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AUCKLAND
Waipapa Taumata Rau
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ENGINEERING

Energy and Business Digital Twins

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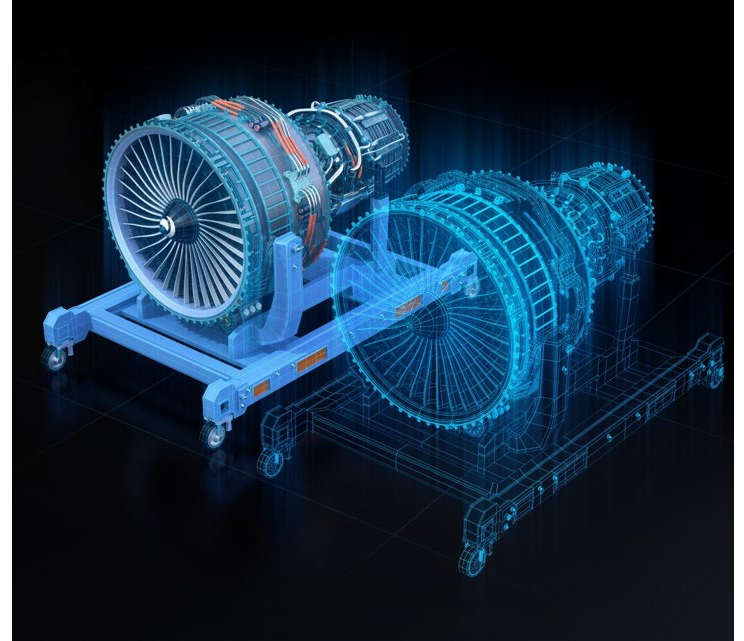
Agenda

- What are Digital Twins?
- Energy Digital Twins
 - Ahuora Research
- Business Digital Twins
 - Integration Gap



Digitalisation word cloud, Chris Hamblin, Keynote, *Advances* 2021

Digital Twins

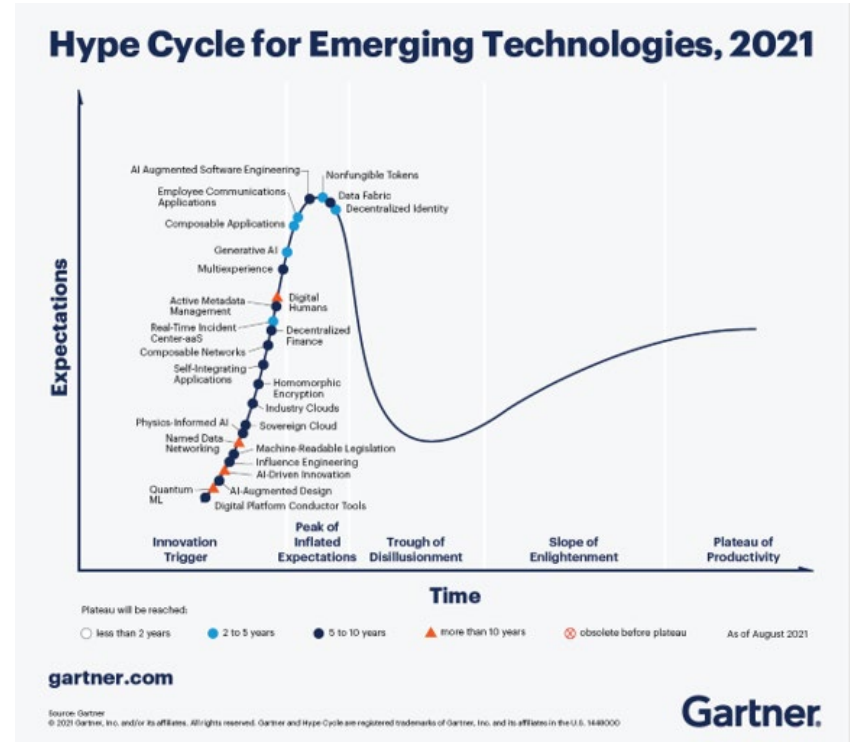


Digital Twins

Hype?

Focus on problem solving

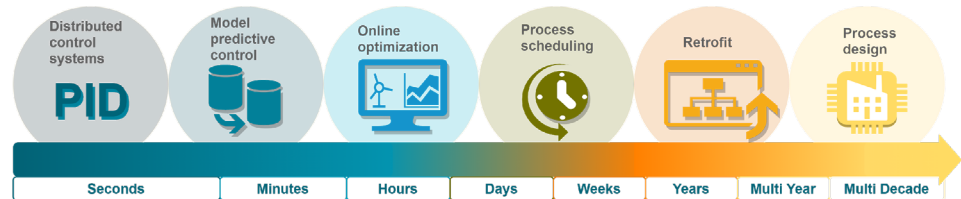
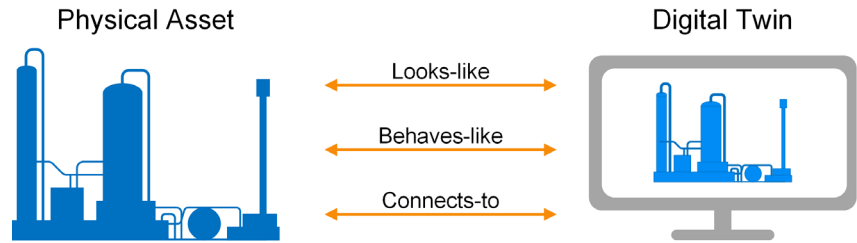
Not just new shiny tech!



What is a Digital Twin?

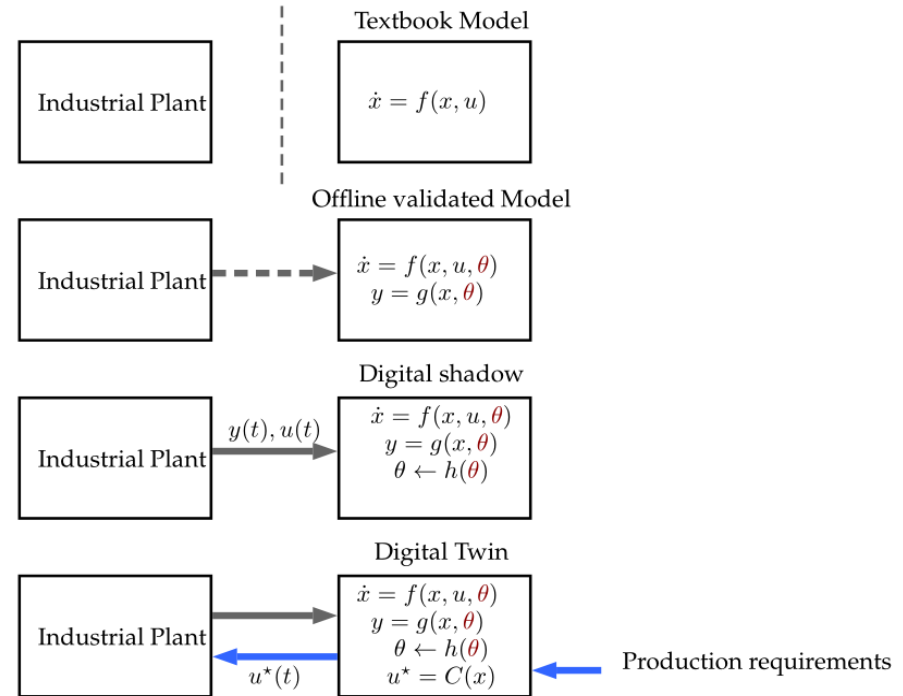
A digital representation that **looks-like, behaviours-like,** and **connects-to** a physical system

