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Energy Transitions: The National Planning Problematique in the context of Global Pressures

Reform Group Meeting 2017
Schloss Leopoldskron, Salzburg

Burkhard Auffermann and Jyrki Luukkanen
Finland Futures Research Centre

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Contents

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EL-TRAN project

Transition to a resource efficient and climate neutral electricity system (EL-TRAN)

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Research questions of EL-TRAN

1. What effects external energy trends have on Finland's prospects for energy transition?
   - Trends, drivers, weak signals, trade-offs
2. Which structural constraints hamper Finland's energy transition?
   - Infrastructure analysis, Economic production mix, Energy production mix, Demographic and household structures
3. What constraints and opportunities for Finland's energy transition stakeholders incl. citizens identify?
   - Participatory Futures Workshops

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Research questions (cont.)

4. What kind of future scenarios can be constructed in Workshops based on Cross-Impact Analysis,
5. What Backcasting Scenarios can be constructed based on:
    1. Gap-analysis
    2. Policy analysis
    3. Transition Management
    4. Roadmap

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Research Problem of EL-TRAN

- How to balance electricity production and consumption every second with the increased share of intermittent energy sources (wind and solar)
  - Hourly balance
  - Day/night balance
  - Seasonal (summer/winter) balance

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Weekly wind power generation in 1-7 July 2017 in Finland

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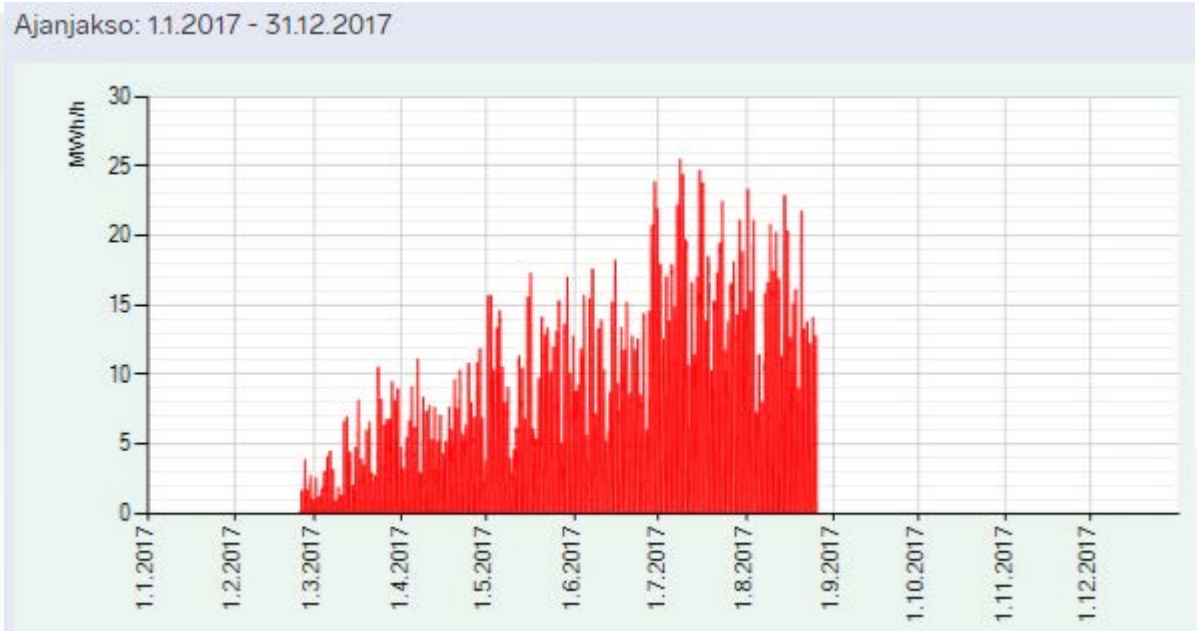
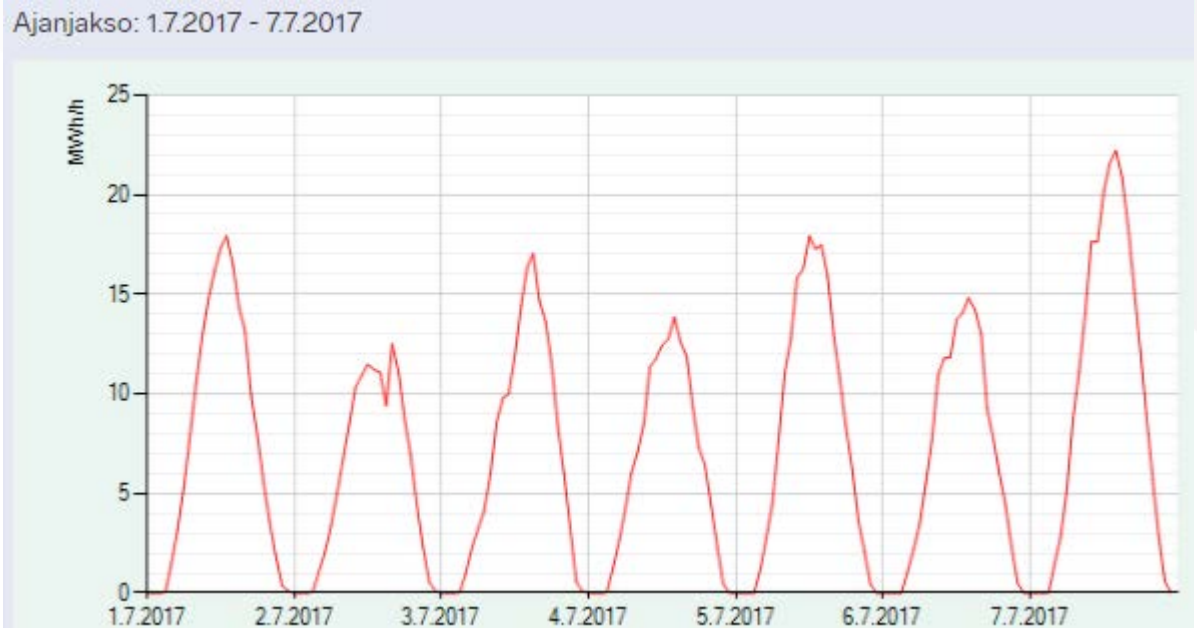
Solar PV production in Finland





- Seasonal changes
- Day/night variation

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Cross-impact analysis

Cross-Impact methods are mostly used for analytical tasks which

- **do not allow the use of theory-based computational models due to their disciplinary heterogeneity and the relevance of “soft” system knowledge,**
- **But, on the other hand, are too complex for a purely argumentative systems analysis.**

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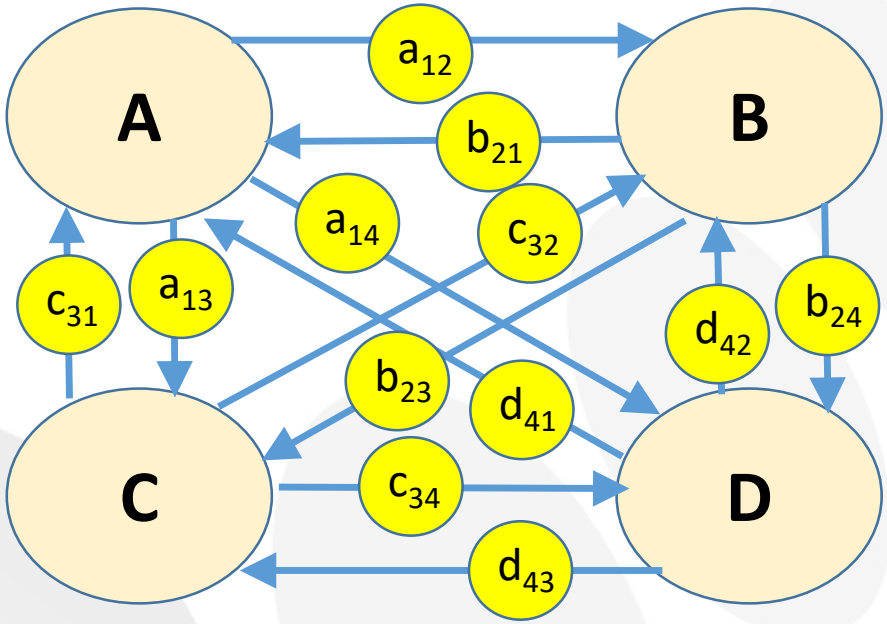
Cross-impact analysis

Variables
A B C D

Interactions of variable



Cross-impact matrix

		Impacted variables			
		A	B	C	D
Impacting variables	A		a12	a13	a14
	B	b21		b23	b24
	C	c31	c32		c34
	D	d41	d42	d43	

Direct impacts

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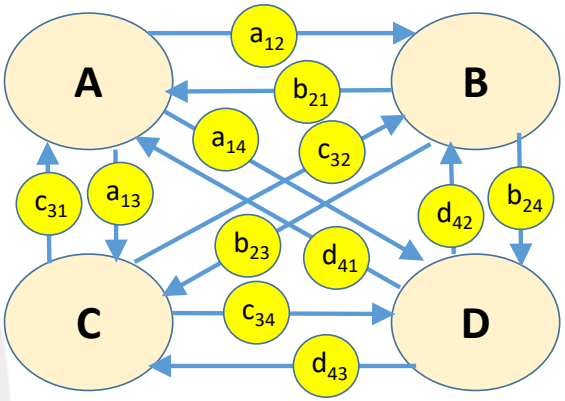
Cross-impact analysis



