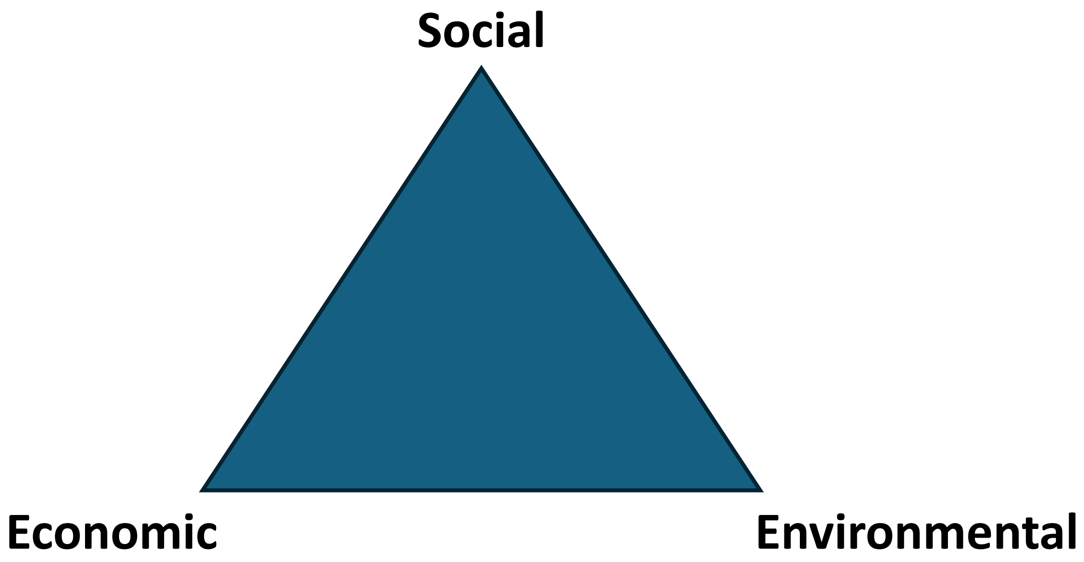
Integrated agent-based and system dynamics modelling for simulation of sustainable mobility.

Eyjólfur Ingi Ásgeirsson

Sustainability challenges

- Balancing economic development with social and environmental objectives
- Energy is central to this challenge

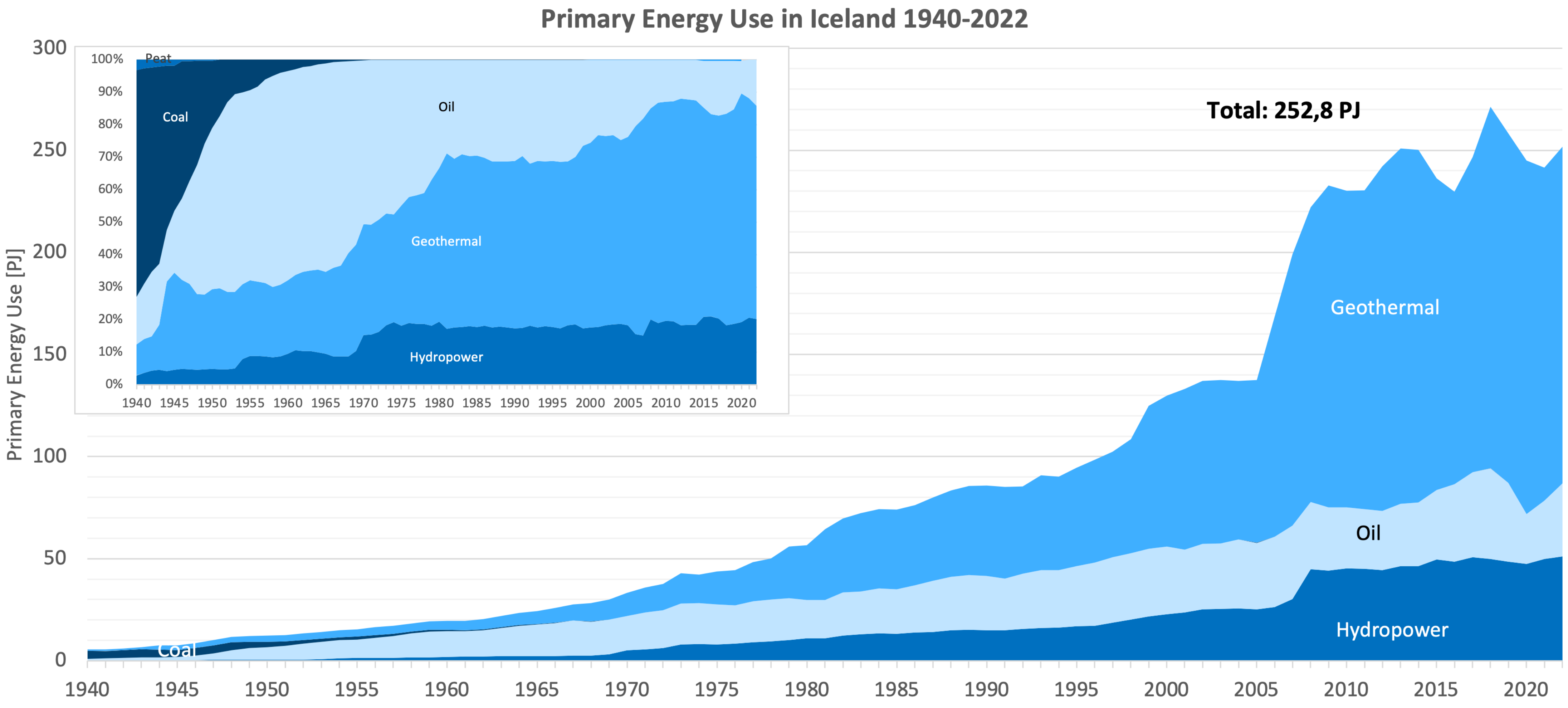


Energy

- Energy plays a key role in the three dimensions:
    - A principal motor of economic growth and economic development
    - A source of environmental stress (e.g. climate change)
    - A prerequisite for meeting basic human needs and securing human wellbeing

