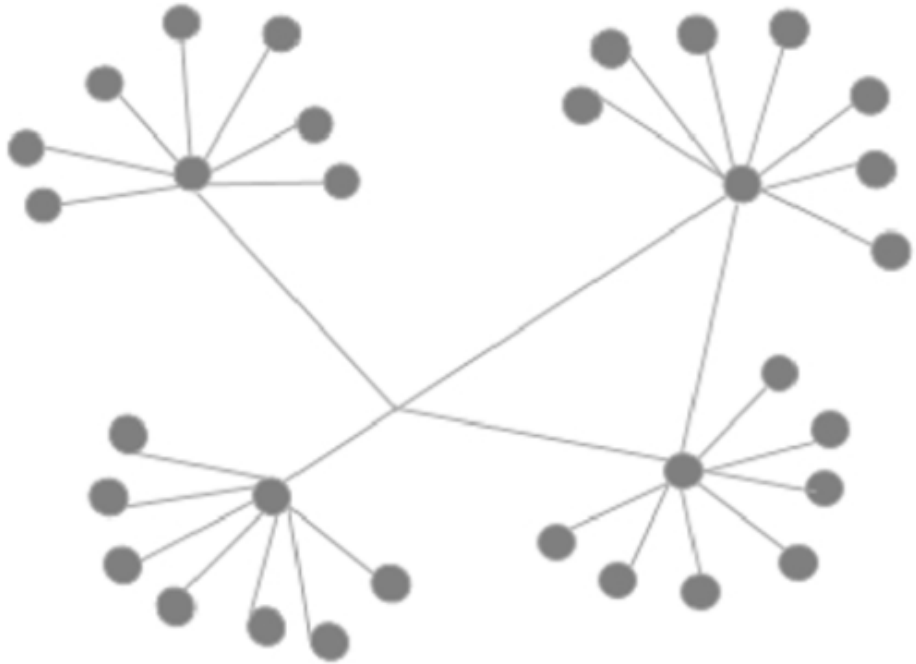
* Transpower. (n.d.). *RCP4 Main Proposal 2023*.

** T. Pullar-Strecker URL https://www.stuff.co.nz/business/132006257/household-electricity-bills-will-double-over-5-years-forecasts-departing-lines-association-boss

Our Solution

Energy Autonomy

- Using Microgrids Residential energy consumers can generate their own energy to suit their needs.
- Given the increased price of electricity and increased incidence of extreme weather events in Aotearoa, a new decentralized power infrastructure is needed to adapt to changing demand and energy resource availability.
- In the past, power generators were deployed close to energy sources, like hydro reservoirs and geothermal fields, and transmitted over a complicated power distribution network.
- Energy users can choose the microgrid configuration to suit their needs, i.e.
  - scale It up as their demand increases and,
  - adapt to their region's available renewable energy resources.



Decentralized

Requirement Analysis in Tairawhiti|Gisborne

- There is a general, recognized need for resilience in the region, not just for climate events but also in case of Covid-19 pandemic-like conditions etc.
- The need identified on Tairawhiti during a 100-year climate event were:
    1. Power,
    2. Food,
    3. Communication,
    4. Waste disposal,
    5. Clean Water,
    6. Medicines and health services.