Example:
A: GDP growth
B: employment
C: energy use
D: energy efficiency

E.g. A (GDP growth) has an impact on B (increases employment)
A has an impact on C (increases energy consumption)
A has an impact on D (improves efficiency)
D has an impact on C (reduces consumption)

Interactions of variables indicated by -4, -3, -2, -1, 0, +1, +2, +3, +4

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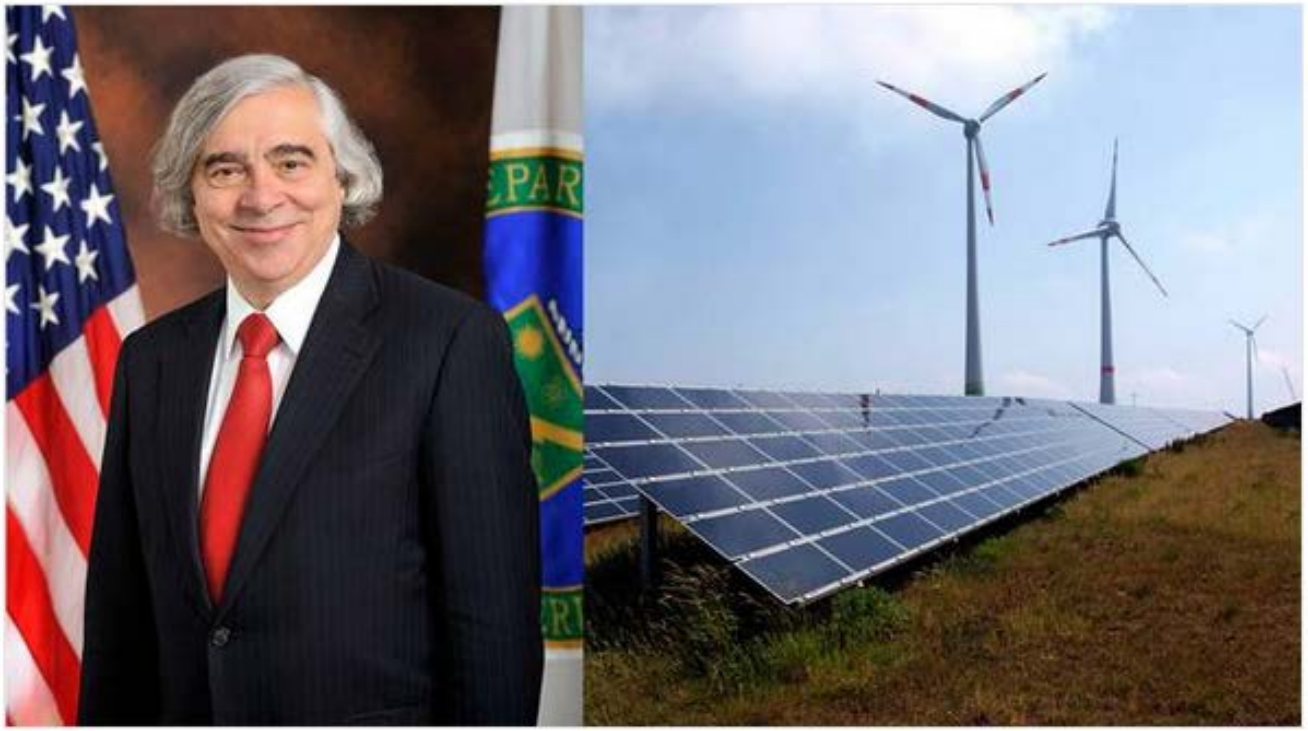
Examples of drivers

U.S. Energy Secretary: Solar and wind energy now cost-competitive without subsidies

Michael Graham Richard (@Michael_GR)
Energy / Renewable Energy
September 1, 2015



Public Domain U.S. Government

And they'll only get cheaper over time...

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Variables in cross-impact analysis

1. Electricity price in Finland will increase
2. Wind and solar power production will increase in Finland
3. Electricity storage will increase in Finland
4. Market based elasticity of electricity consumption will increase
5. New nuclear power plants will be constructed in Finland
6. Electricity consumption will increase in Finland
7. Electricity price fluctuations will increase
8. Electricity transmission capacity from neighbouring countries will increase
9. Fluctuations in electricity consumption will increase
10. Subsidies for solar and wind power will increase

Based on expert opinions and workshop processes

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Cross-impact analysis

- Experts determine what are the direct impacts between the variable
- Interactions of variables indicated by

  -4, -3, -2, -1, 0, +1, +2, +3, +4
- Interaction discussed in workshops
- Experts filled in the cross-impact matrix
- Average values of expert opinions used as input for the analysis

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Cross-impact matrix

- Expert opinions of the direct interactions of variables

	Price increase	Wind and solar increase	Increased storage	Increased elasticity	New nuclear	Consumption increase	Price fluctuations	Transmission capacity increase	Consumption fluctuations	Subsidies for solar and wind
Price increase	0	6	4	5	4	-5	2	3	3	-4
Wind and solar increase	0	0	7	6	-6	0	8	3	4	-1
Increased storage	-1	6	0	0	-1	1	-4	-2	-1	0
Increased elasticity	-5	3	0	0	0	0	-3	-2	-1	0
New nuclear	-1	-4	-1	-1	0	3	-2	2	-1	-2
Consumption increase	6	5	3	4	5	0	5	4	3	2
Price fluctuations	3	-1	7	8	-1	0	0	3	5	-1
Transmission capacity increase	-3	0	-4	-2	0	1	-3	0	-2	0
Consumption fluctuations	5	-1	6	6	-2	0	8	2	0	0
Subsidies for solar and wind	1	10	4	4	-3	1	5	3	3	0

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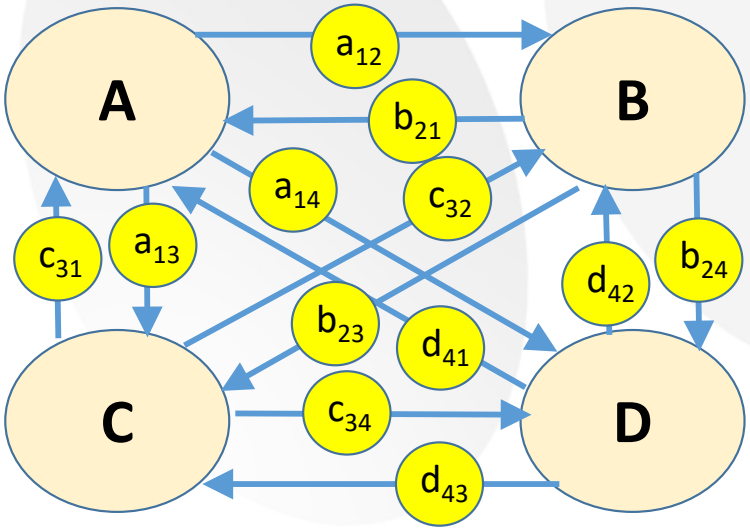
Cross-impact analysis

- We compared in the analysis the expert opinions of **direct** interactions between the variables (e.g. A ➡ B) and the impact of the **indirect** interactions (e.g. A ➡ C ➡ B) changing the actual interactions between variables.



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Cross-impact analysis

- We have developed EXIT algorithm which calculates the indirect impacts caused by the chains of impacts between different variables
- As a result we get a new cross-impact matrix based on the direct + indirect impacts between the variables
- We can compare the direct and indirect impacts