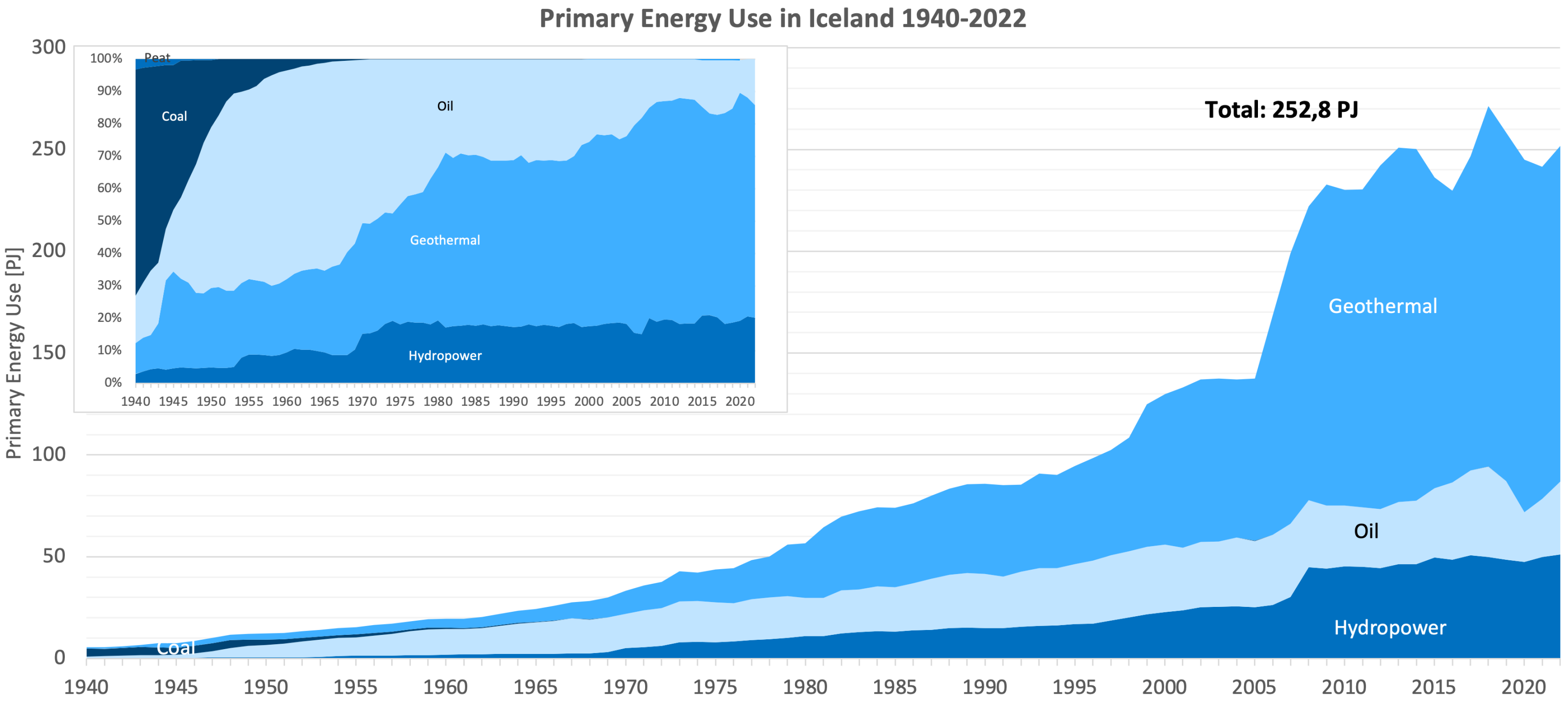
=> We must get the energy dimension right to enable sustainable development

Energy use in Iceland



Orkustofnun Data Repository: OS-2023-T011-01

Energy use in Iceland



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Three energy transitions

1. 1900 – 1940:
From biomass based to coal
(84% coal 1940)