With the **goal to optimise** decision-making across all time horizons



Digital Twin Classification

- Digital Model
 - Non-automatic data flow
- Digital Shadow
 - One-way automatic data flow
- Digital Twin / Digital Manager
 - Two-way automatic data flow



Digital Twin Classification

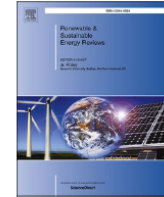
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Energy digital twin technology for industrial energy management: Classification, challenges and future



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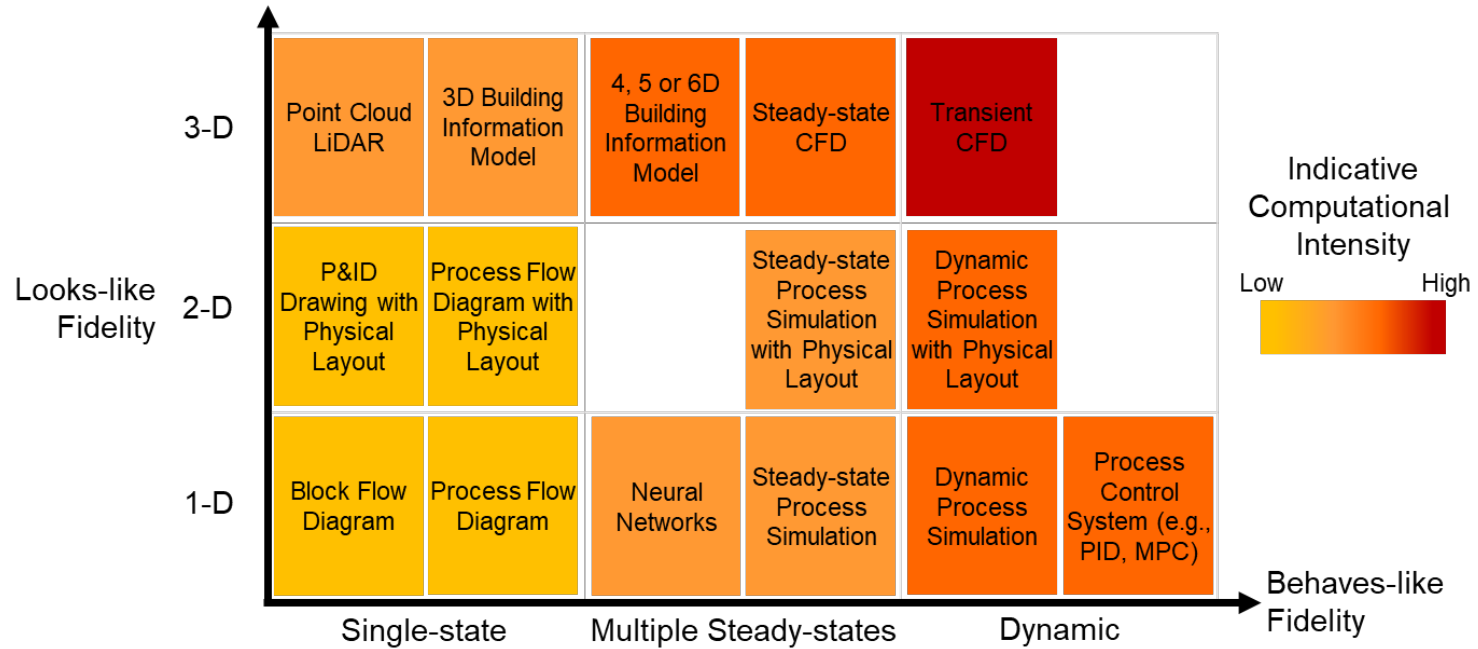
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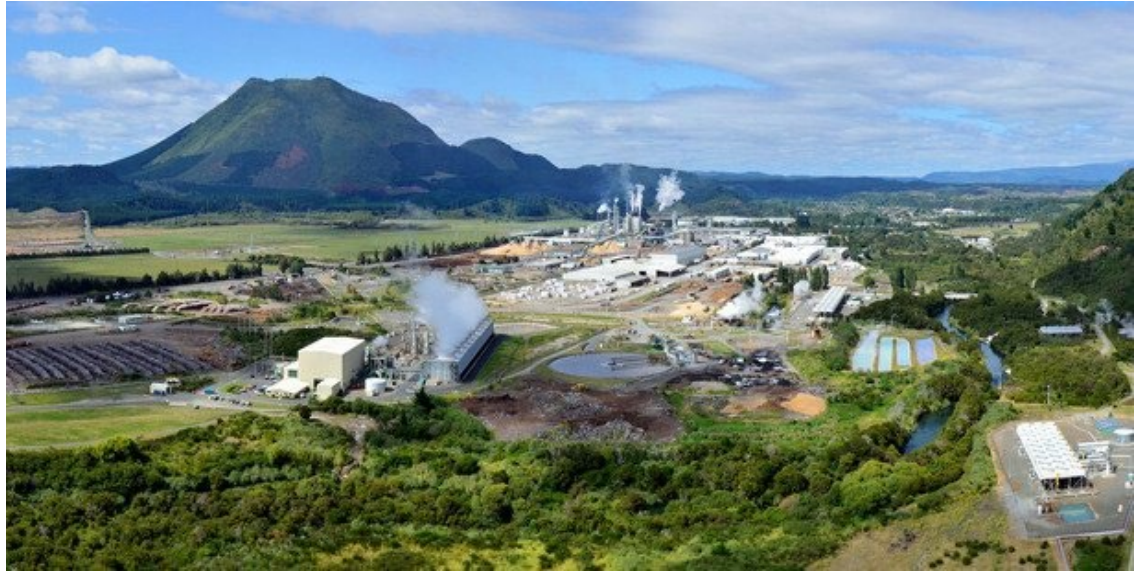


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Digital Twin Classification



Energy DTs



Energy Digital Twins



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Advanced Energy Technology Platform

Govt funded, industry support
\$12.5 Million / 7 years
12 initial industry partners
rep >50% of NZ process industry
Started October 2020