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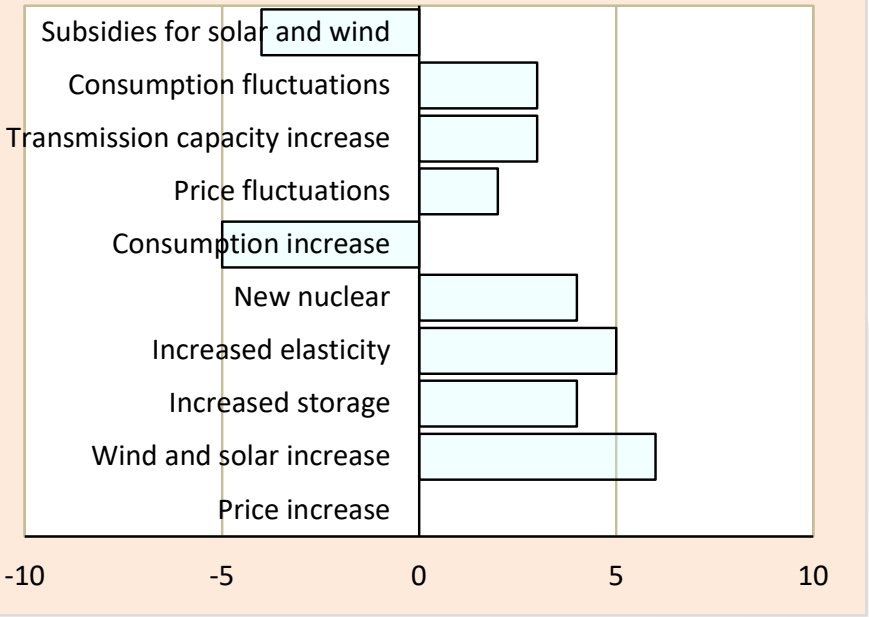
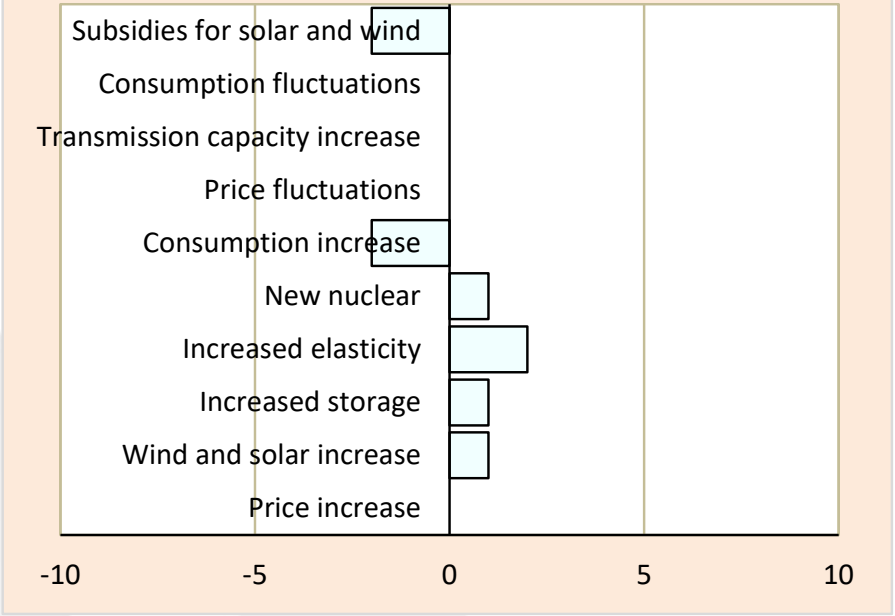
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of **electricity price** increase on other variables

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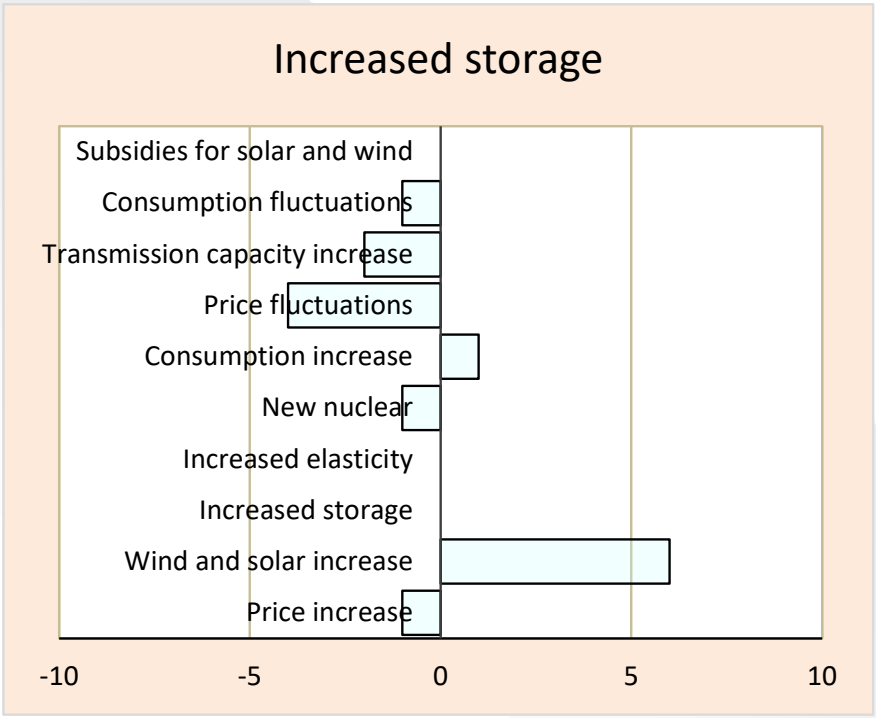
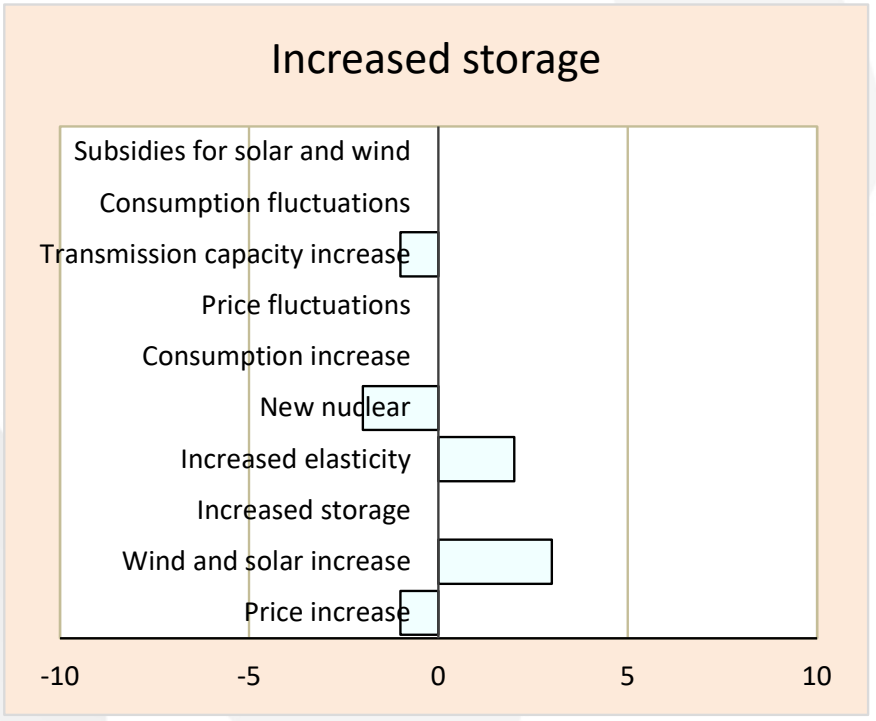
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increased **storage capacity** (battery or pumped storage) on other variables

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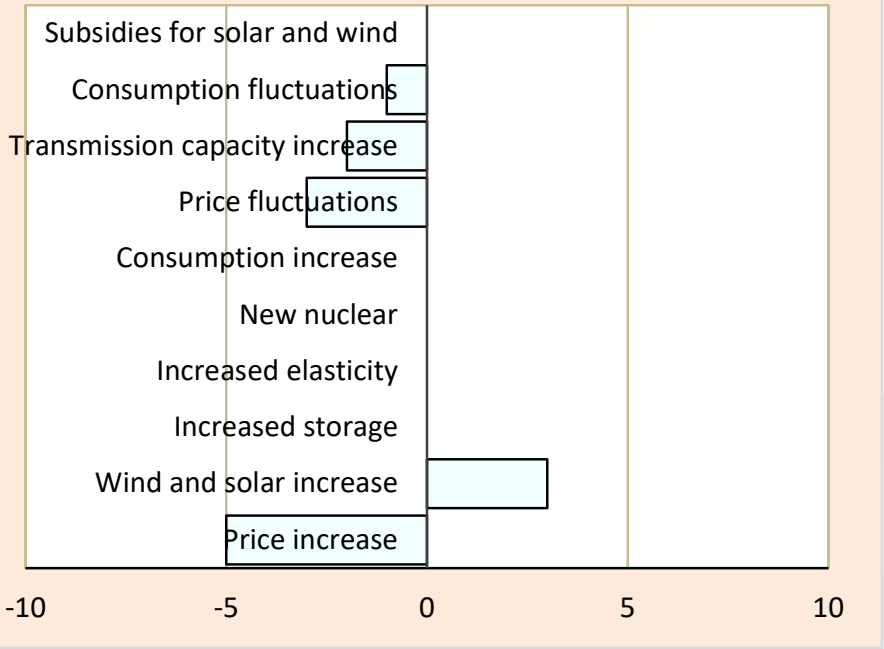
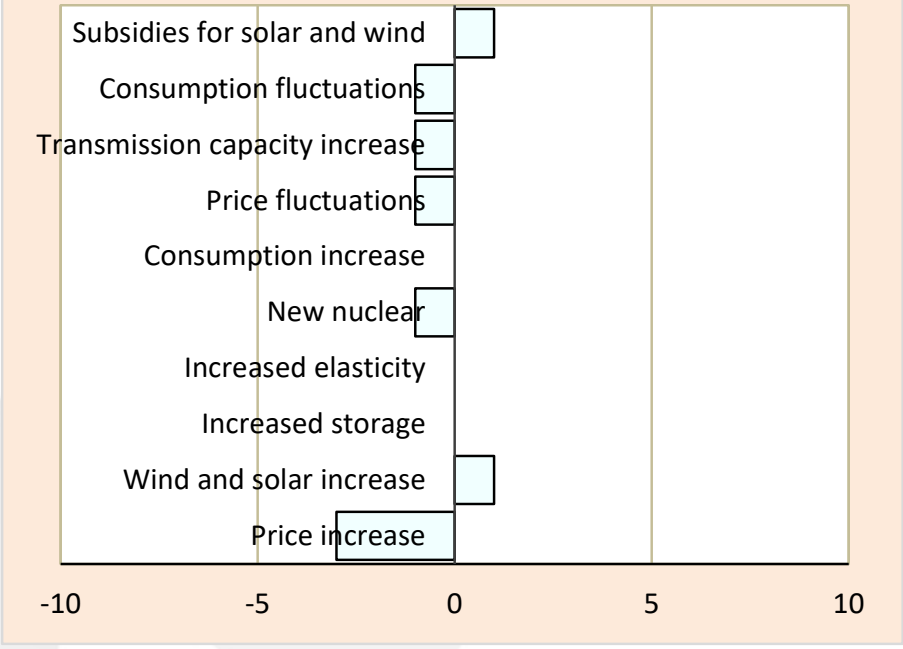
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increased **elasticity of consumption** on other variables

