Societal Acceptance in Wave Energy

A systems perspective

Carrie Anne Barry, Kush Bubbar, Fabiano Pallonetto,
John V. Ringwood

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Introduction

Societal Acceptance (SA)

- Commercialisation depends not only on technology and economics
- **SA** is under-studied in wave energy
- Early neglect of SA risks delays, opposition, and project failure

Approach

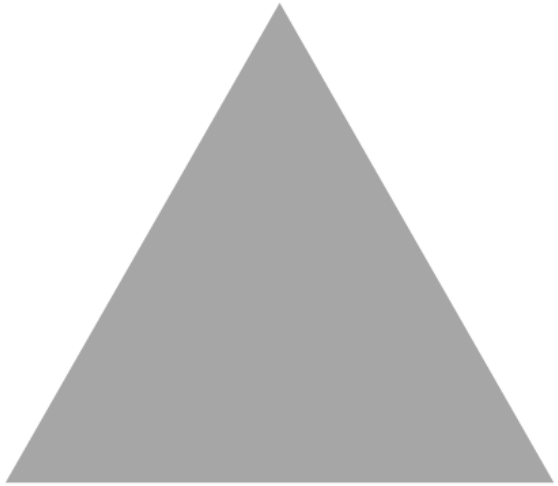
- **Systems thinking** captures complexity and multi-stakeholder dynamics
- Mixed-methods + qualitative modelling
- Learning from **Danish wind energy** as an analogous system

Contribution

Identification of **leverage points and policy-relevant interventions** to support wave energy technology development toward deployment

Background: Societal Acceptance

Socio-political acceptance
- Of technology and policies
- By the public
- By key stakeholders
- By policy makers



Community acceptance
- Procedural justice
- Distributional justice
- Trust

Market acceptance
- Consumers
- Investors
- Intra-firm

Fig 1: Triangle of social acceptance, adapted from Wustenhagen, 2007

Background: Systems Thinking

SA of wave energy is a ‘wicked problem’

- Multiple stakeholders
- Interdependent technical, social, economic, and environmental factors
- No single optimal solution

Why systems thinking?

- Reveals **feedback loops and interdependencies**
- Identifies **leverage points** where small interventions can create system-level change
- Helps avoid short-term ‘fixes that fail’ to address root causes