What are Microgrids

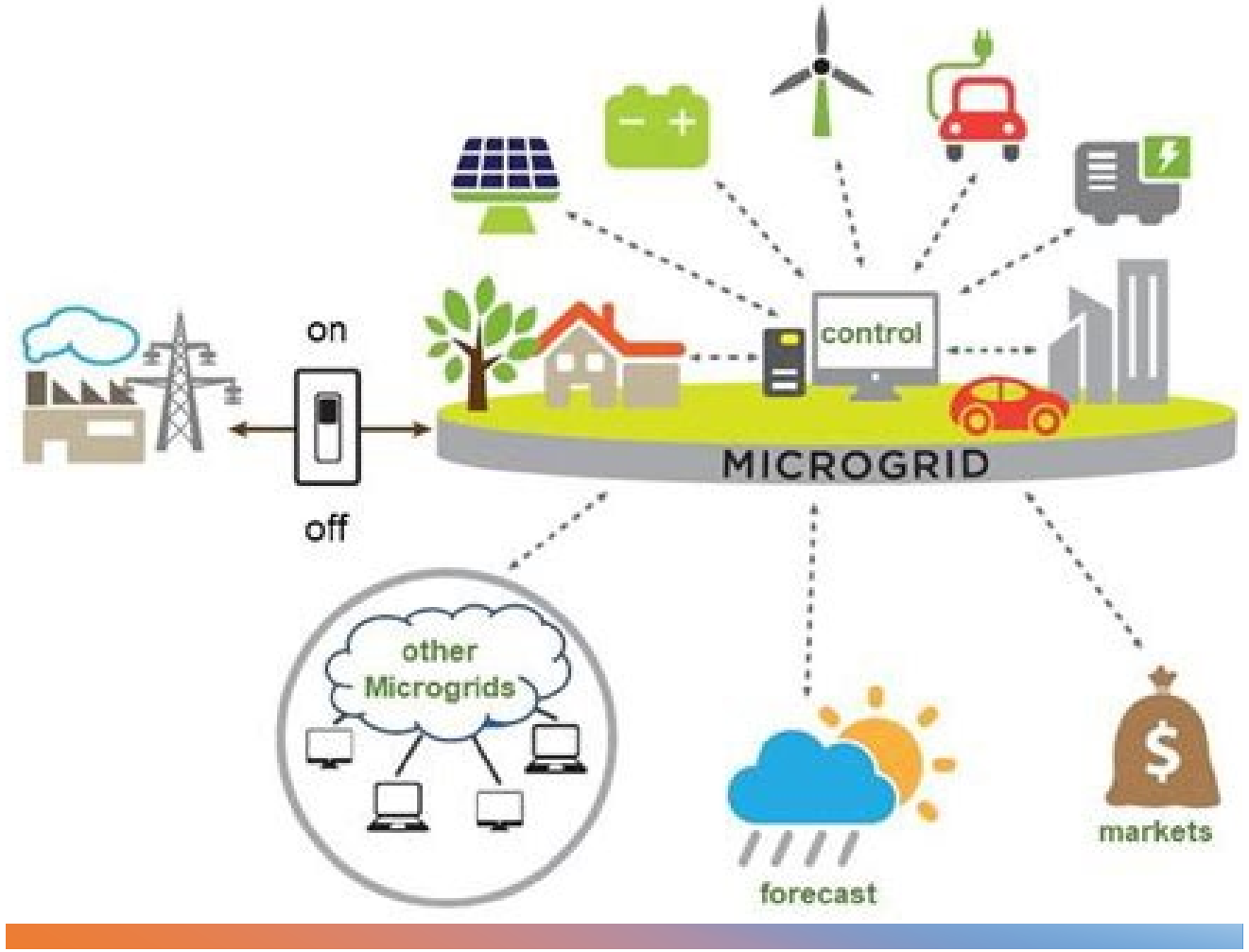
- A microgrid typically consists of distributed generation (fossil-based and/or renewable), energy storage, load control, and distribution system management.

Ref: Surveillance-Defining-Microgrids-November-2019.pdf (cooperative.com)

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

- Communities are increasingly adopting microgrids to harness renewable energy resources to attain energy autonomy and reliance in the face of climate change.