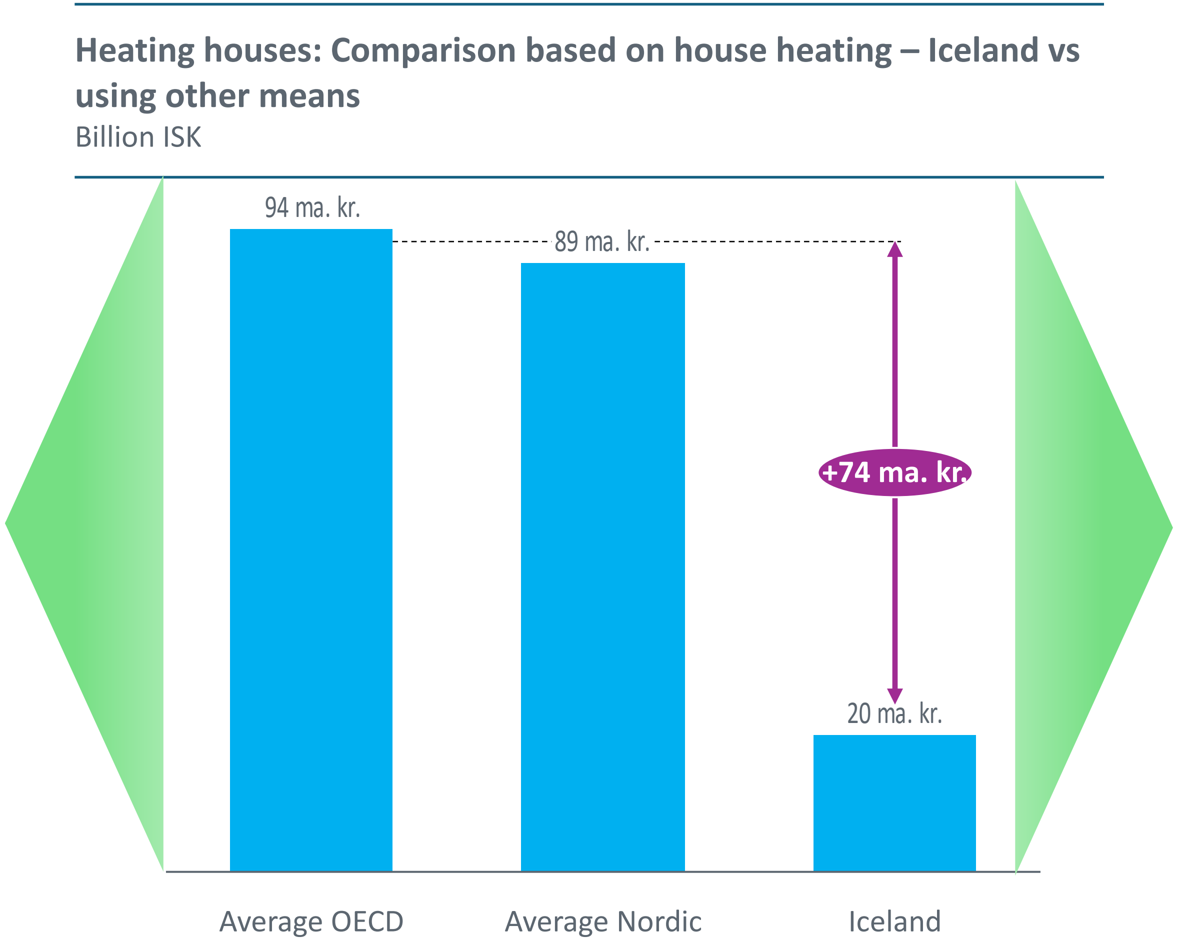
2. 1940 – 1965:
From coal to oil and renewable energy
(oil 65%)

3. 1965 – now:
From oil to renewable energy
- for electricity generation and heat

(1965-1980: Geo district heat)

Direct use of geothermal heat
significant savings for each household as well for the nation

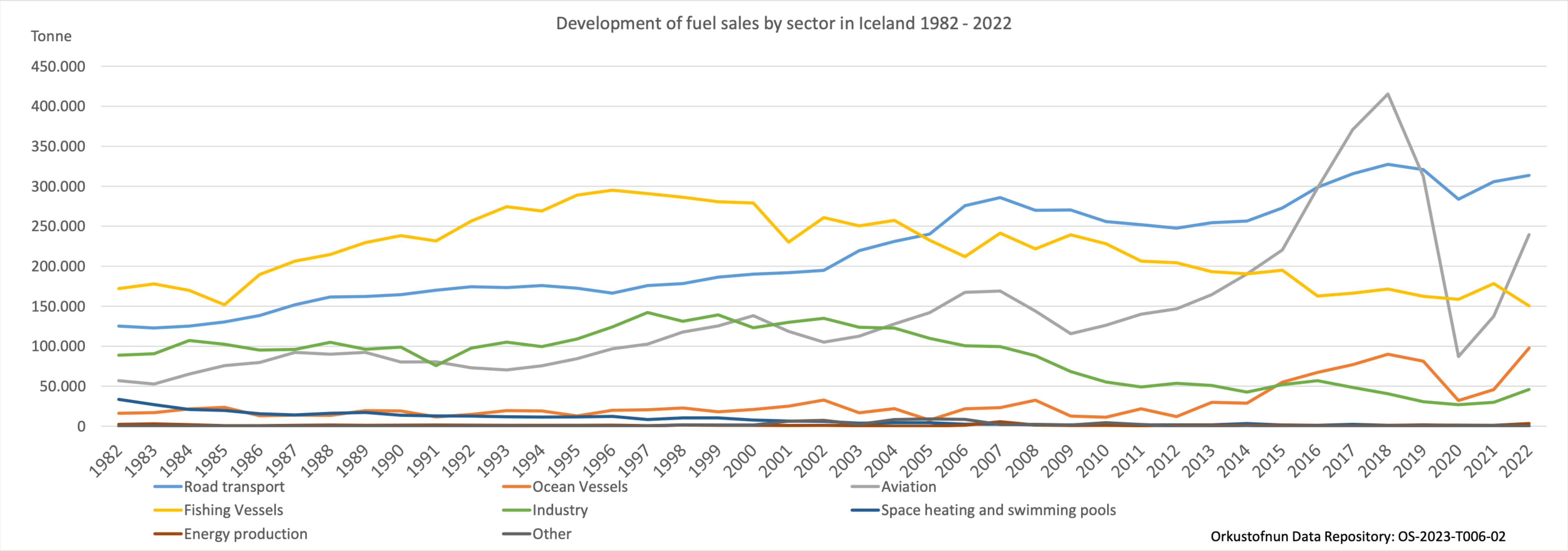
Yearly savings of
> €5K
per household!



Yearly national savings -
Comparable to government spending on education

Source: Ásdís Kristjansdottir; Energy Authority, Samorka, Confederation of Icelandic Enterprise (2014)

Oil consumption in Iceland



How to transition to a fully renewable energy economy?