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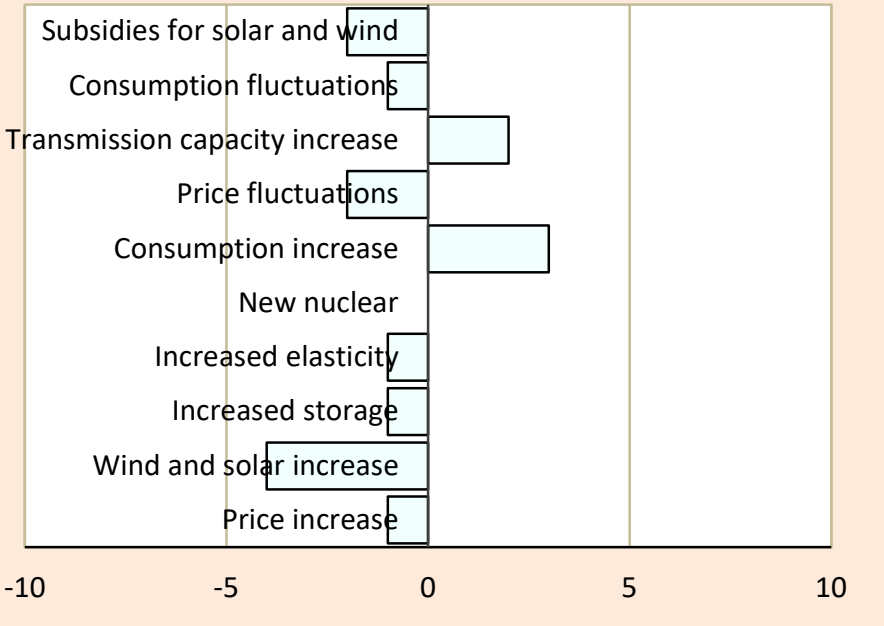
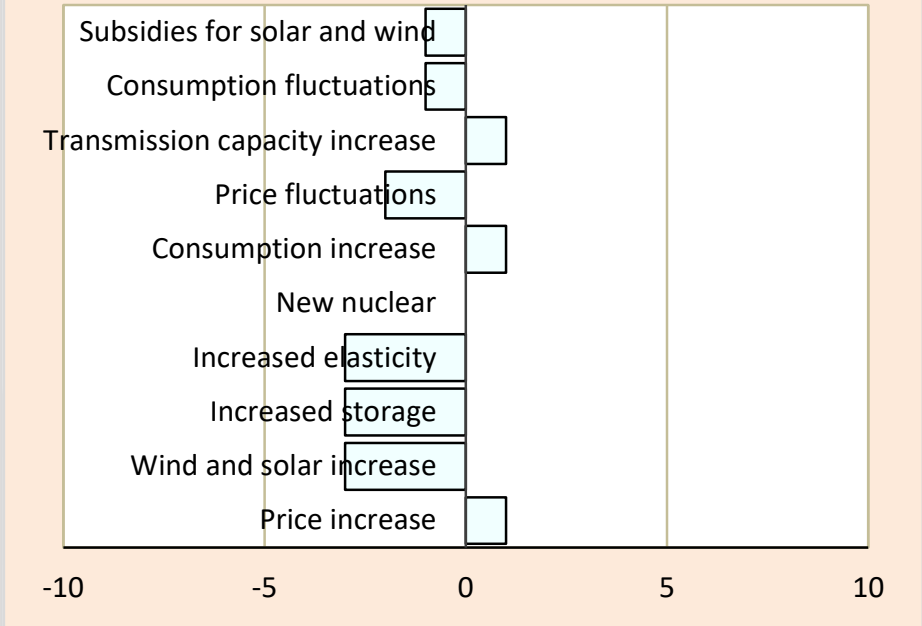
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of new **nuclear power** on other variables

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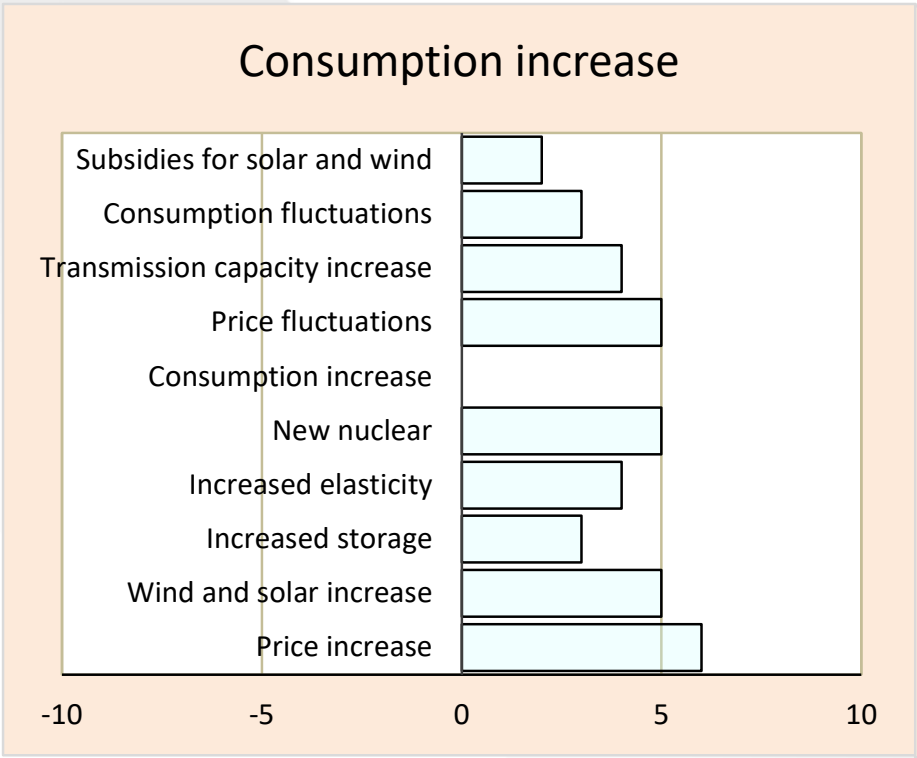
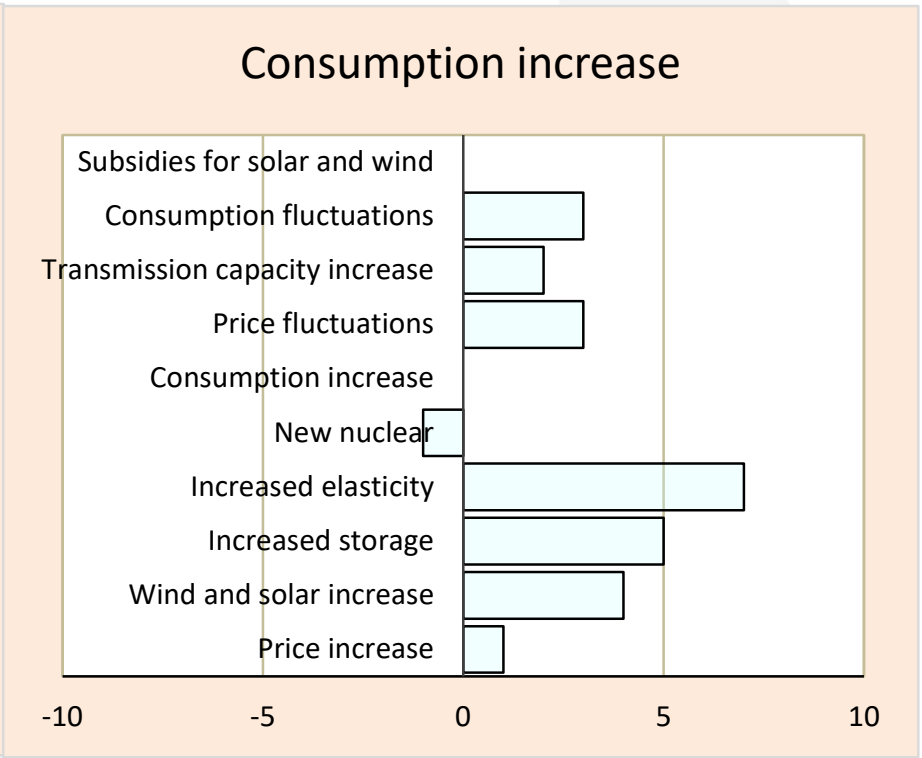
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increase of **electricity consumption** on other variables