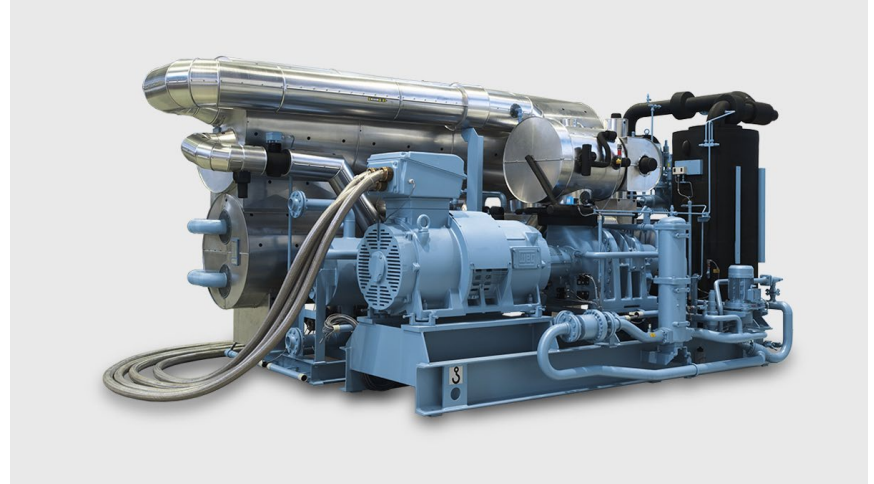
11 Academics
3 Post Docs
12 PG students
15 UG students

Ahuora Research

- **Energy Digital Twins for Process Heat Decarbonisation**
- Re-engineer the way we **use**, **convert**, and **provision** energy for process heat using a smart systems approach
 - Plant efficiency
 - Boilers & Heat pumps
 - Renewable energy
- Produce open-access software tools for NZ industry
- Develop the next generation of **Digital Twin** technology called a **Adaptive Digital Twin**
 - Smart design and operation

How will Digital Twins help?

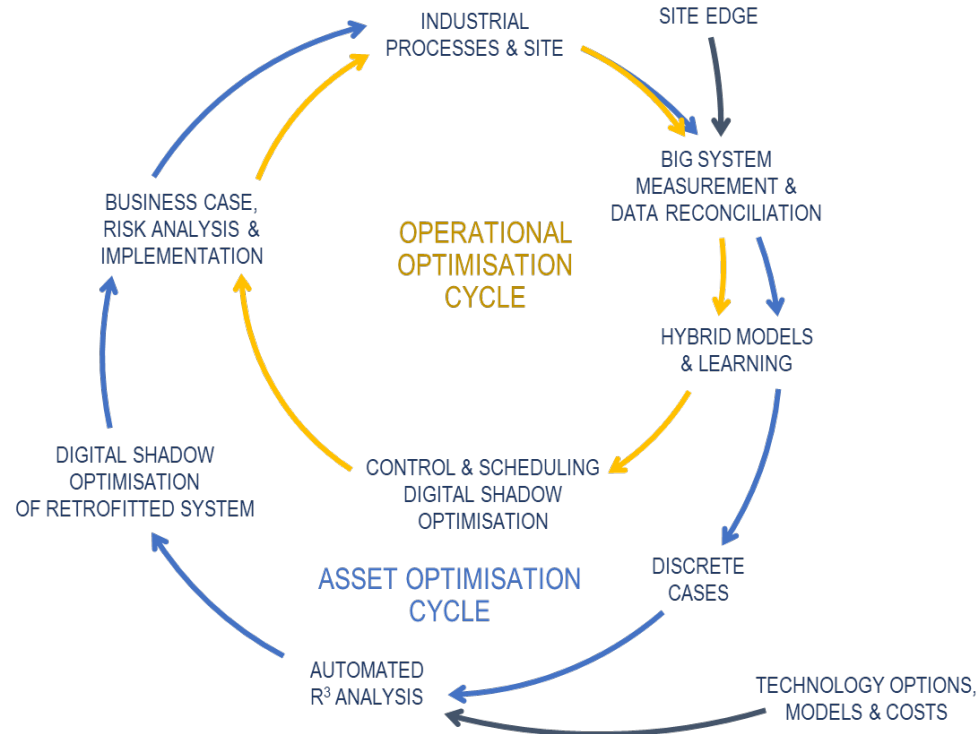
- Real time optimisation & control
- Evolve Energy Assets for efficiency
 - Retrofit, Replace, Retire (R3)
- Integration and optimisation of energy
- Energy storage
- Energy procurement
- Emissions management