Supply possibilities

Electricity from renewable sources; hydrogen (electrolysis), biofuels/gas (from energy crops; organic waste, CH4 from landfills, CO2 converted to methanol)

Resource dynamics

Impact of climate change on hydropower and biomass

Resource limitations of geothermal resources (drawdown)

Physical limitations of biofuel supply

Demand considerations

Expected increase in electricity demand – what are the implications for transition options?

- Energy intensive industries
- Electric cable to Europe

Must ensure affordable supply

Minimizing environmental impact

Mitigating GHG emissions, impact on land etc..

The importance of models

- Data-driven insights
- Scenario planning
- Policy evaluation
- Resource allocation
- Risk management
- Transparency and accounting
- Long-term planning

Modeling complex systems

A complex system is a collection of interconnected elements or components whose interactions give rise to emergent behaviors and properties that cannot be easily understood by analyzing the components in isolation.

Common features of complex systems:

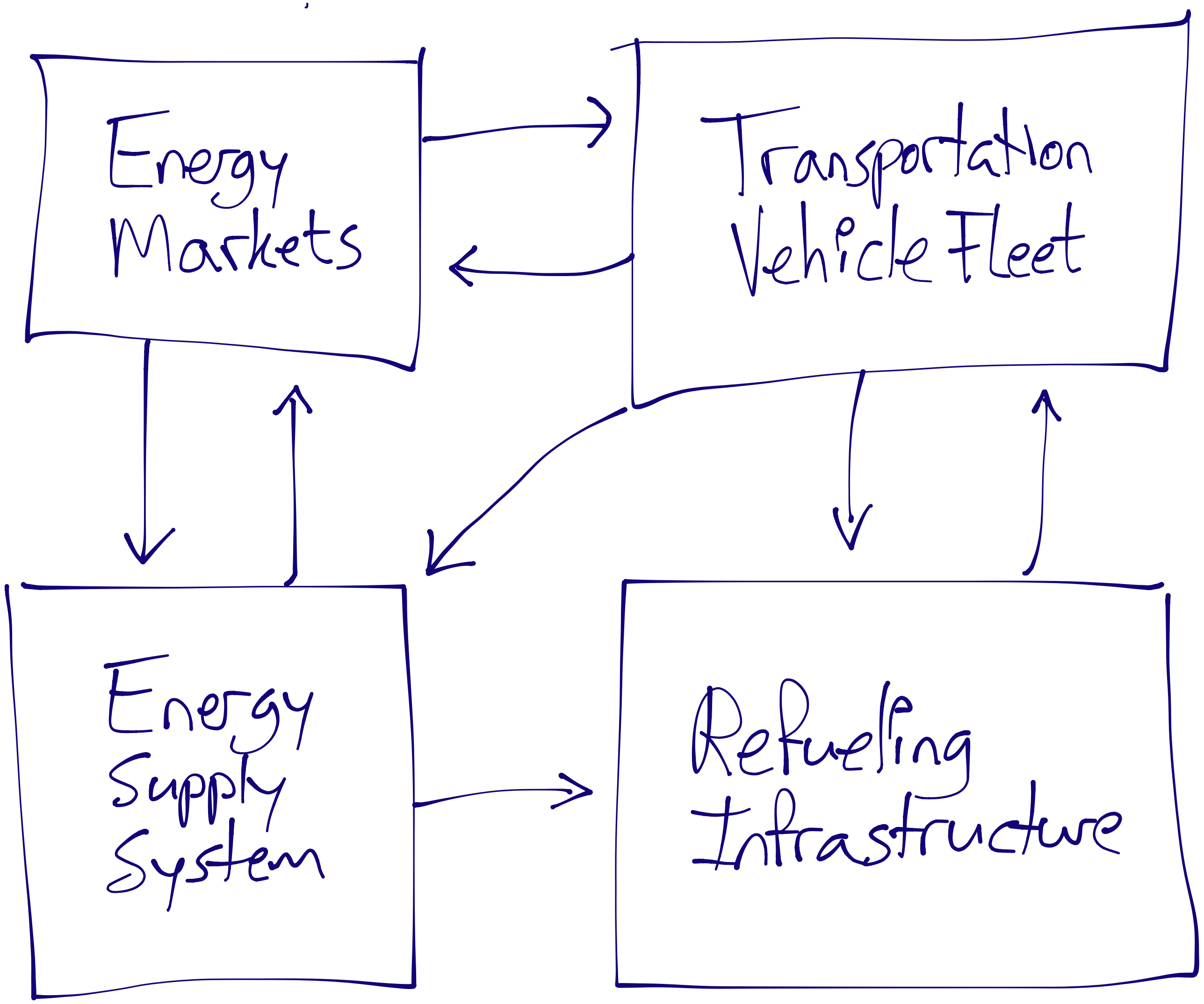
- Interconnectedness
- Nonlinearity
- Emergence
- Adaptation
- Feedback loops