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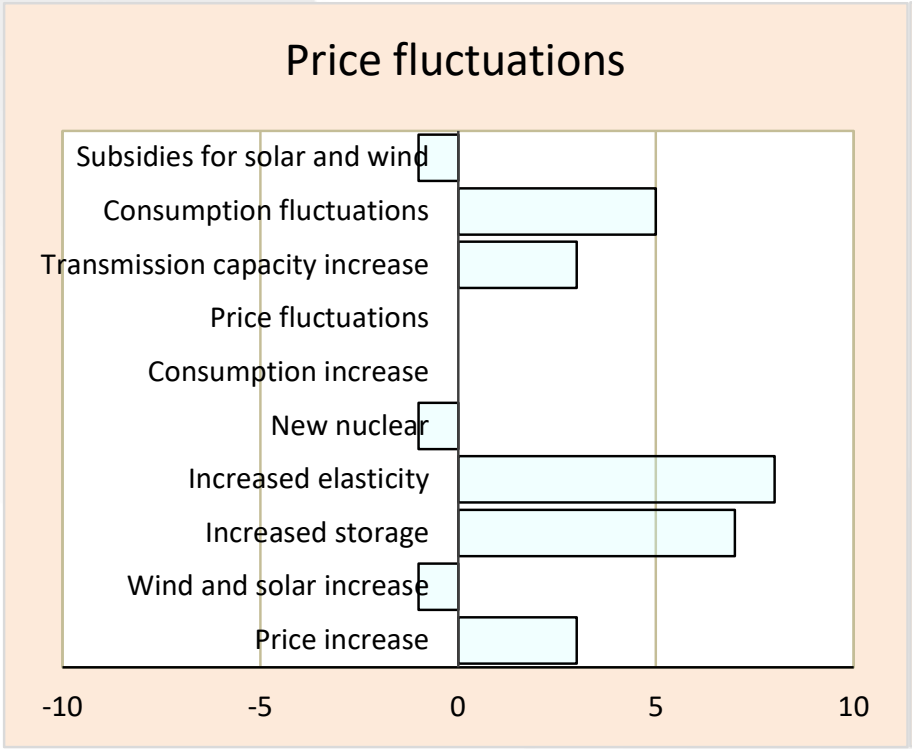
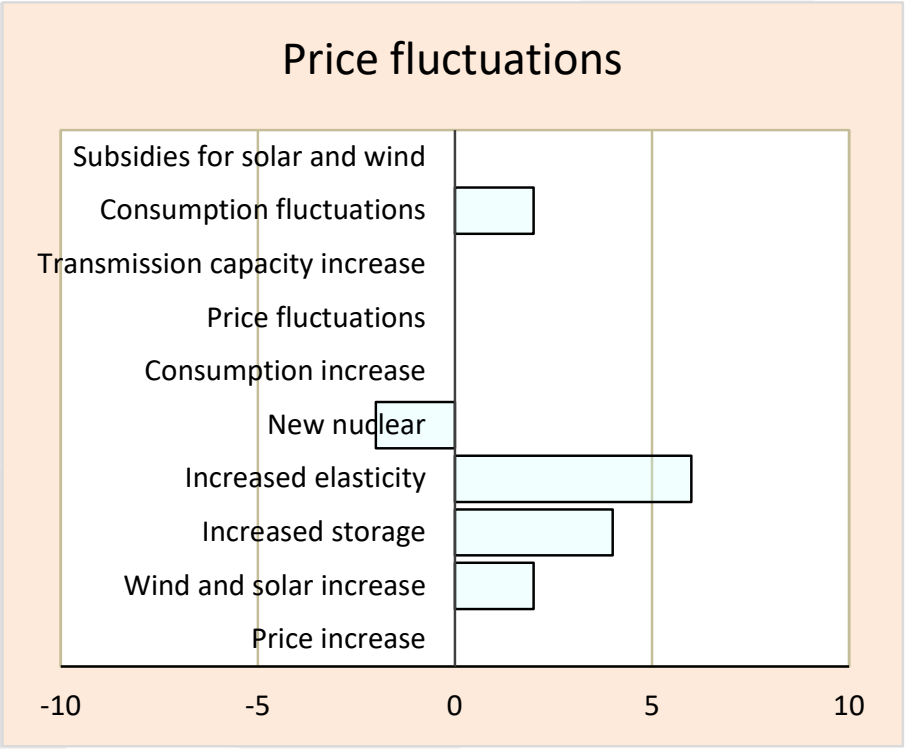
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increase of electricity **price fluctuations** on other variables

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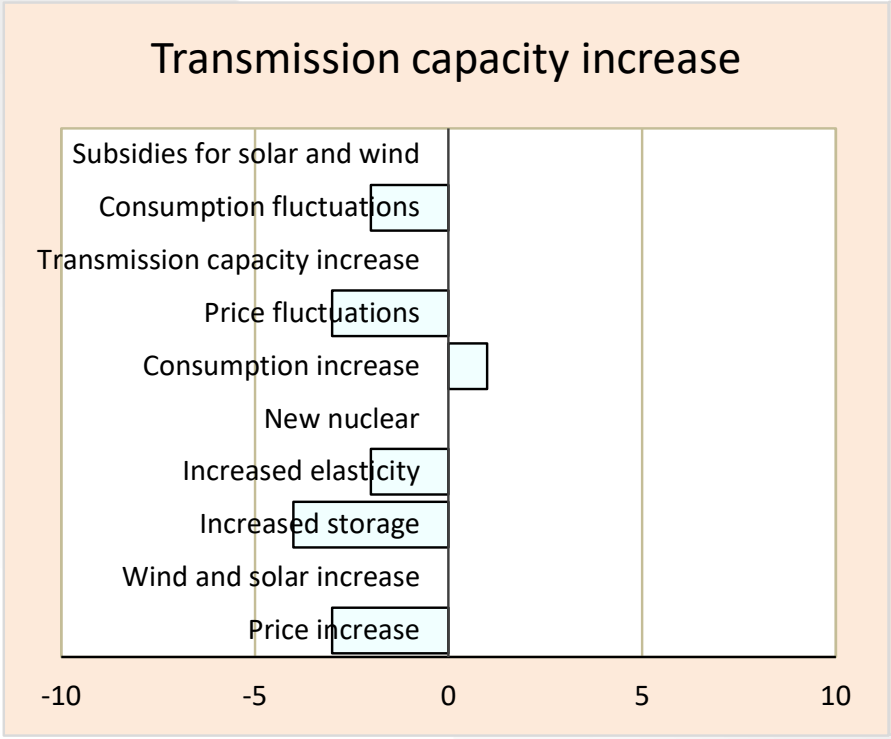
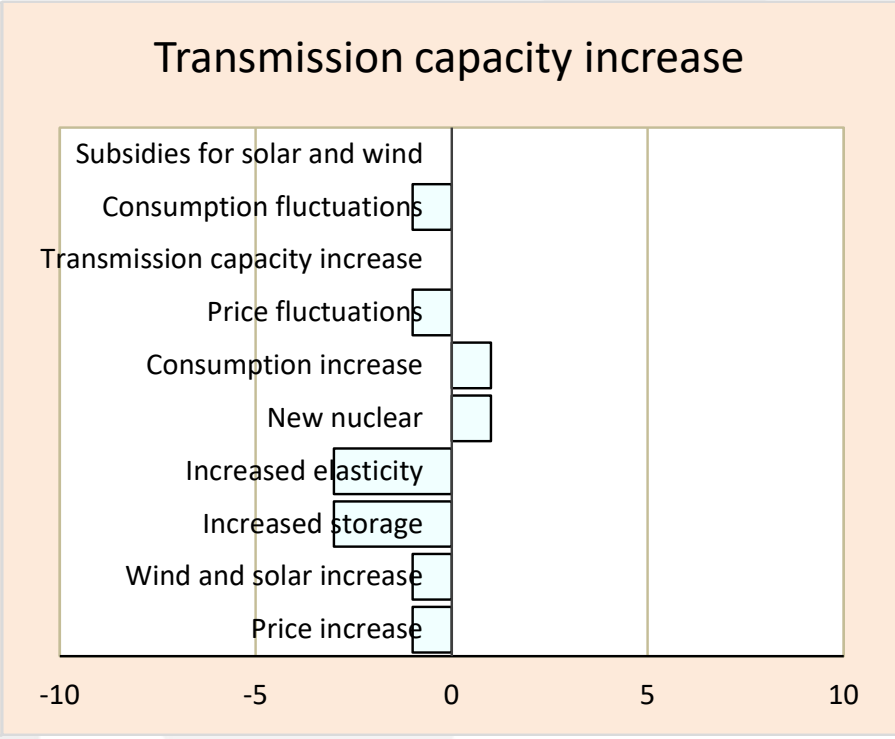
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increase in **transmission capacity to neighbouring countries** on other variables