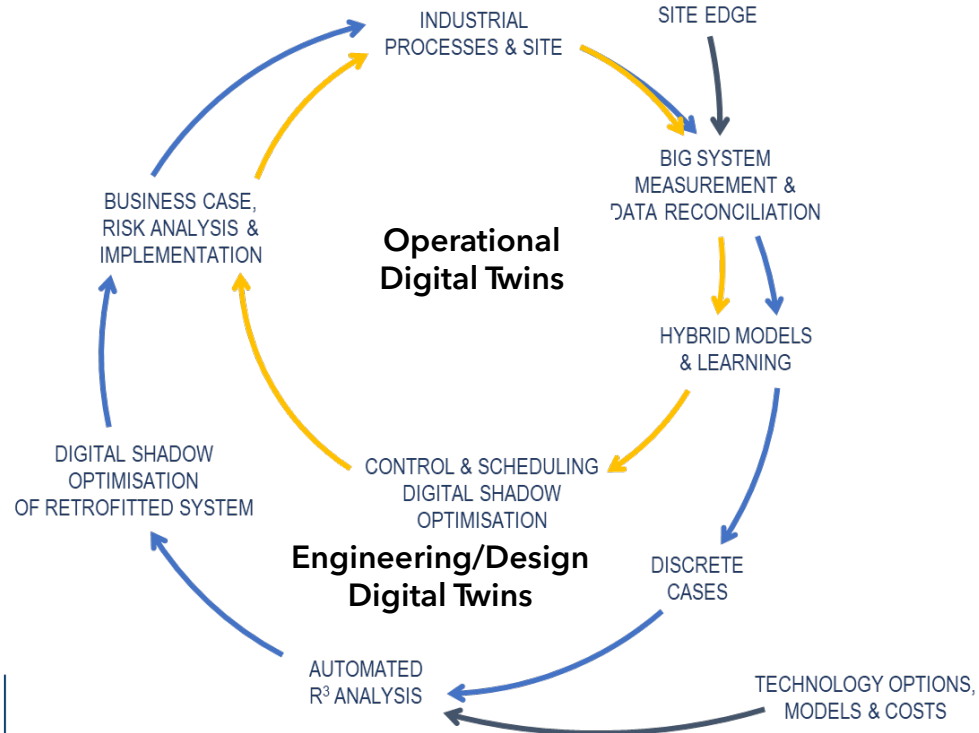
Example

Industrial Heat Pumps
Design, Integration & Operation

DTs & Improvement Cycles



DTs & Improvement Cycles

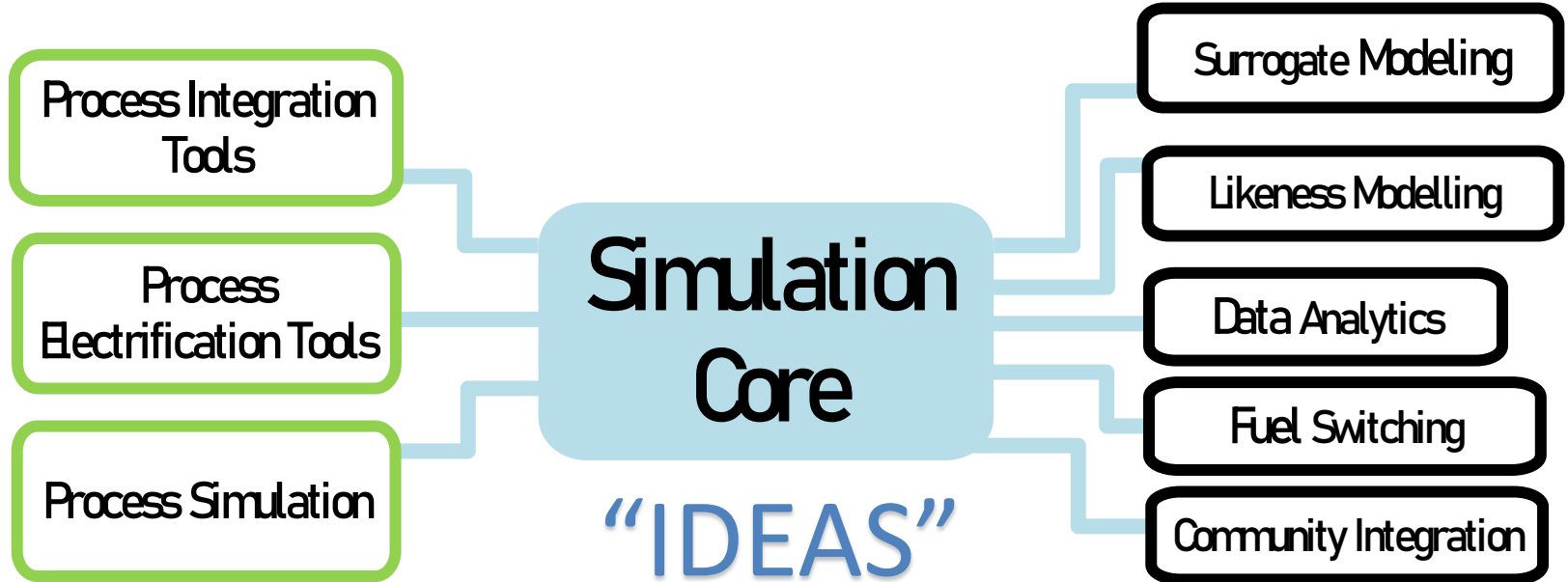


Tool Development

- Tool development necessary
- Existing ones are rebranding
 - e.g. process simulation
- New methods to exploit industry 4.0, IoT, big data, machine learning
- Integration between DTs
 - e.g., energy DT & business DT

