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System analysis and simulation modeling for Australia’s low carbon energy transition

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Outline

- Introduction
- Approach and findings
  - Transition theory analysis of Australia’s electricity system
  - System dynamics analysis
- Strategies to support low carbon transition
- Conclusions
Overview

Difference between historical and contemporary transitions (Papachristos, 2014).
Transition theory


Fig. 2. A dynamic multi-level perspective on system innovations. Adapted from Geels (2004).
Australian electricity production socio-technical system

Quinton & Halog 2014
Barriers to change?

- Infrastructure & institutional structures
- Uncertainty
- Vested Interests
- Consumer attitudes
- Cost
- Storage (?)

Quinton & Halog 2014
System thinking and modeling methodology

Research Scope

1. **Problem structuring**
   - 1. Identify problems or issues of concern
   - 2. Collect preliminary information and data

2. **Causal loop modelling**
   - 1. Identify main variables
   - 2. Prepare behaviour over time graphs
   - 3. Develop causal loop diagram
   - 4. Analyse loop behavior over time and identify loop types
   - 5. Identify system archetypes
   - 6. Identify key leverage points
   - 7. Develop intervention strategies

3. **Dynamic modelling**
   - 1. Develop a systems map or rich picture
   - 2. Define variable types and construct stock-flow diagrams
   - 3. Collect detailed information and data
   - 4. Develop a simulation model
   - 5. Simulate steady state/stability conditions
   - 6. Reproduce reference mode behavior (base case)
   - 7. Validate the model
   - 8. Perform sensitivity analysis
   - 9. Design and analyse policies
   - 10. Develop and test strategies

Research Extension

4. **Scenario planning and modelling**
   - 1. Plan general scope of scenarios and modeling
   - 2. Identify key drivers of change and keynote uncertainties
   - 3. Construct forced learning scenarios
   - 4. Simulate scenarios with the model
   - 5. Evaluate robustness of the policies and strategies

5. **Model-based interactive learning tool**
   - 1. Communicate results and insights of proposed intervention to stakeholders
   - 2. Develop a microworld and learning lab based on the simulation model
   - 3. Use learning lab to examine mental modes and facilitate learning
Causal loop diagram of Australia’s socio-technical electricity system including emerging changes and uncertainties (simplified)

Quinton & Halog 2014
System archetypes - eroding goals

Quinton & Halog 2014
Leverage and Strategies

• Sustainability at an operational level – reassessing priorities
• Addressing procrastination
• Addressing eroding goals
• Promoting a national conversation
• Electricity’s role in the broader low carbon transition?
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References

• ClimateWorks, 2014. *How Australia can thrive in a low carbon world: Pathways to prosperity in 2050*