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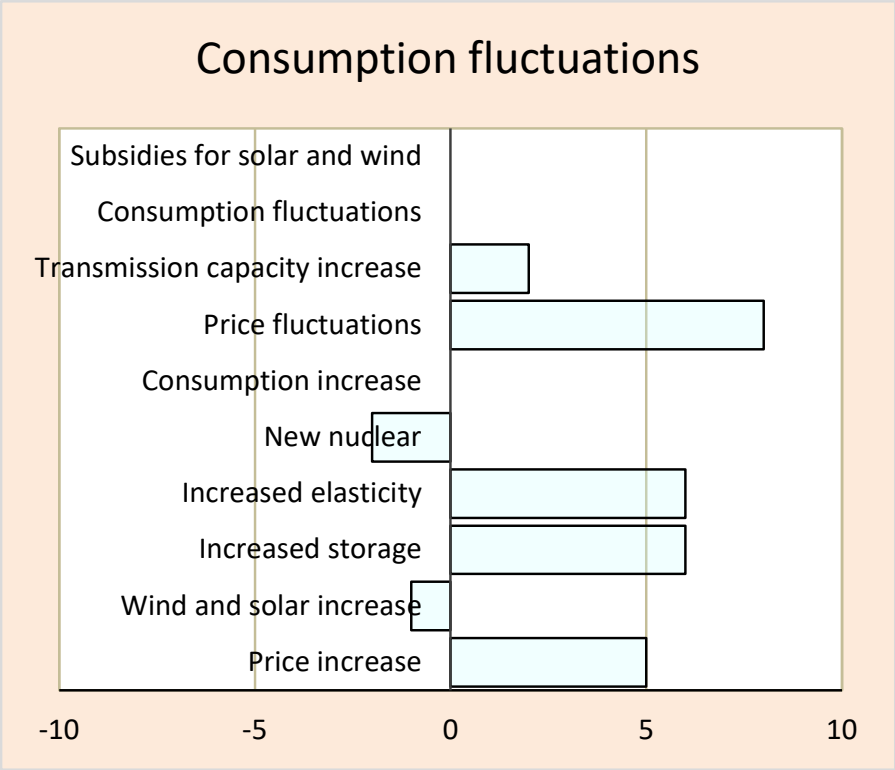
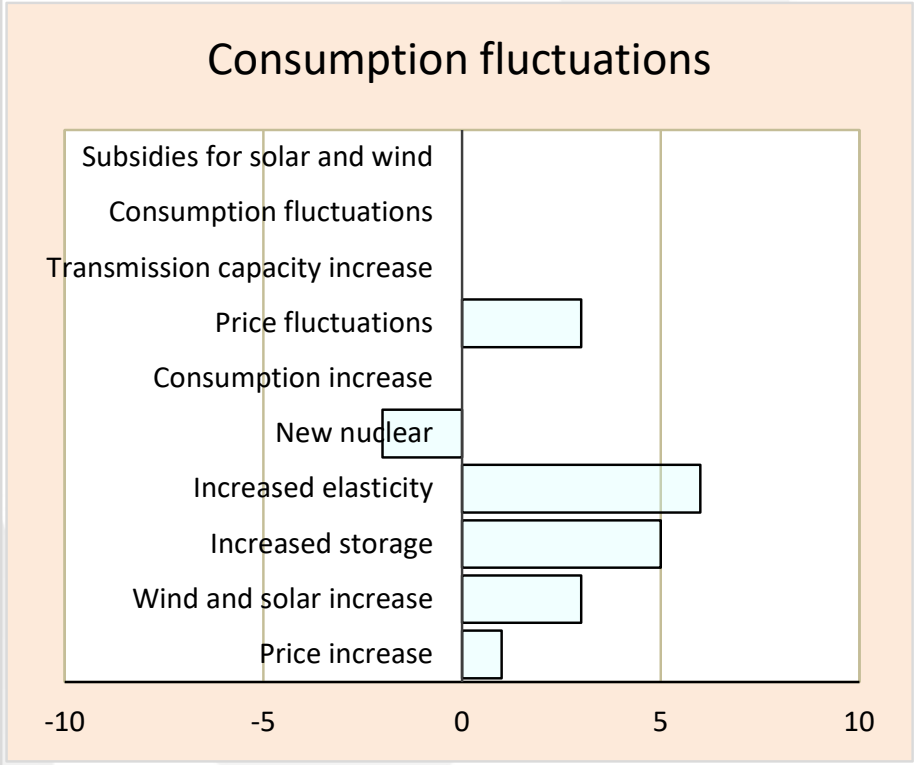
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increase in electricity **consumption fluctuations** on other variables

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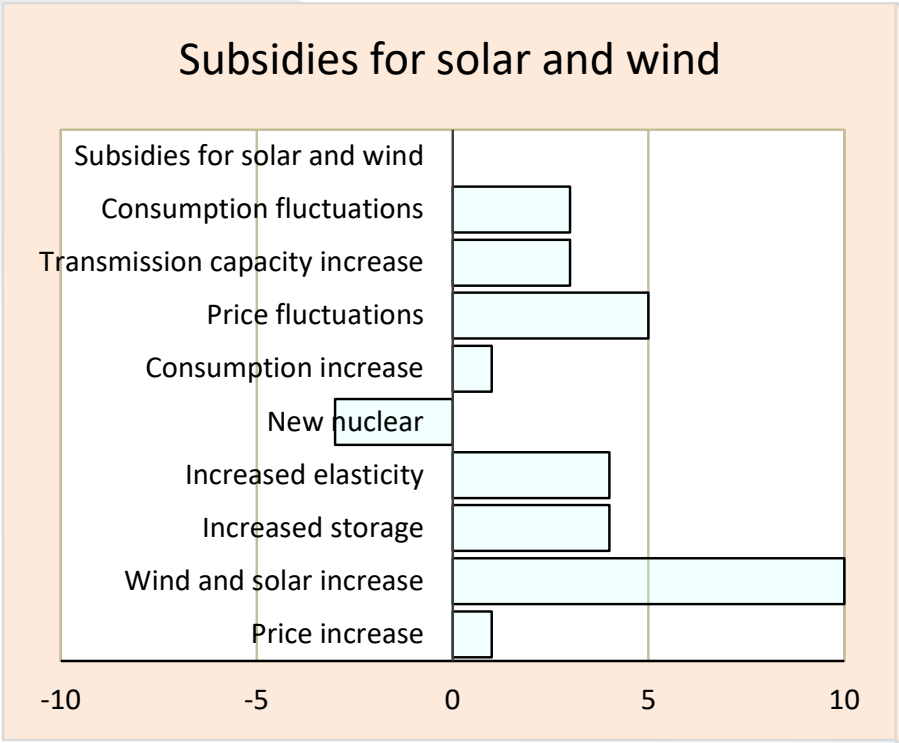
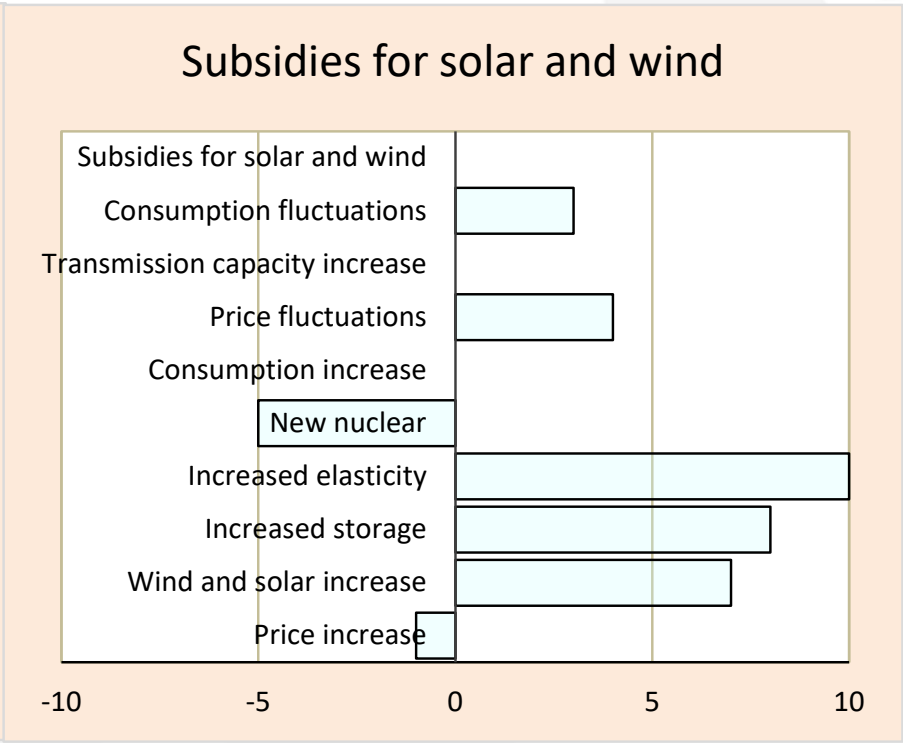
Direct and indirect impacts