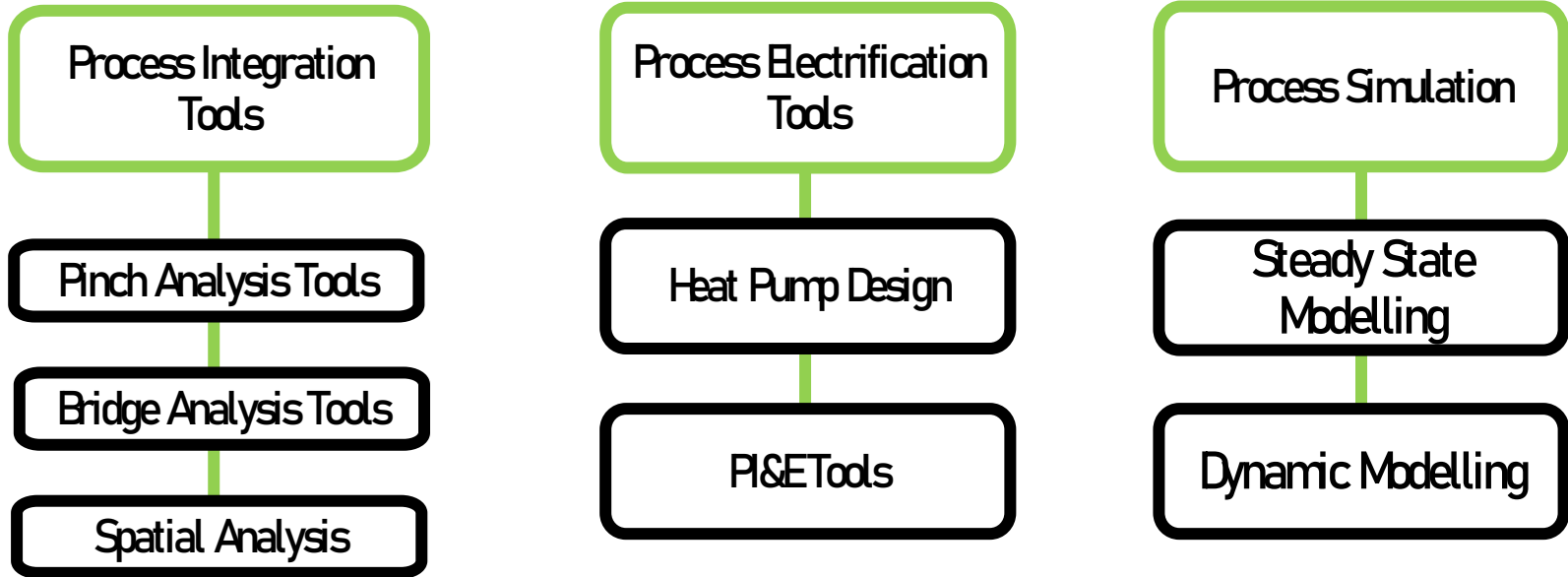


Open Source Platform

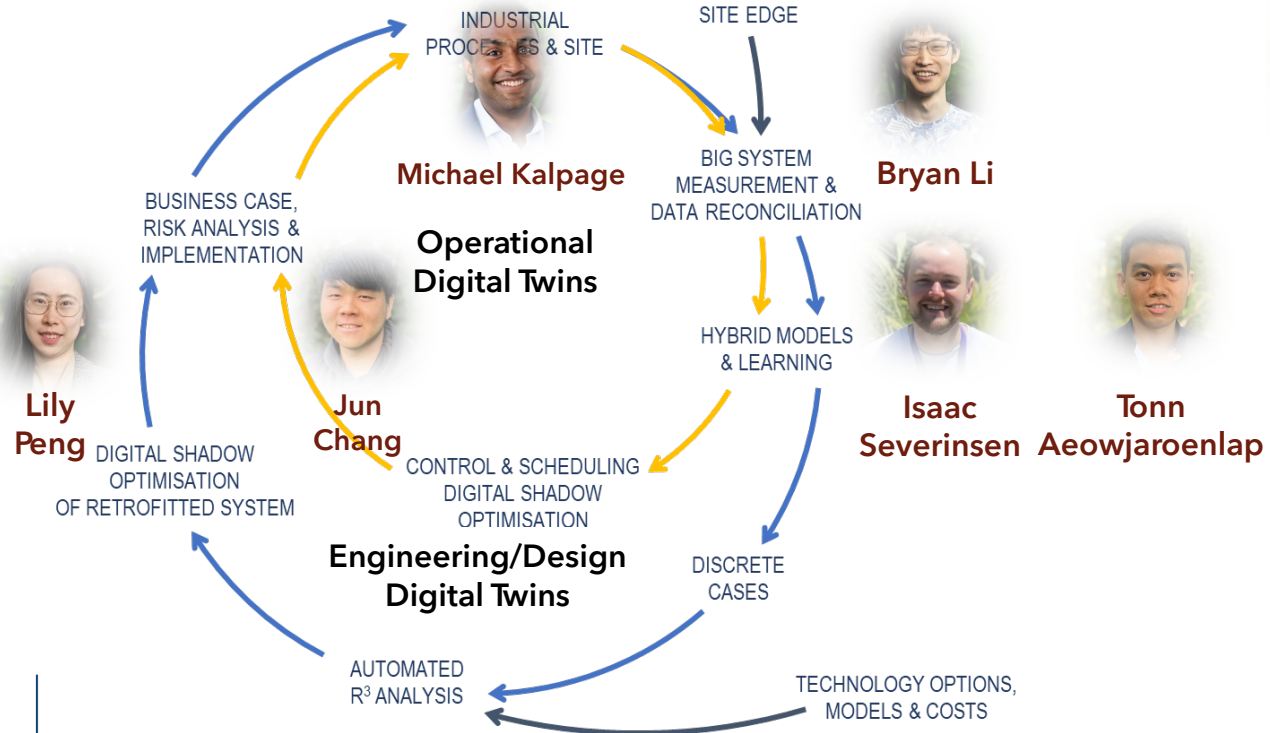


Institute for Design of
Advanced Energy Systems

Open Source Platform



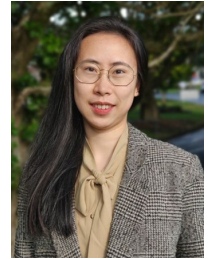
UOA Ahuora Research



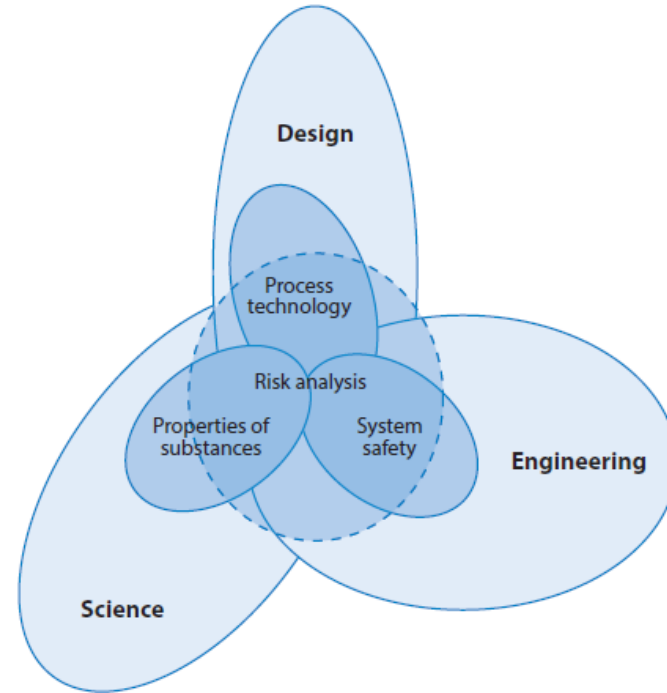
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Process Safety DTs

- **Objectives**
 - Energy Efficient
 - Safer
- **Approach**
 - Risk analysis
- **Problem Space**
 - Multi-criteria optimisation

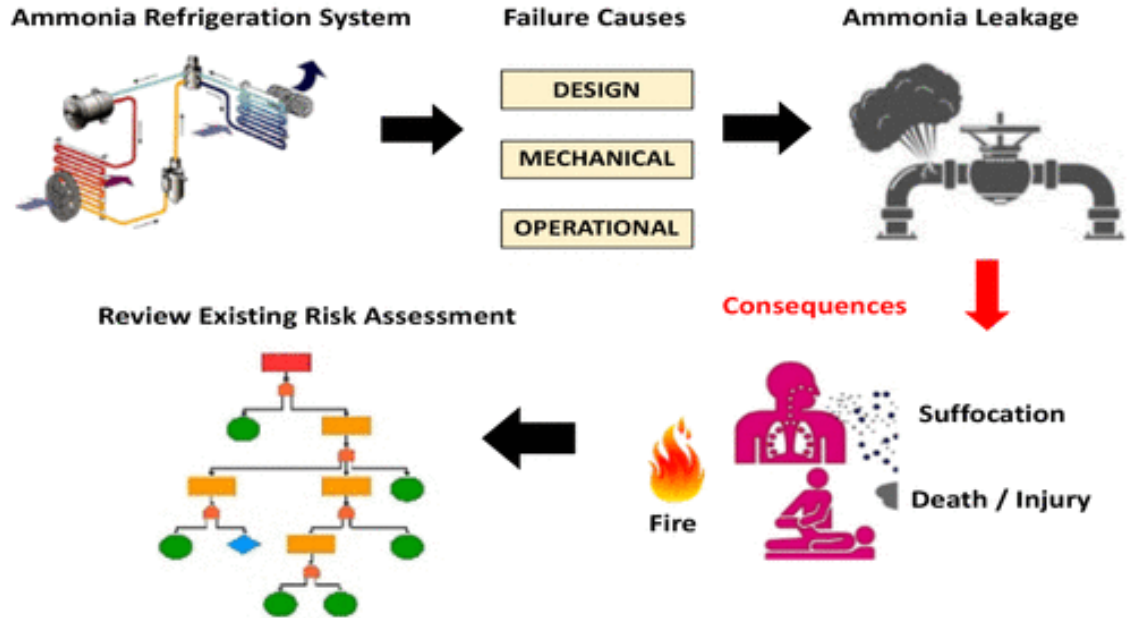


Lily Peng



Process Safety DTs

- Energy efficiency
- Inherent Assessment
- Safety indicators
- Risk Quantification