Cost breakdown Community Microgrid vs One-house solar array solution in NZ

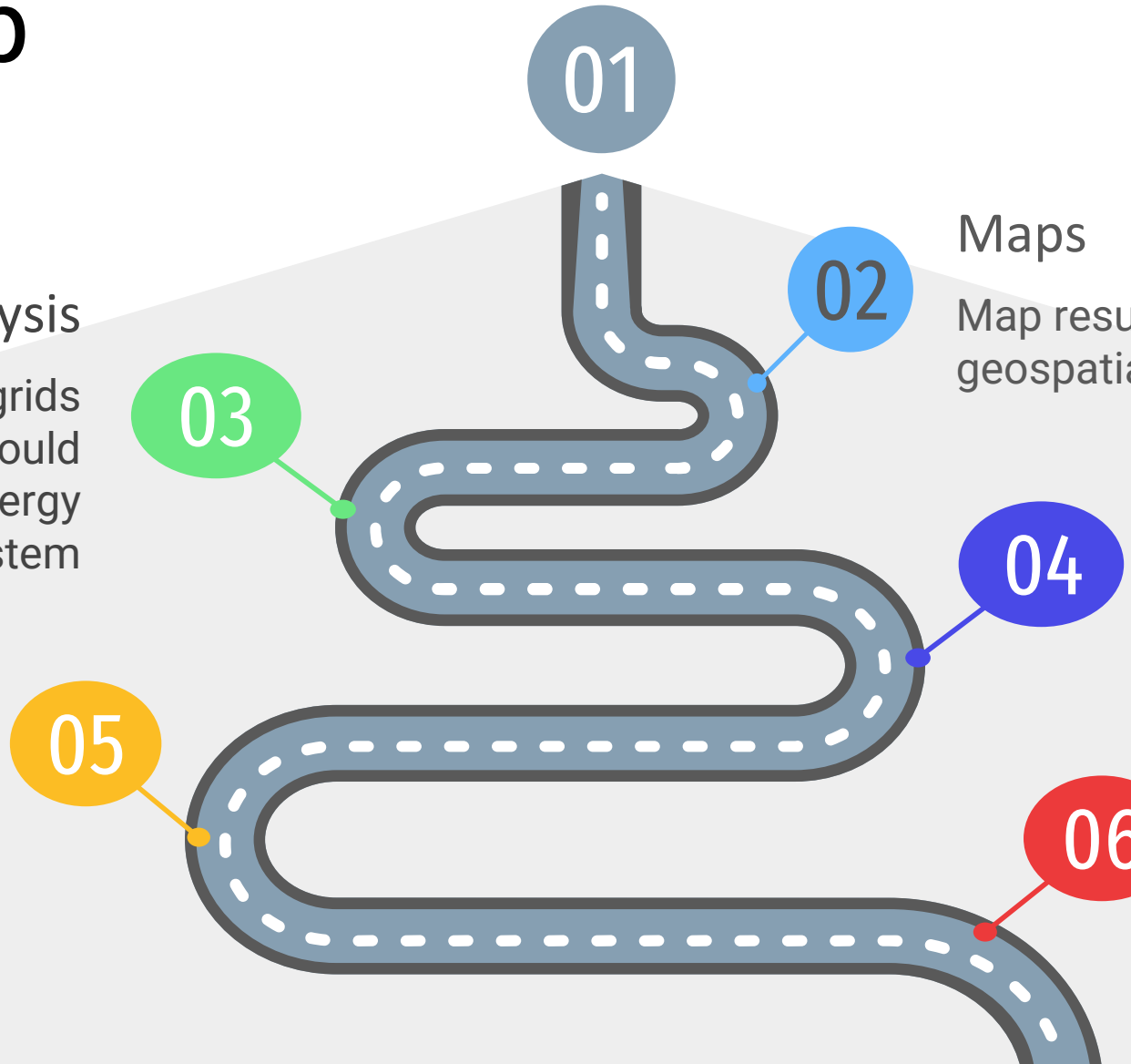
Configuration	Shared Microgrid	Infrastructure Costs 5x Townhouses	Infrastructure Cost 1x Townshouse	Efficiency	Reason
System Type	60-panel shared solar system	$32,480.00	$6,496.00	11%	Economies of Scale, Design Efficiency
Panel Specification	Q CELLS Q Peak DUO 390W All Black				
Installation and wiring	Install + Wiring	$15,750.00	$3,150.00	5%	Economies of Scale, Design Efficiency
Inverter	Centralized high-capacity inverter	$7,650.00	$1,530.00	8%	Shared Infrastructure
Smart Meter	Centralized smart metering system	$3,200.00	$640.00	11%	Shared Infrastructure
Racking & Mounting Hardware	Premium Black Racking & Mounting	$2,750.00	$550.00	33%	Economies of Scale, Design Efficiency
Battery Storage	Shared commercial-scale battery storage	$36,000.00	$7,200.00	25%	Shared Infrastructure, Design Efficiency
TOTAL		**$97,830.00**	**$19,566.00**	**17%**	

Methodology – Mathematical modeling

- We are using the mathematical models, JaDE and vSPD, to predict how the New Zealand Energy System will react to regions like Tairawhiti becoming energy independent.
- These models encompass the New Zealand energy system, enabling decision-making for hydropower generation and dispatch to ancillary power generation from other energy resources like geothermal, gas, and coal.
- JADE is a Stochastic Dual Dynamic Programming model that solves the hydro scheduling problem for Aotearoa | New Zealand.
- vSPD is a emulates the New Zealand Electricity Market to estimate the price and quantity of electricity sold at each of the 250 nodes.
- These models determine the cost of electricity generation for Aotearoa and can be used to predict the impact of Microgrid introduction to the system.
- We are interested in modelling decentralized, renewable power generation in the affordable, resilient manner.

Roadmap

JADE Simulation Results



Maps

Map results in the geospatial domain

Sensitivity Analysis

What degree of microgrids adoption in Tairawhiti would affect the national energy system

TCO Microgrid Costs

Incorporate the capital investment and O&M costs

Incorporate Capacity and Resilience demands

Estimate the cost of building resilience and capacity into the distribution system.

Decentralized Energy System

Build a robust energy system model for Aotearoa | New Zealand to recommend a DES

Thank you

New Questions

- How to estimate the cost of incorporating resilience for the traditional grid?
- How to incorporate the cost of infrastructure disruption due to “100-year events”?
- What does a decentralized resilient infrastructure look like?