Direct



Direct + Indirect



Direct (left) and Direct+Indirect (right) impacts of increase in **subsidies for solar and wind** power on other variables

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DRIVER and DRIVEN variables

Cross-impact matrix

		Impacted variables			
		A	B	C	D
Impacting variables	A		a12	a13	a14
	B	b21		b23	b24
	C	c31	c32		c34
	D	d41	d42	d43	

DRIVER
Sum of absolute values of rows indicate how much the variable impacts on other variables

DRIVEN
Sum of absolute values of columns indicate how much the variable is impacted by other variables

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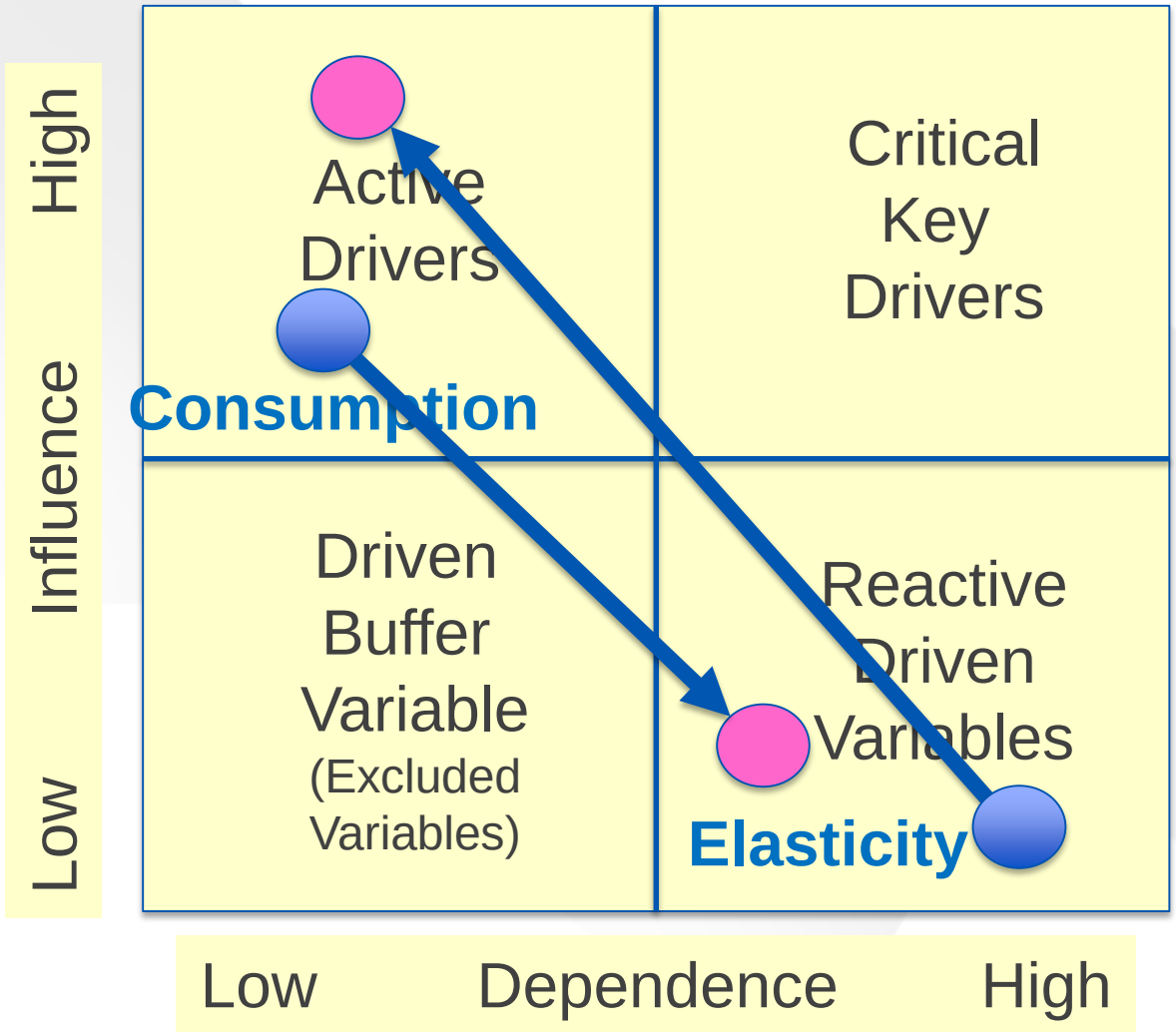
Characterization of variables



- We can map the variables based on their driver-driven dimension
- With cross-impact analysis you can see the properties of variables
- We can analyse the change caused by interactions

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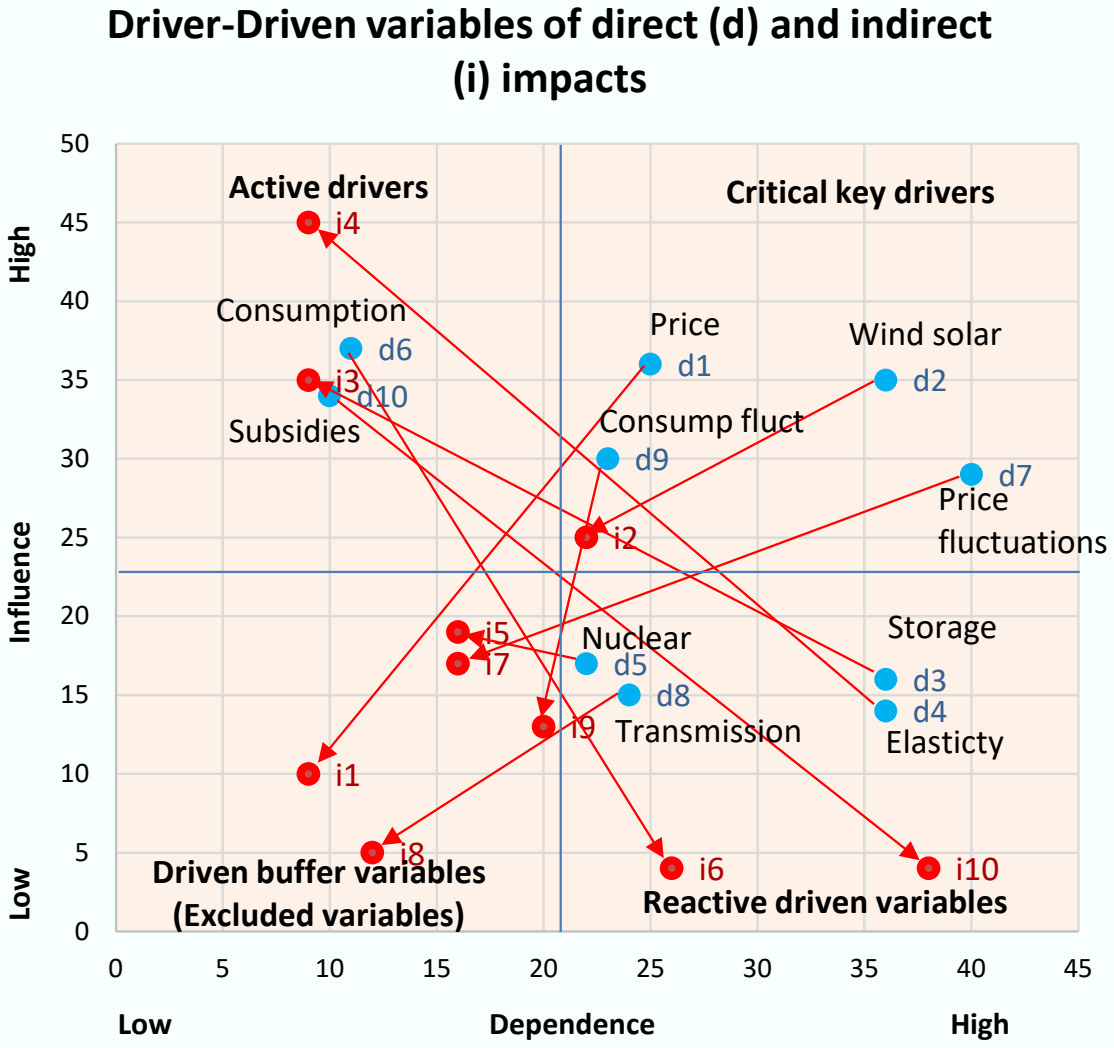
Changes caused by interactions in DRIVER – DRIVEN variables



1. Electricity **price** in Finland will increase
2. **Wind** and **solar** power production will increase in Finland
3. Electricity **storage** will increase in Finland
4. Market based **elasticity** of electricity consumption will increase
5. New **nuclear** power plants will be constructed in Finland
6. Electricity **consumption** will increase in Finland
7. Electricity **price fluctuations** will increase
8. Electricity **transmission** capacity from neighbouring countries will increase
9. **Fluctuations** in electricity **consumption** will increase
10. **Subsidies** for solar and wind power will increase