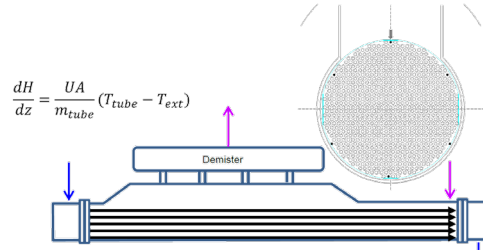
Digital Modelling



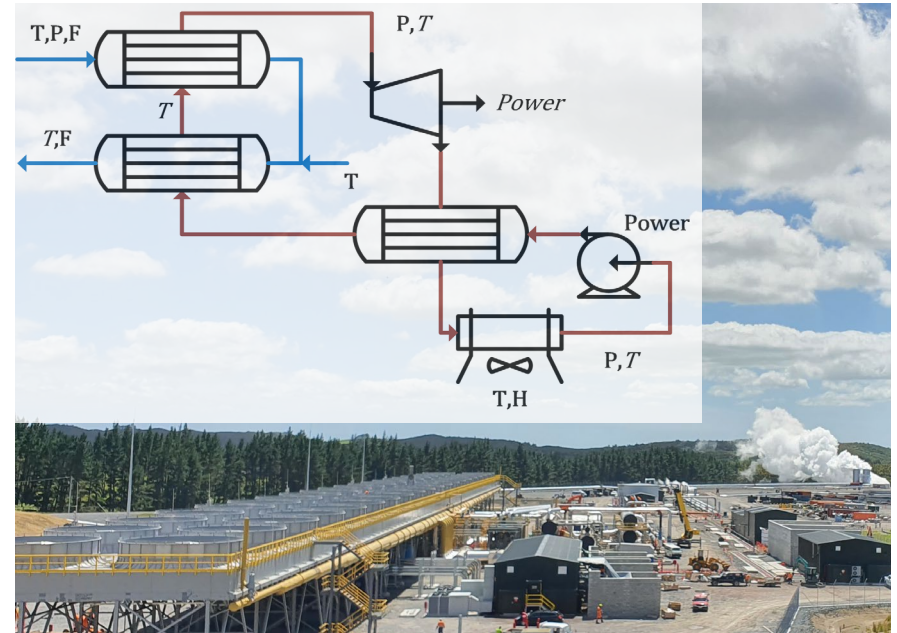
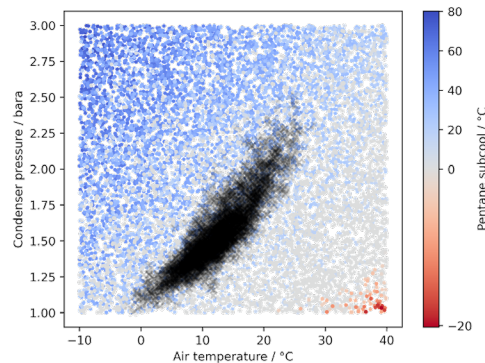
Isaac Severinsen

- **Efficient, dynamic, digital twin models** of unit operations using modern regression

- First Principles:

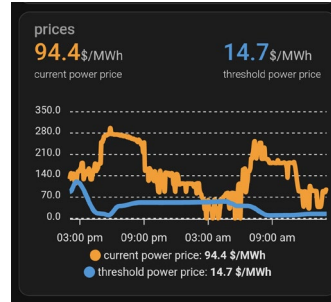


- Data Driven:



Digital Modelling

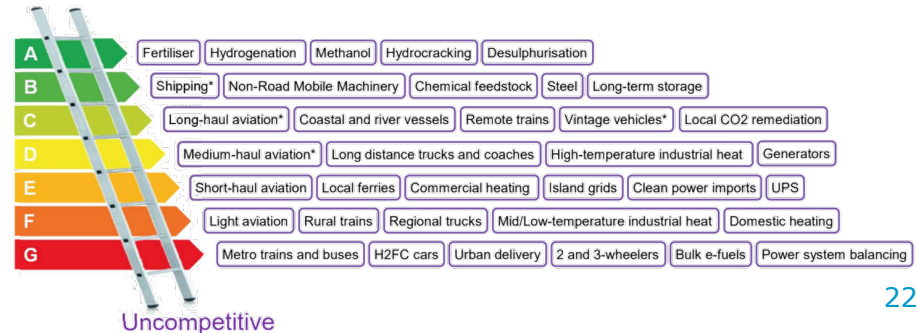
- **Demand Response**
 - Residential Hot water
- Price Response Hydrogen Production



Clean Hydrogen Ladder

Liebreich
Associates

Unavoidable



Time Series Forecasting



Tonn
Aeowjaroenlap

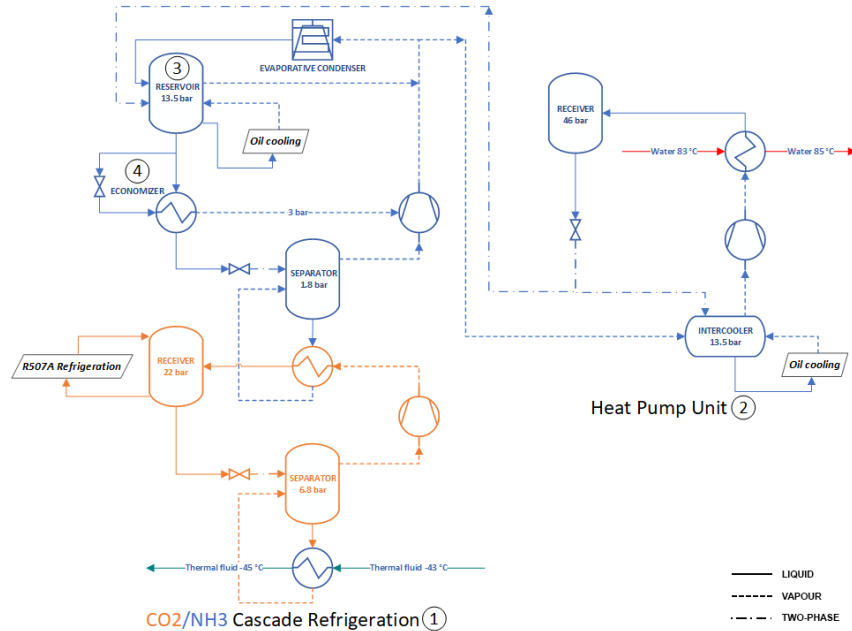
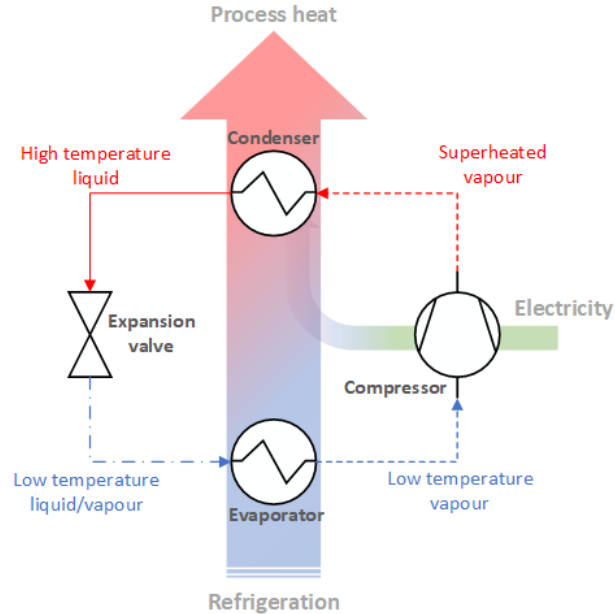
Machine Learning for Time Series Forecasting