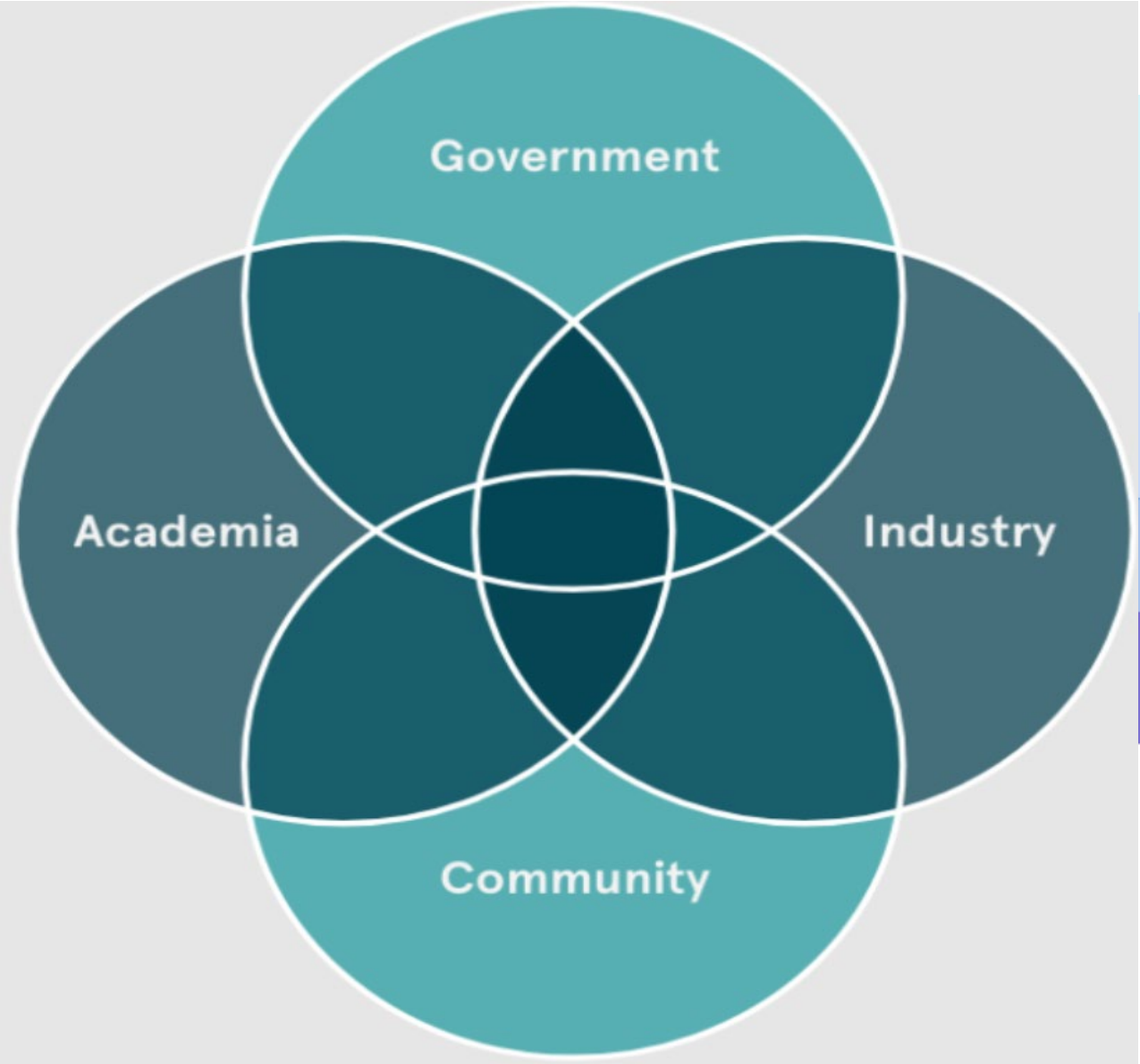
Background and context

Conceptual tools used

- **Quadruple Helix Framework**
- **Iceberg Model**
- **Causal Loop Diagram (CLD)**

Why this matters for wave energy

- Acceptance shaped by deep-seated values
- Visual system models support **shared understanding, policy design, and stakeholder dialogue**



- *Fig 2: Quadruple Helix Framework*
- *Fig 3: Iceberg model, adapted from Senge 1990*
- *Fig 4: Causal Loop Diagram, Sterman, 2012*

Methodology

Purpose

- To develop a **systems thinking framework** to understand factors influencing the SA of wave energy.
- Visualise interconnections and feedbacks using a **CLD** to identify leverage points for policy and practice.

Research Design

- **Mixed-methods approach** grounded in systems thinking
- **Quantitative surveys** to identify key variables shaping SA
- **Qualitative interviews & focus groups** to uncover mental models, causal links, and validate system structure
- Stakeholder perspectives using a **Quadruple Helix framework**