Modeling complex systems

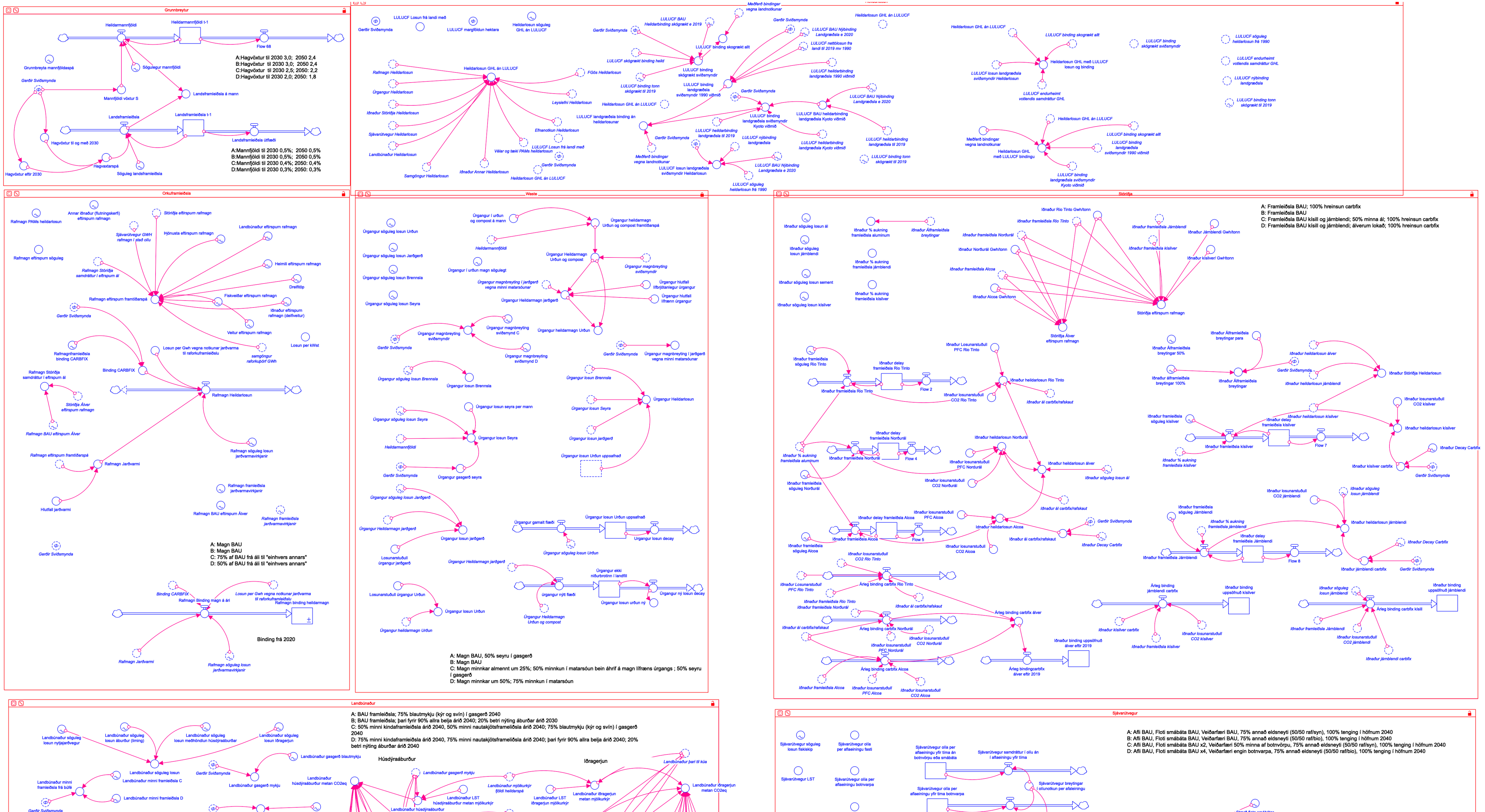
- Top-down modeling
  - **System Dynamics**
    Most useful when the primary interest lies in understanding global or macroscopic patterns, behaviors, or outcomes.

- Bottom-up modeling
  - **Agent Based Simulation**
    Particularly useful for studying emergent phenomena and complex behaviors that arise from the interactions of many individual entities.

High level model – Vehicle part



Some detailed parts of the model



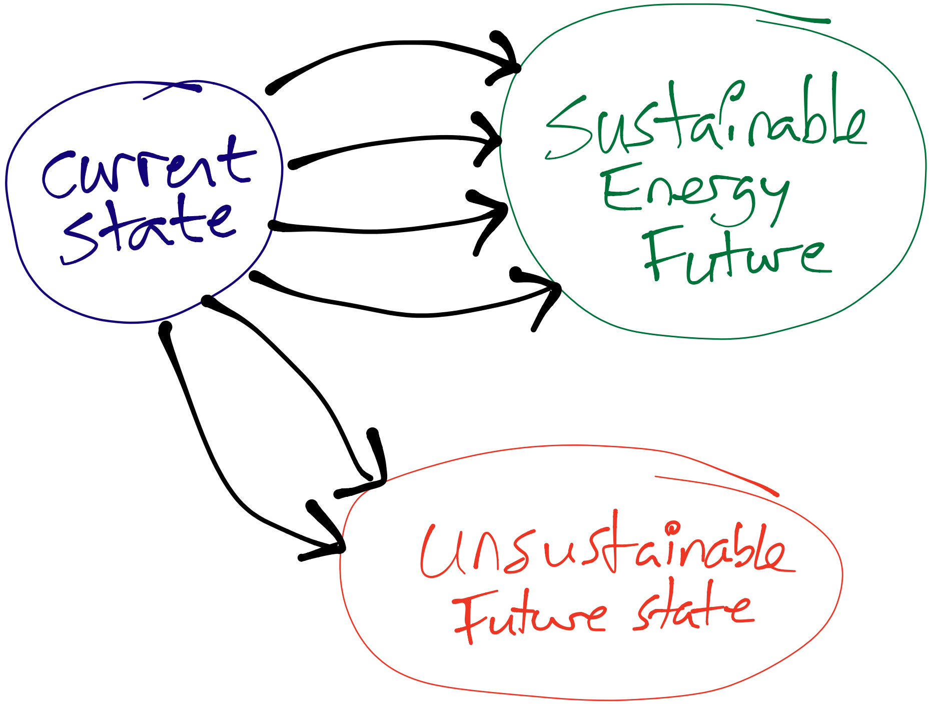
Forecasting

- Official forecasts:

ORKUSTOFNUN
(National Energy Regulatory)

Hagstofa Íslands
(Statistics Iceland)

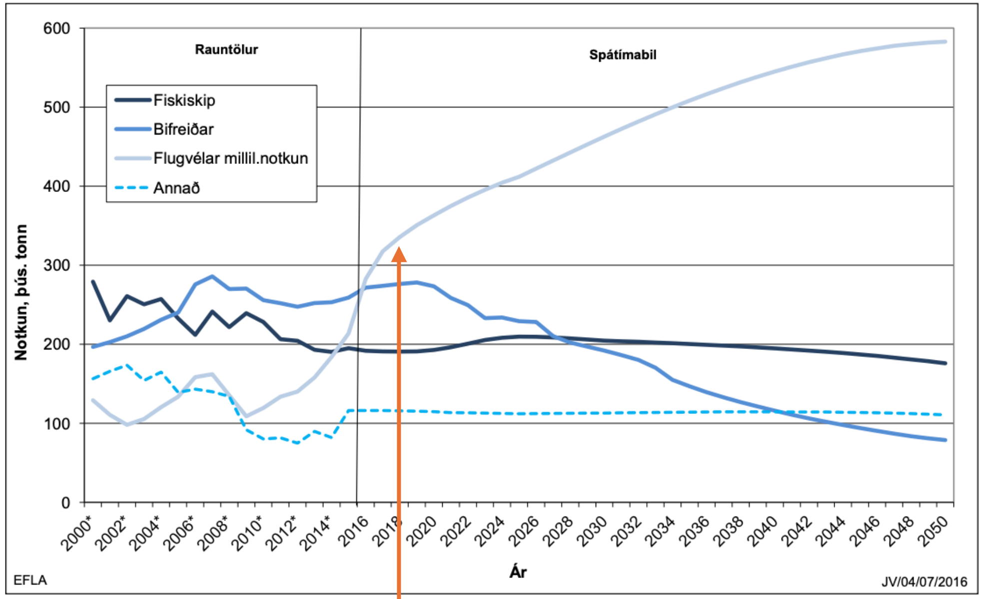
- Other forecasts:
  - Assumptions, s-curves, emergent behaviour, point-estimates and regression/splines, modification to official forecasts, etc.



Forecasting - downsides

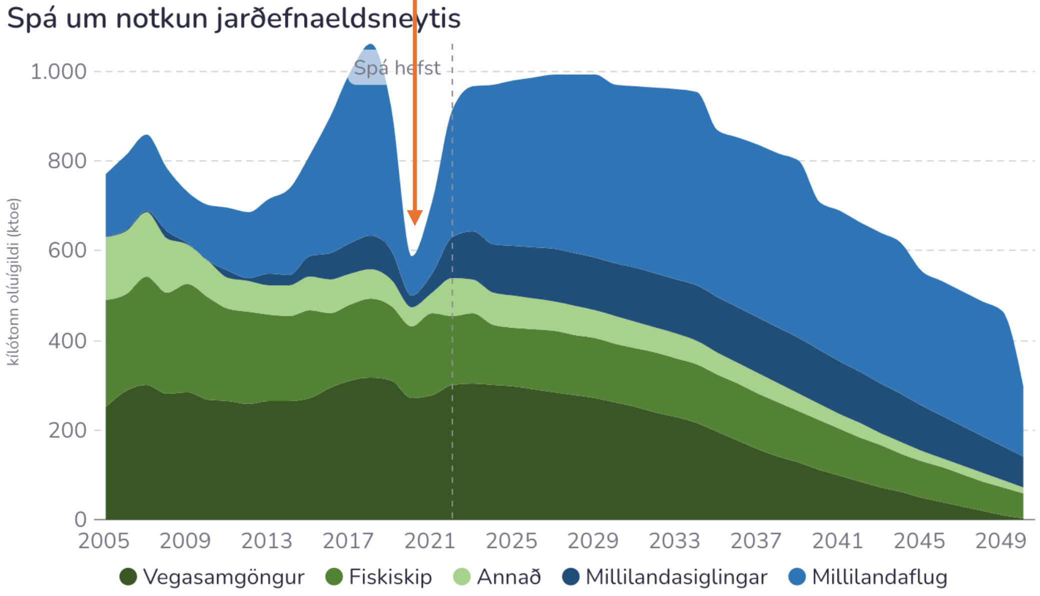
- Uncertainty
- Assumptions
- Data Limitations
- Overfitting
- Lack of Consensus
- Black Swan Events