- Machine Learning Approach: Trends, Patterns, Fluctuation, Outliers
- Time Series Modelling: e.g., Naïve, ARIMA, ANN
- Applications: Process and Energy Optimization in the Dairy Industry

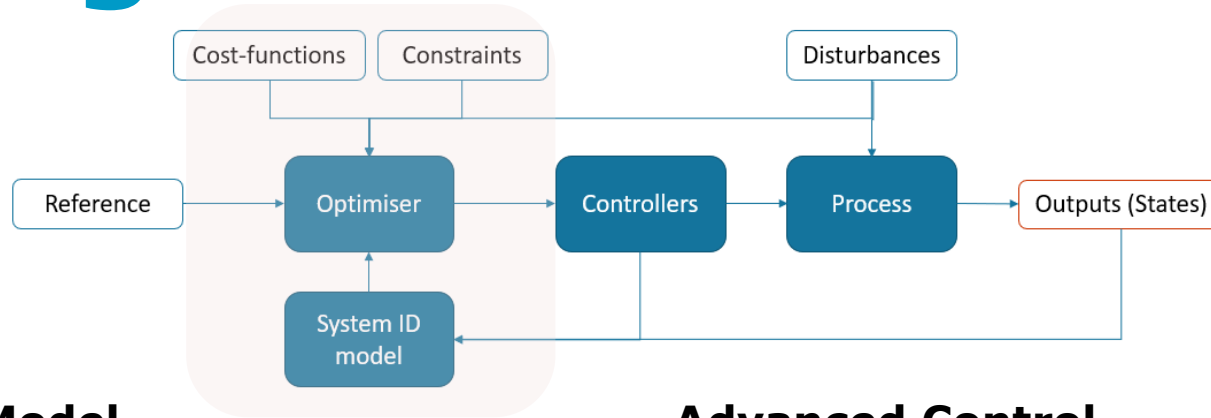
Refrigeration Control



Jun Chang



Refrigeration Control



Dynamic Model

- Identifying operational issues and potential improvements
- Developing advanced control methods

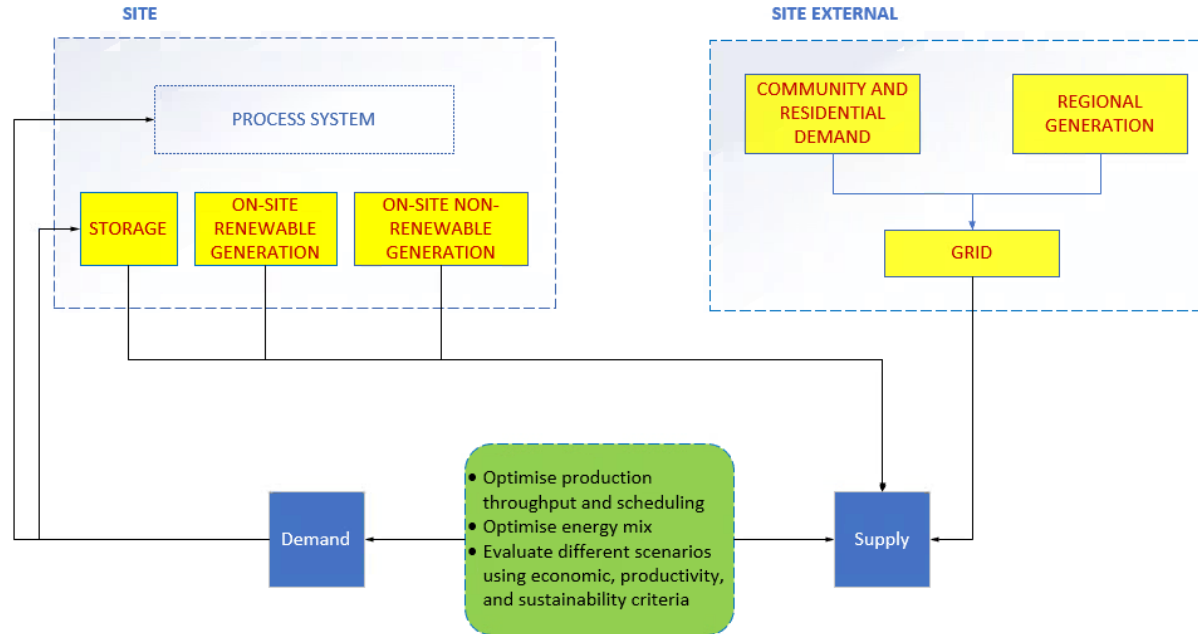
Advanced Control

- Stable operation closer to design
- Economic benefit

Energy flexible planning

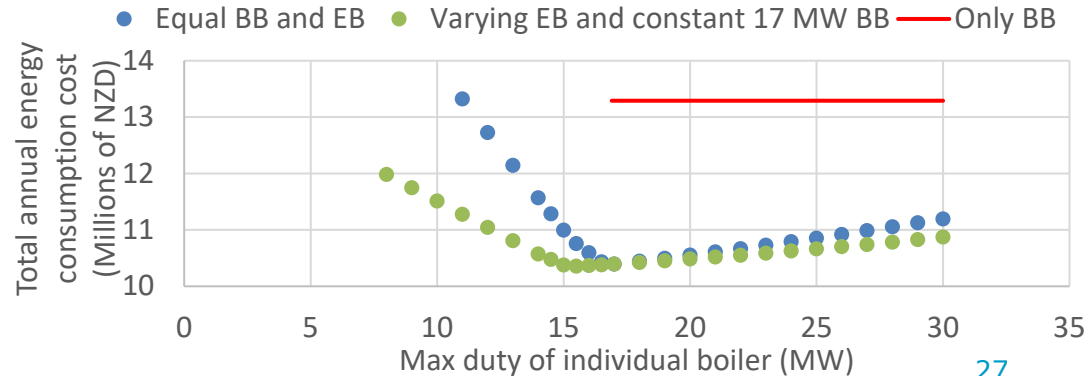
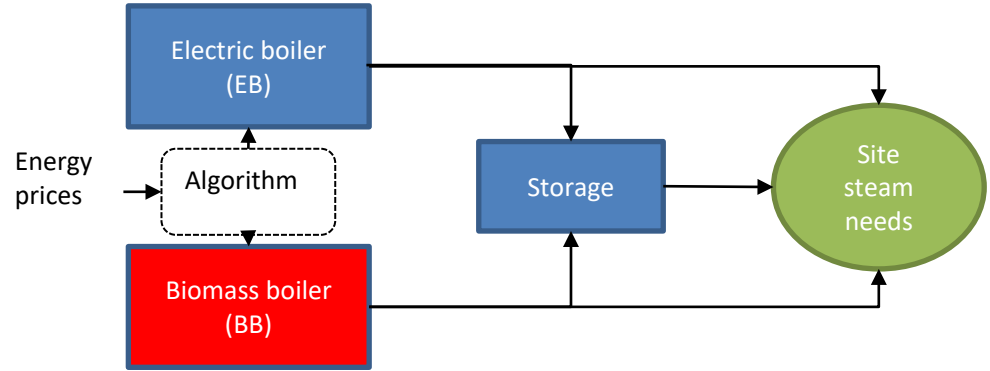