Methodology

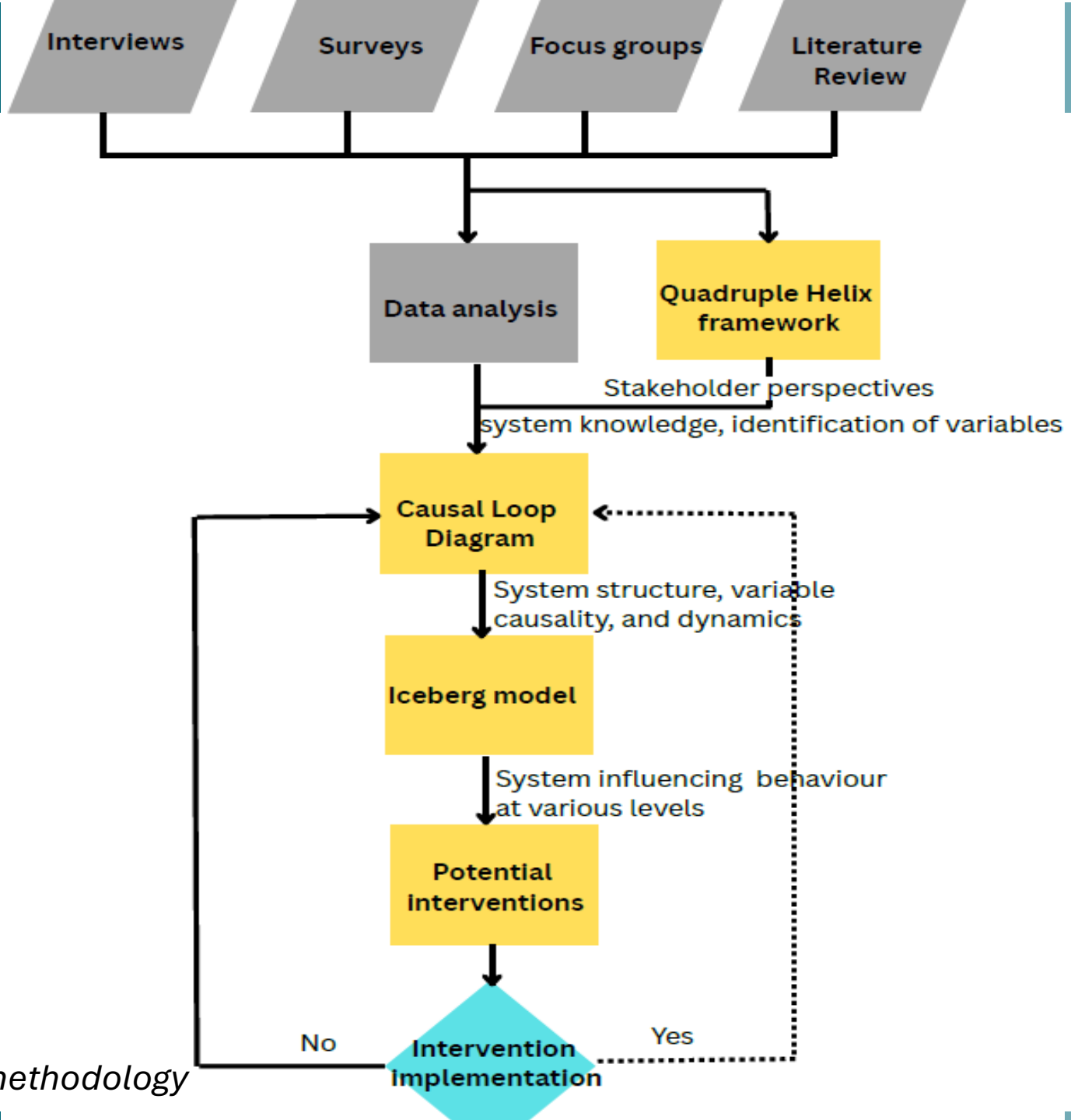


Fig 5: SA for wave energy methodology

Retrospective CLD — Danish Wind Energy

Purpose

- Use Danish wind energy as a **benchmark system** to understand how societal acceptance (SA) emerges
- Inform analogous leverage points for **wave energy in Ireland**

Why Denmark?

- Successful transition from **emerging → commercially viable RET**
- Strong integration

What the CLD Represents

- System of **interconnected variables** influencing SA of wind energy
- 70 feedback loops identified across:
  - Policy & governance
  - Economic conditions
  - Technology & R&D
  - Social & cultural dynamics
  - Environmental context