2016



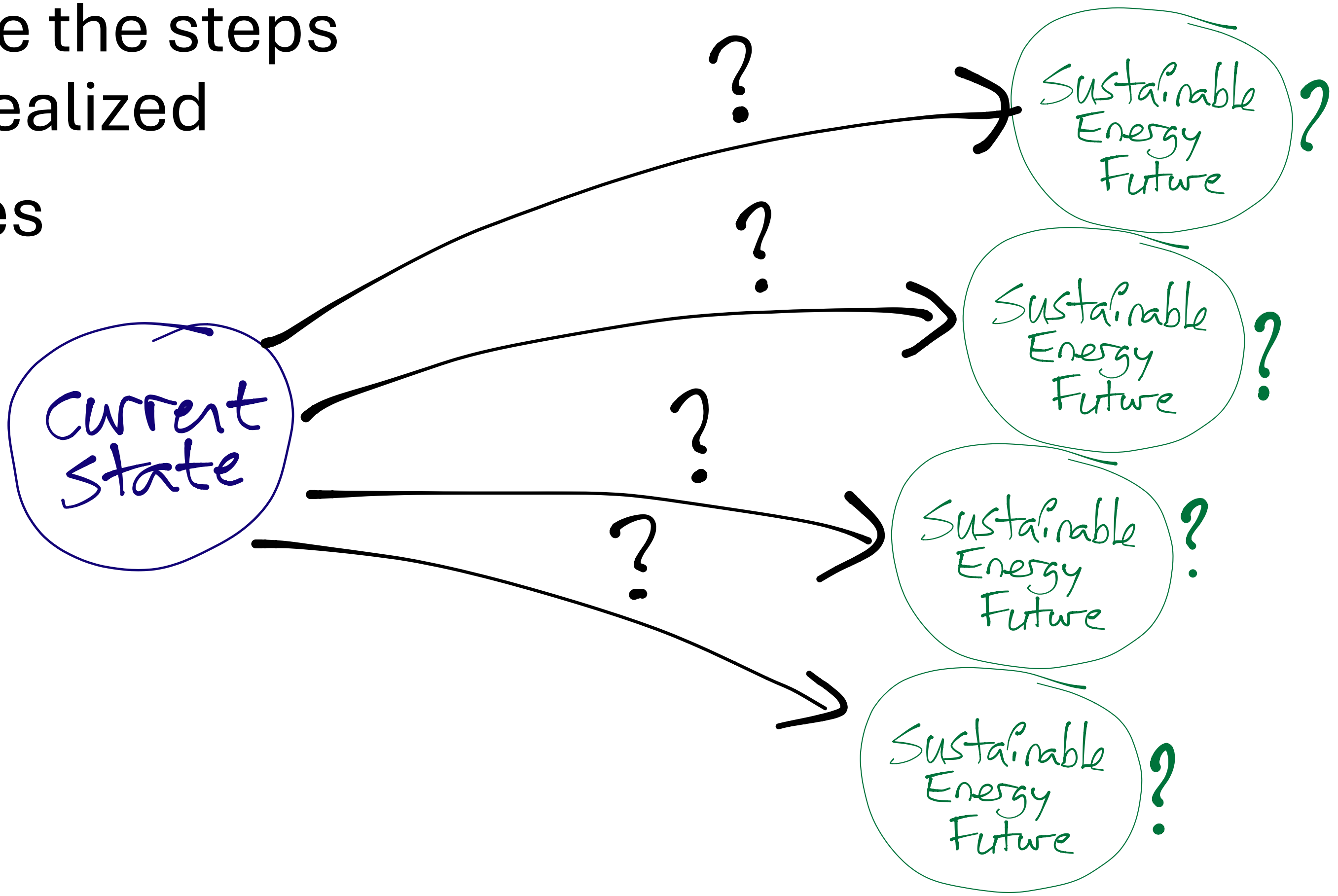
Mynd 5.5 **Spá um notkun olíu eftir meginflokkum tímabilið 2016-2050 ásamt rauntölum áranna 2000-2015, notkun landsmanna alls.**