Michael Kalpage

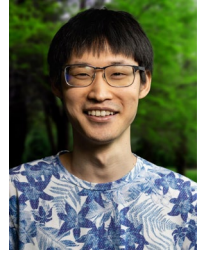


Energy flexible planning

- **Simulation**
 - 30-minute time intervals
- **Current/Future work:**
 - Storage implementation
 - Scheduling demand
 - Classical optimisation



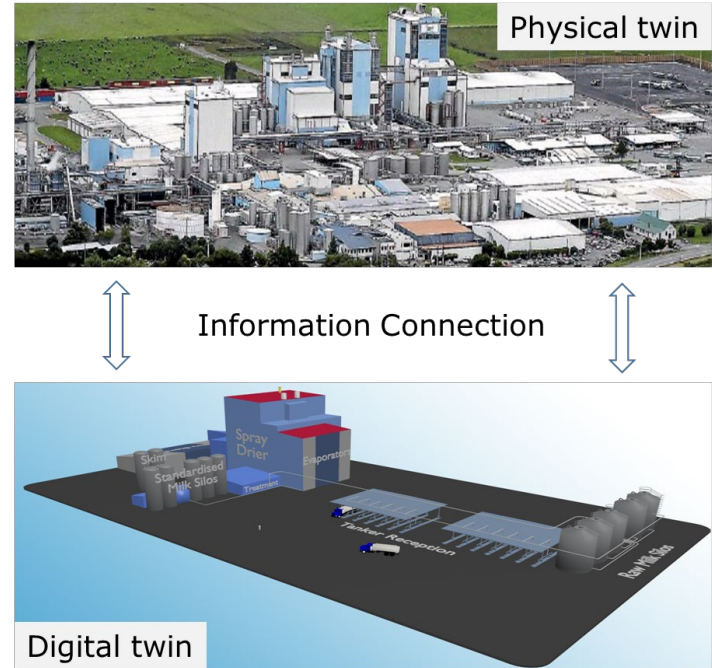
Multi Plant Clusters



Dynamic Large Scale Digital Twin for Optimization of Multi-plant Industrial Clusters **Bryan Li**

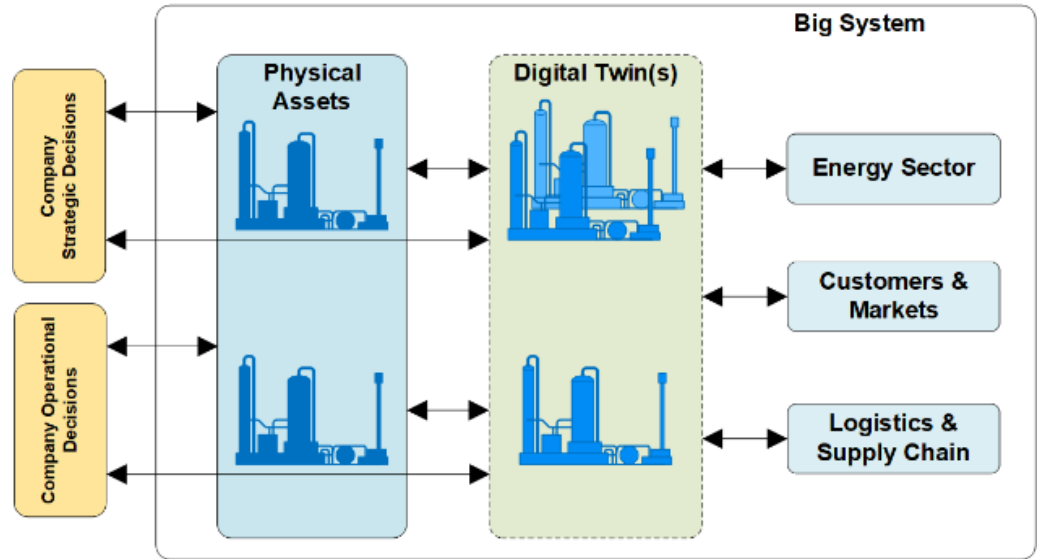
- To develop a novel digital twin to dynamically simulate and optimize the use of energy and product streams for large-scale multi-plant industrial clusters.
- To ultimately identify the types of new businesses which could join the cluster to bring about mutual benefits.

Energy and Business DTs



Energy and Business DTs

- In this talk and in our research we have so far focused on company level DTs
- For decarbonization & demand response, DTs **need** to include: The '**Big System**', i.e., the company, the grid, and the community DTs



New research proposed

Energy Demand Response Dynamic Digital Twins

- A system and a framework of dynamic digital models and twins
- That will integrate energy digital twins and business digital twins
- To provide optimal demand response and flexibilization for industry, business and residential

W. Yu et al.

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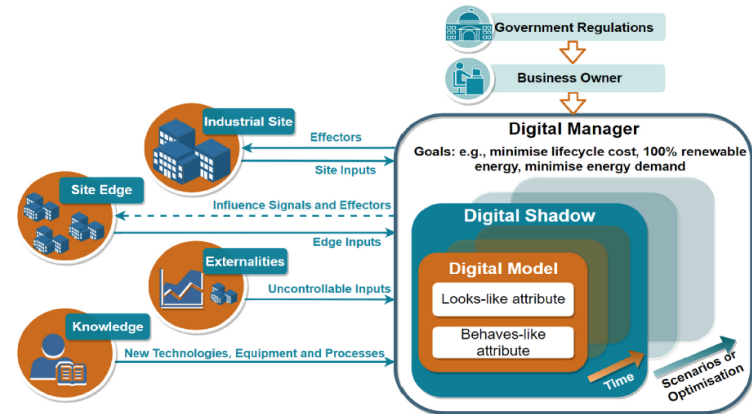


Fig. 8. A framework for the application of Energy Digital Twin technology (including Digital Model, Digital Shadow, and Digital Manager) to the process and energy industries.

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- MBIE for funding of the Ahuora Advanced Energy Transformation Program
- Colleagues and collaborators at University of Auckland, University of Waikato, Massey University and our industrial partners



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