CLD SA Danish wind

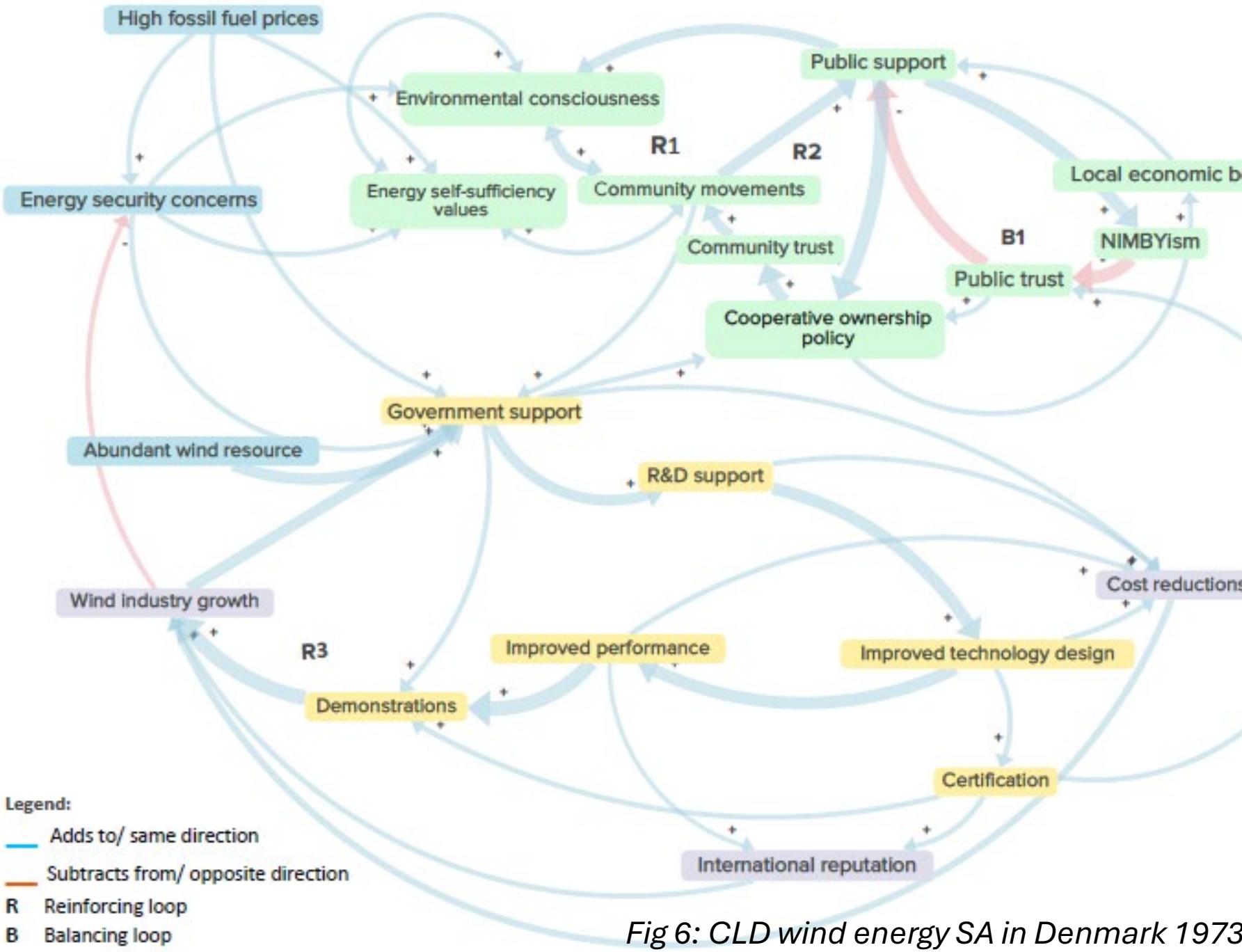
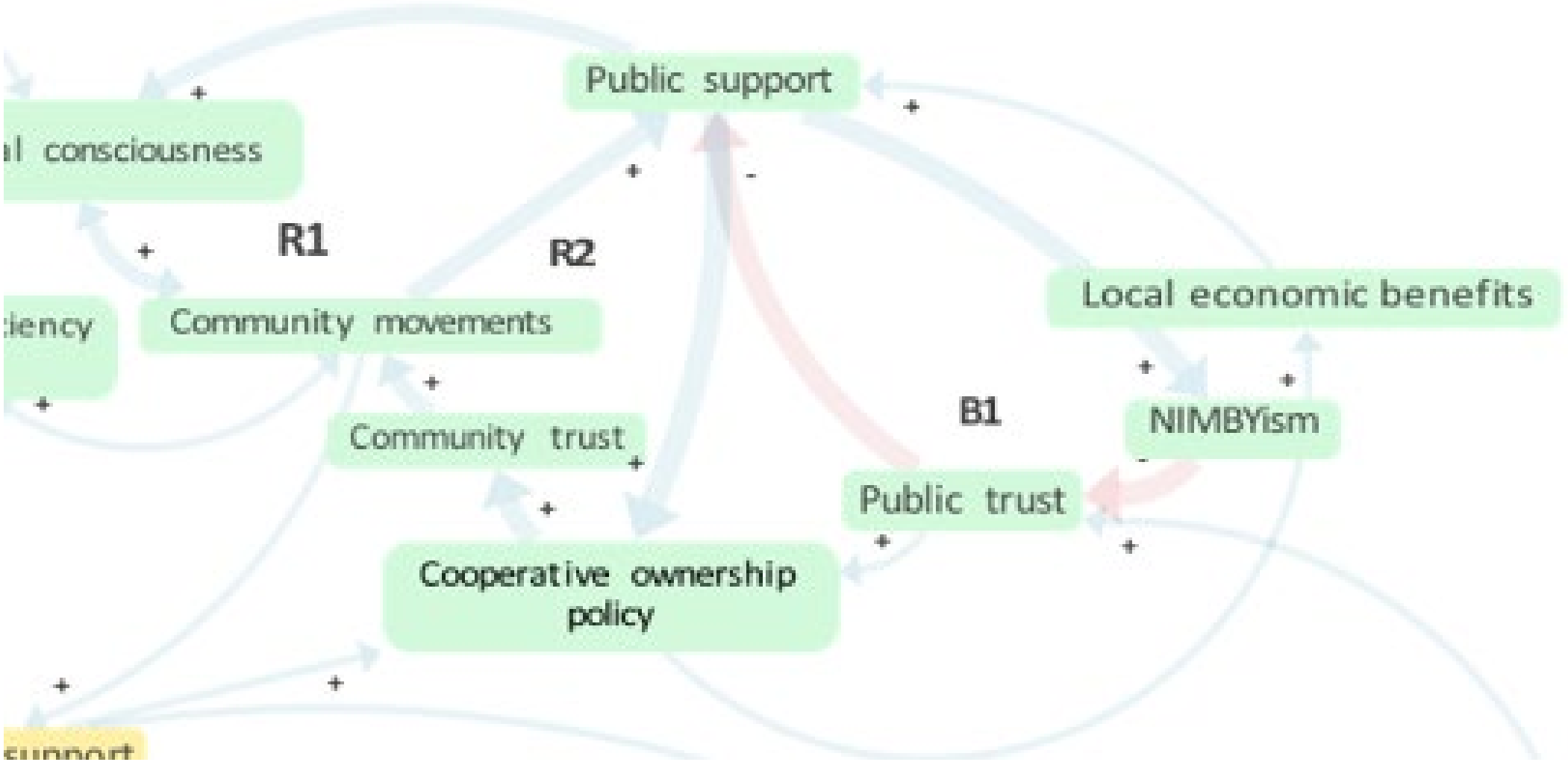


Fig 6: CLD wind energy SA in Denmark 1973

CLD SA Danish wind



Key feedback loops – Danish wind

R1 – Community Activism (Reinforcing)

- Community movements → public support → environmental awareness → community movements
- Demonstrates the role of grassroots engagement and advocacy

R2 – Cooperative Ownership (Reinforcing)

- Cooperative ownership → community trust → public support → cooperative ownership
- Ownership structures mitigated opposition and strengthened legitimacy

B1 – NIMBYism (Balancing)