2022

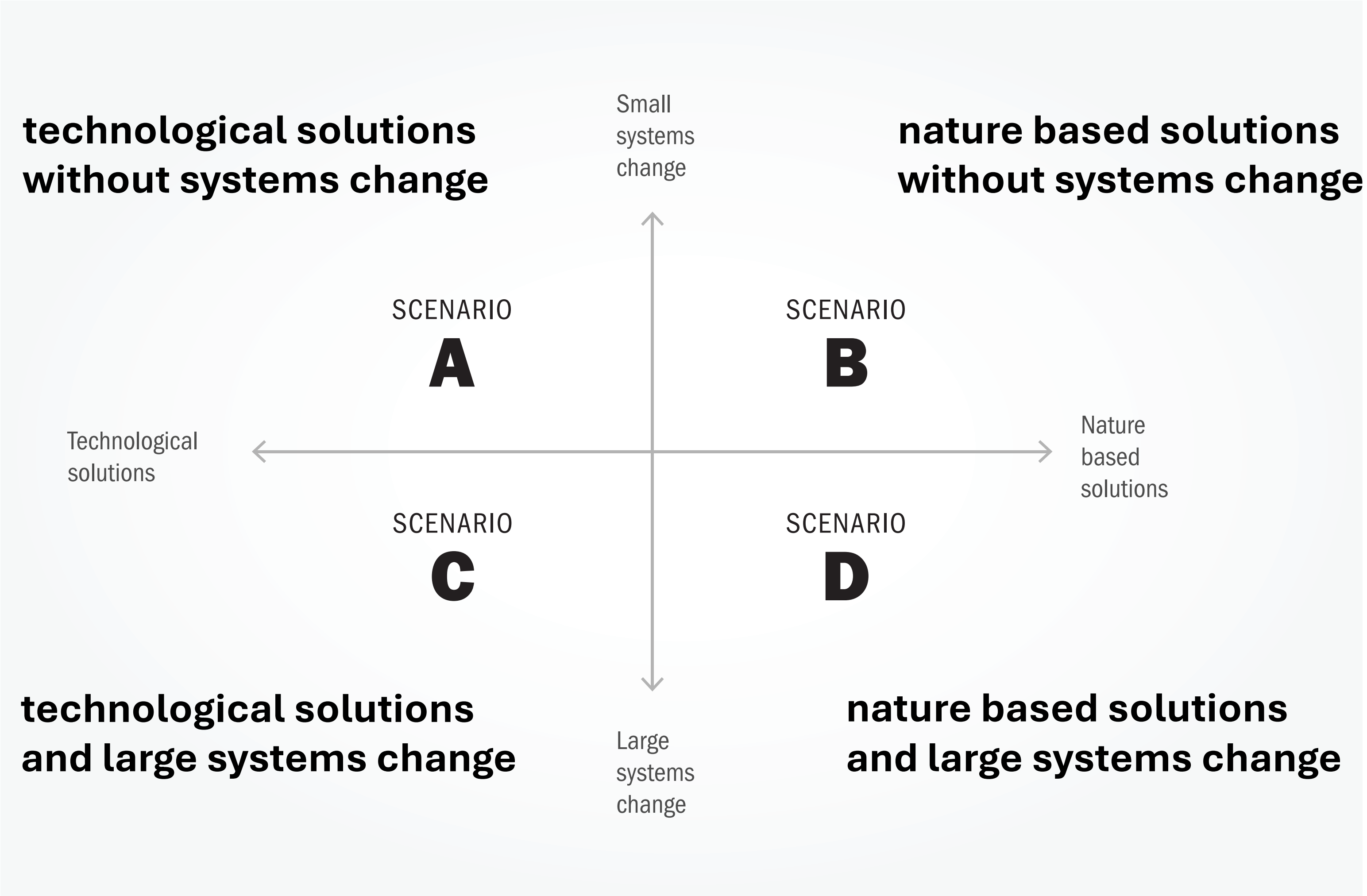


Backcasting

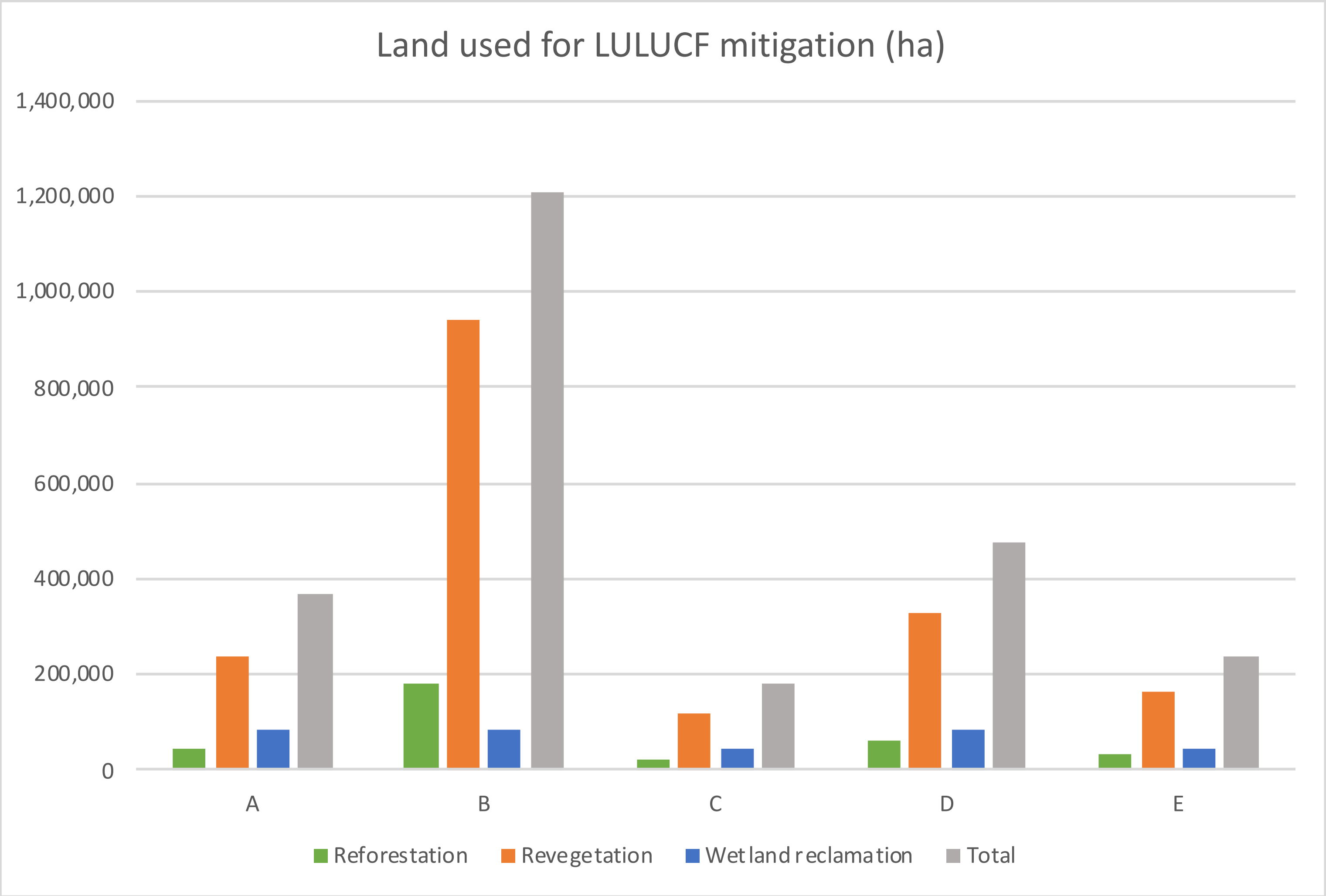
- Start with a vision of the future
- Work backwards to determine the steps needed for that future to be realized
- Identify barriers and obstacles
- Identify strategies and required actions



Towards carbon neutrality
Scenarios from stakeholder engagement



LULUCF mitigation to reach carbon neutrality in 2040



Using forestry, revegetation and wetland reclamation as levers, different scenarios require vastly different amount of land to achieve carbon neutrality

The transition to a fair carbon neutral society needs both quick decisive action and clear long-term thinking.