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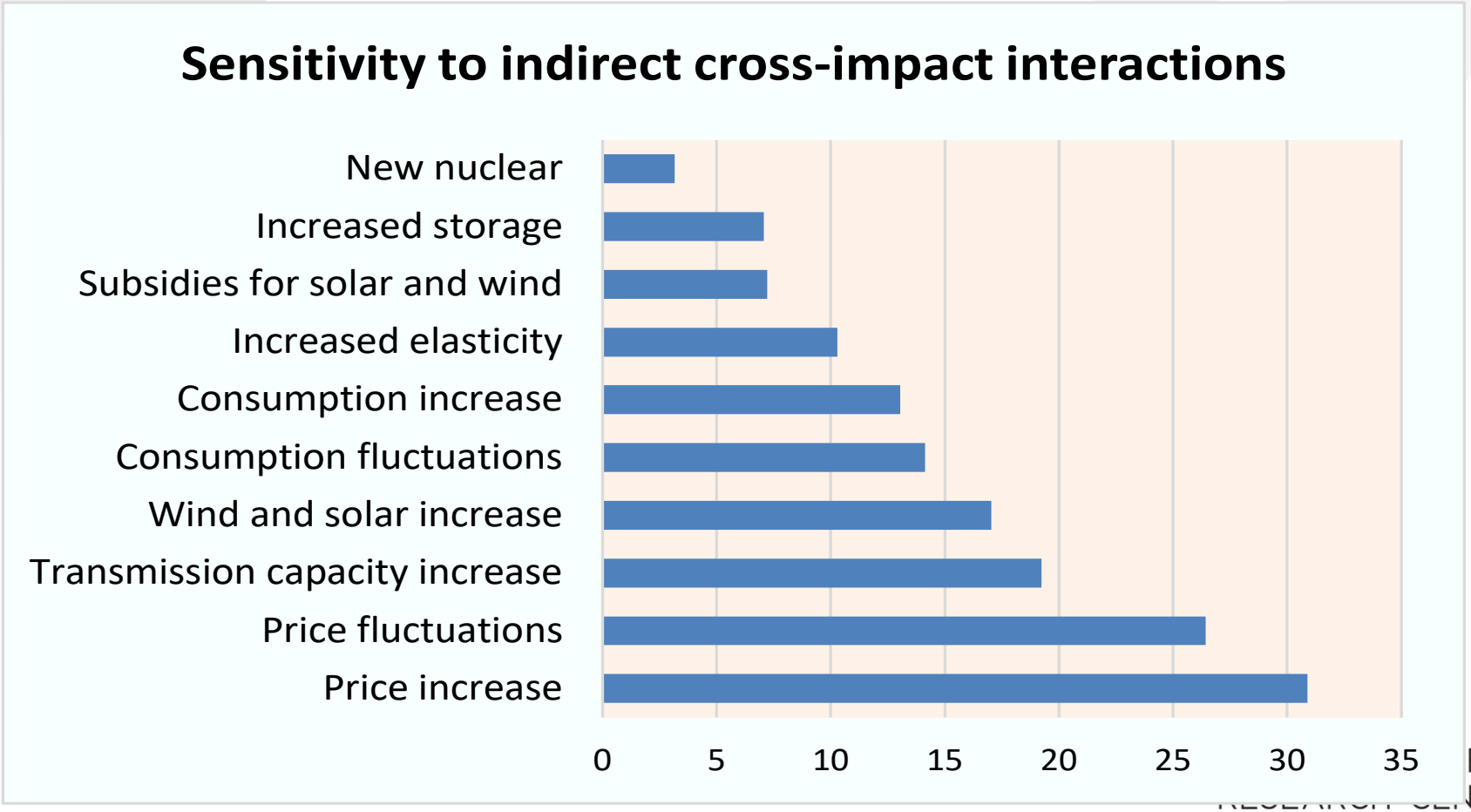
Sensitivity to interactions

Based on the direct and indirect impacts it is possible to calculate the sensitivity of variables to cross-impacts



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Global Pressures
5 Mega Trends

- Climate Change
- Population Growth
- Urbanization
- Globalization
- Digitalization & Technologisation
- Scarcity of Resources

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Trends on European & National Levels

- Effects of Global developments
- STEEPV (social, technological, economic, ecological, political, values)
- Same on national dimensions, and regional, provincial etc.
- And vice versa: Effects of the local on the global

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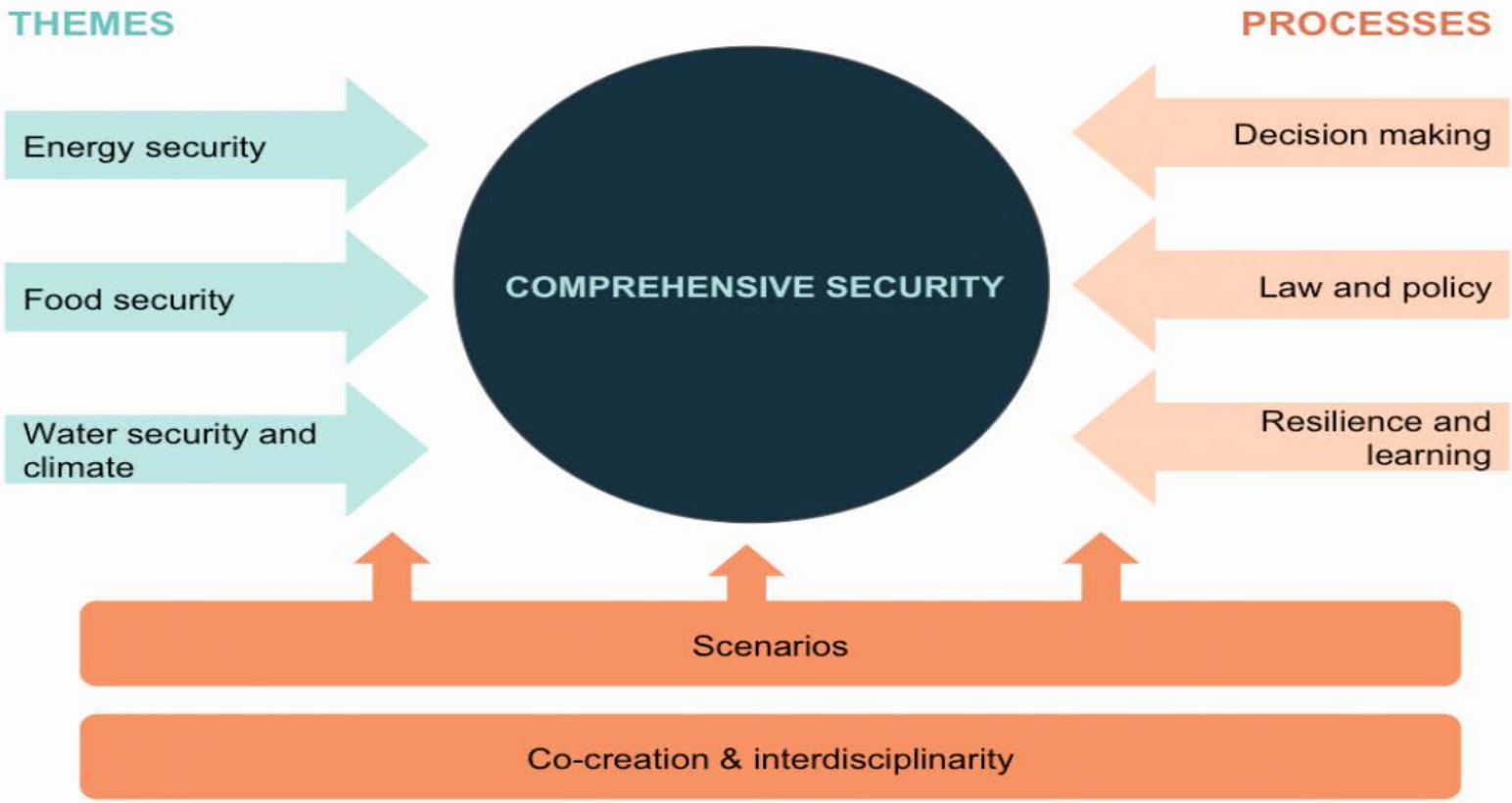
FROM FAILAND TO WINLAND

Research elements



Winland is a ‘strategic research project’ exploring future energy, water & food security in Finland

- *Multidisciplinary consortium consisting of Aalto University, Finland’s Future Research Center, University of Helsinki, University of Eastern Finland, National Defense University, Finnish Environment Institute and Demos Helsinki.*

Our guiding questions

- How do the shocks and pressures to our energy and food system and their related policy measures affect Finland’s comprehensive security in the future?
- How can we improve the resilience of our society? How do we prevent Finland from becoming Failand and proceed toward Winland?

Perspectives and methods

- We investigate these questions through various viewpoints from global to local scale. We take into account systemic pressures that are for instance linked to water use, climate change, geopolitics, and demographics.
- We also look at the key planning and decision-making processes relevant for food and energy security, and for comprehensive security in general.
- Our research approach is interdisciplicinary and even transdisciplinary. We pay special attention to integrating various viewpoints and knowledge together. We apply co-creation and **scenario methodologies that encourage different stakeholders** into dialogue with us as well as with each other.

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Modelling and Scenario Planning

- Path dependence: choices of the research team
- Participative workshops
- ”Experts’” roles: focuses, biases, interests, competences,…
- General metodological problem of policy -oriented research

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THANK YOU

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