- NIMBYism → ↓ trust → ↓ support → ↑ NIMBYism
- Balanced—and ultimately weakened—through trust-building and incentives

R3 – Industry Growth (Reinforcing)

- Government support → R&D → improved technology → demonstrations → industry growth → govt support
- Shows how long-term policy commitment enabled market formation

CLD – a Qualitative Modelling Tool for Wave Energy SA

Purpose of the CLD

- Represent the **societal acceptance (SA) of wave energy device deployment in Ireland** as a dynamic, interconnected system
- Integrates **social, policy, industry, academic, and external drivers**

Built from:

- Surveys
- Multidisciplinary literature & government reports
- Validation with **industry, academia, and government stakeholders**
- Insights from the **Danish wind benchmark**

CLD – a Qualitative Modelling Tool for Wave Energy SA

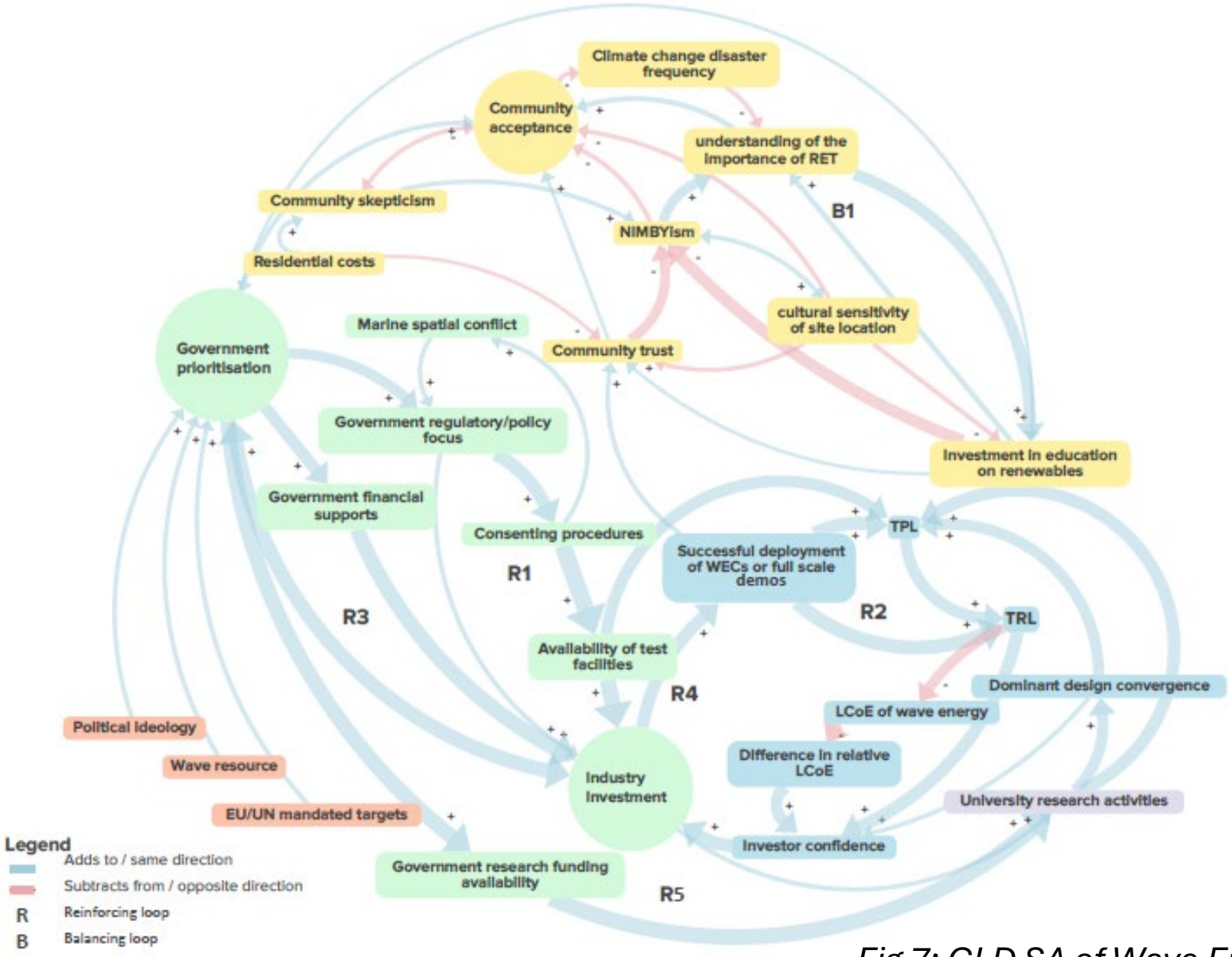


Fig 7: CLD SA of Wave Energy

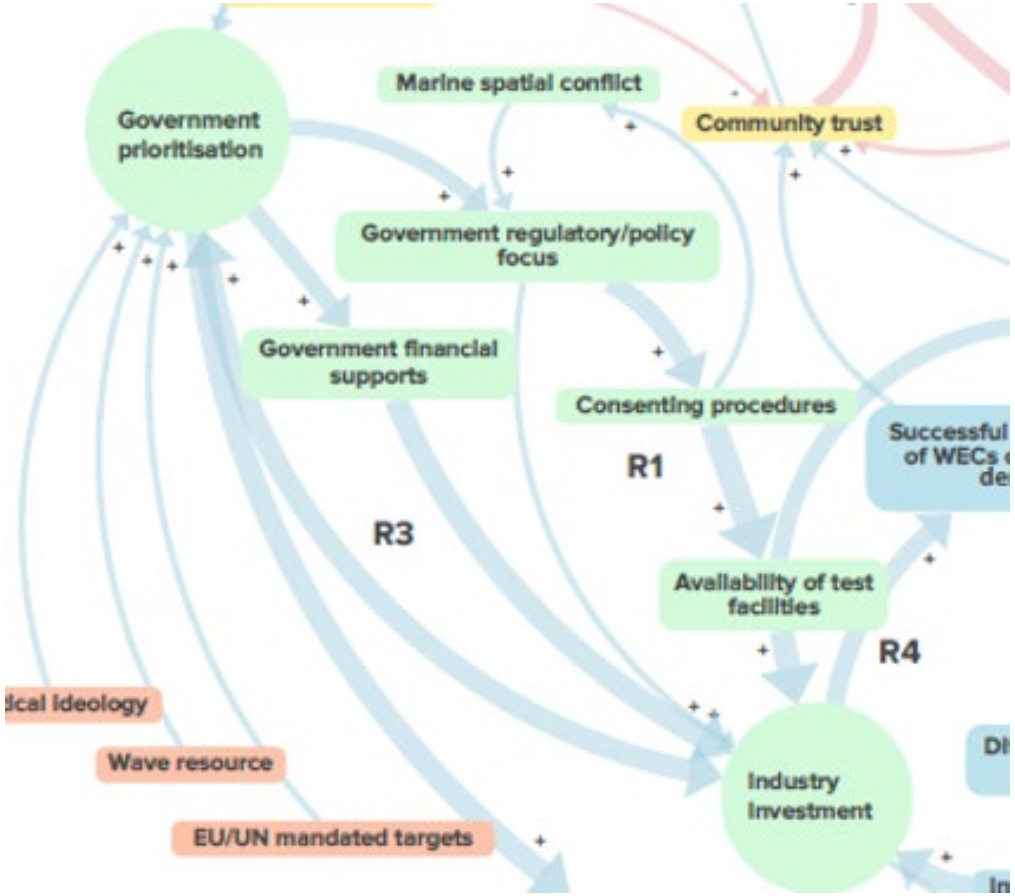
Key Feedback Loops in the Wave Energy SA Sstem

Government Support → Demonstration → Acceptance (Reinforcing)

- Government prioritisation & funding → test facilities → full-scale demos
- Demonstrated performance → improved understanding → increased acceptance

Leverage Point

Improve consenting procedures to accelerate test facility use and reinforce government attention



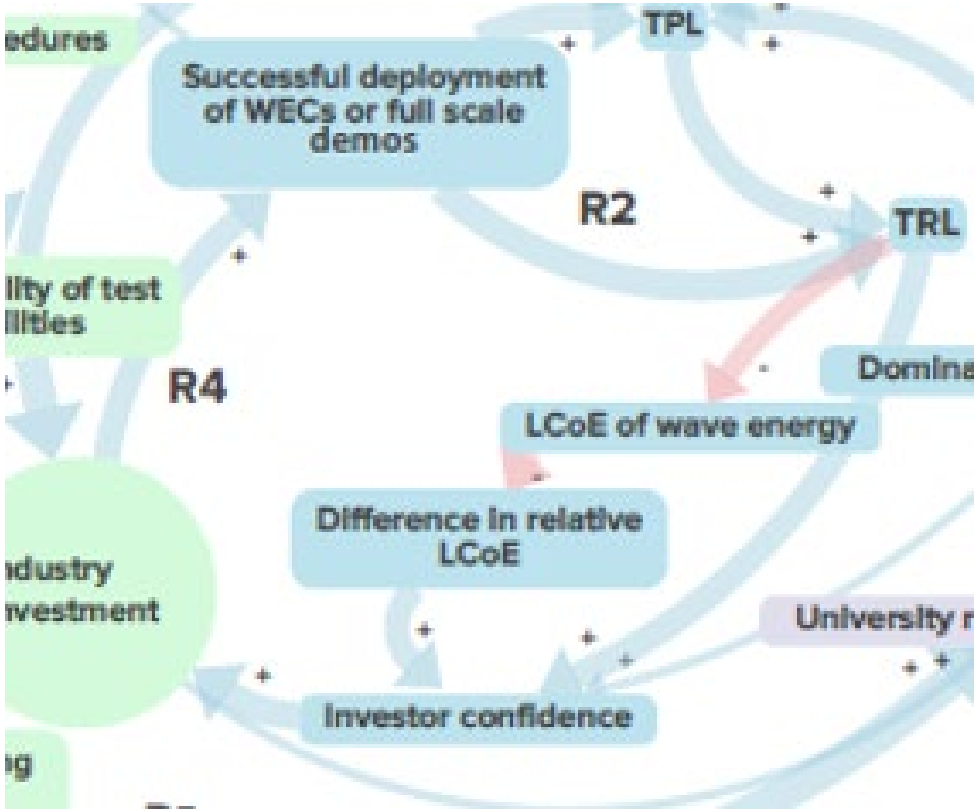
Key Feedback Loops in the Wave Energy SA

R2 – Technology Maturity → Investment → Cost Reduction (Reinforcing)

- Higher TRL & dominant design convergence → investor confidence
- Increased investment → lower LCoE → improved competitiveness

Leverage point

Accelerate learning & knowledge transfer between prototypes to build investor confidence



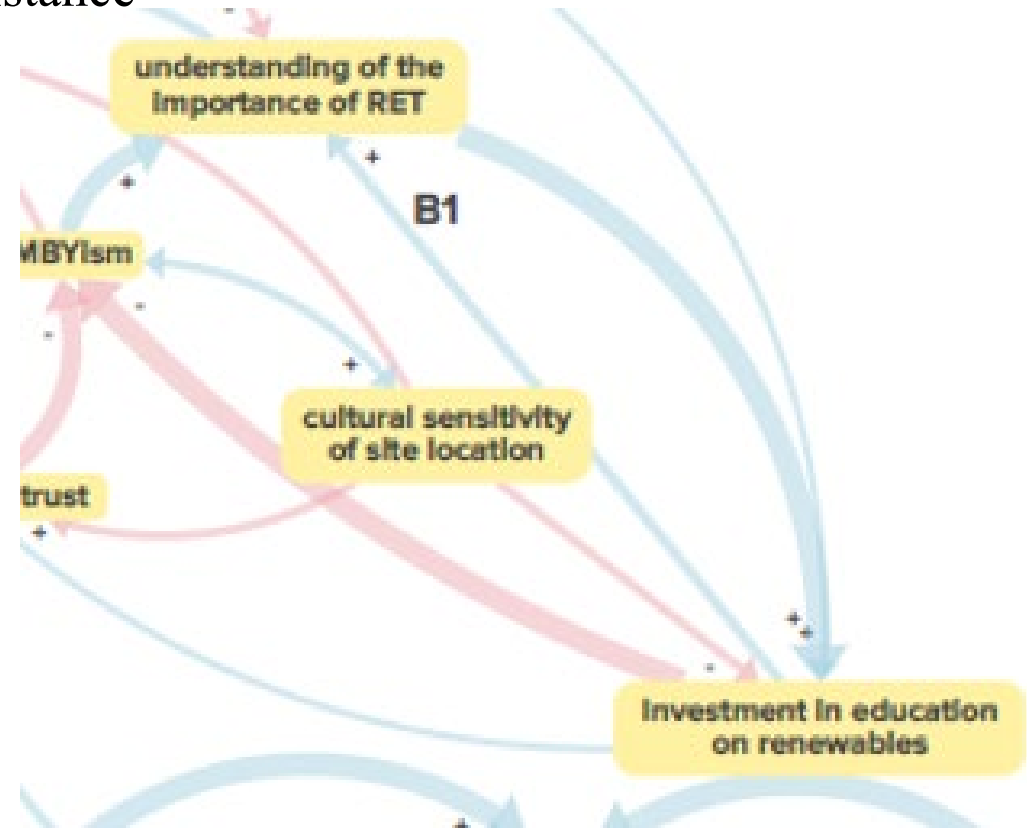
Key Feedback Loops in the Wave Energy SA

B1 – NIMBYism & Community Scepticism (Balancing)

- Marine spatial conflict & residential cost concerns → skepticism
- Reduced trust → opposition → delayed deployment
- Acts as a stabilising but constraining force on growth

Leverage Point

Early and participatory education campaigns to manage public resistance



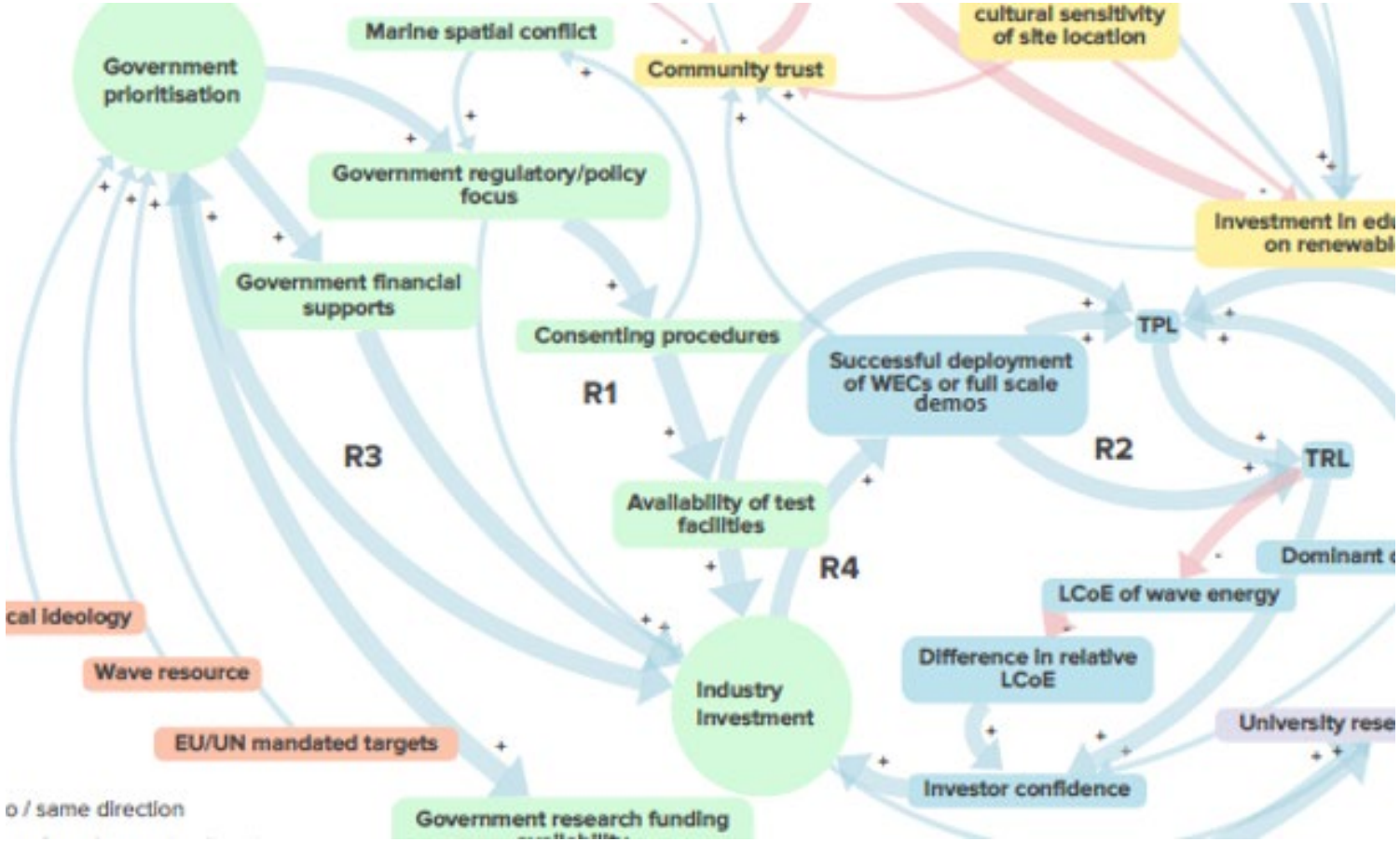
Key Feedback Loops in the Wave Energy SA

R3 / R4 – Education, Trust, and Long-Term Acceptance (Reinforcing)

- Investment in education → understanding of RET importance
- Increased trust → acceptance → political and financial support

Leverage Point

Predictable, strategic funding to reduce LCoE and attract private investment



Discussion: SA & Systems Thinking for Wave energy

Critical for a **robust, reliable renewable energy system**

- Commercial viability is limited by **SA**

SA insights

- Beyond NIMBYism: includes **socio-political, community, and market acceptance**
- **Quadruple helix model** helps explore SA comprehensively
- **Iceberg Model** uncovers deeper mental models driving public perceptions

Systems thinking approach

- Combines SA frameworks, **Quadruple Helix stakeholder analysis**, and CLDs
- **Exposes feedback loops & gives a clear visualisation of the system**
- Identifies **leverage points** to guide pragmatic policy, funding, and project planning

Takeaway: Early consideration of SA mitigates protest, delays, and potential project failure

Conclusions

Key findings from CLDs

- Irish wave energy CLD: **68 feedback loops**, with 5 key loops influencing system behaviour
- Reinforcing loops (R1–R5) strengthen technology deployment & investment
- Balancing loops (B1) mitigate social resistance

Leverage points for intervention

- **Government:** improve consenting, prioritisation, and financial support
- **Industry:** accelerate deployment and TRL progression
- **Community:** invest in education to reduce NIMBYism
- **Academia:** research drives performance, design convergence, and investor confidence

Comparative insights

- Danish wind energy CLD shows: **cooperative ownership, long-term policy, education, and financial incentives** were crucial
- Suggests the need for a **wave energy champion** to coordinate stakeholders

Future work

- Apply **stock & flow diagrams** for dynamic simulations
- Integrate **Futures/Foresight and Theory of Change frameworks** to explore intervention pathways

Finally:

SA emerges from **interacting social, policy, economic, and technological loops**; strategic, systemic interventions are essential for successful wave energy deployment.

Thank you

- **News & Opportunities from COER:**

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