Transitions Pathways and Risk Analysis for Climate Change Mitigation and Adaptation Strategies

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TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

Implementation and consequential risks of a solar-based transition pathway in Greece: Insights from a stakeholder-driven analysis

Decarbonising our Energy System

Transformation pathways, policies and markets: spotlight on Greece

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CONTEXT

Motivation

Understanding the dynamics of a solar-based low-carbon transition of the Greek power sector

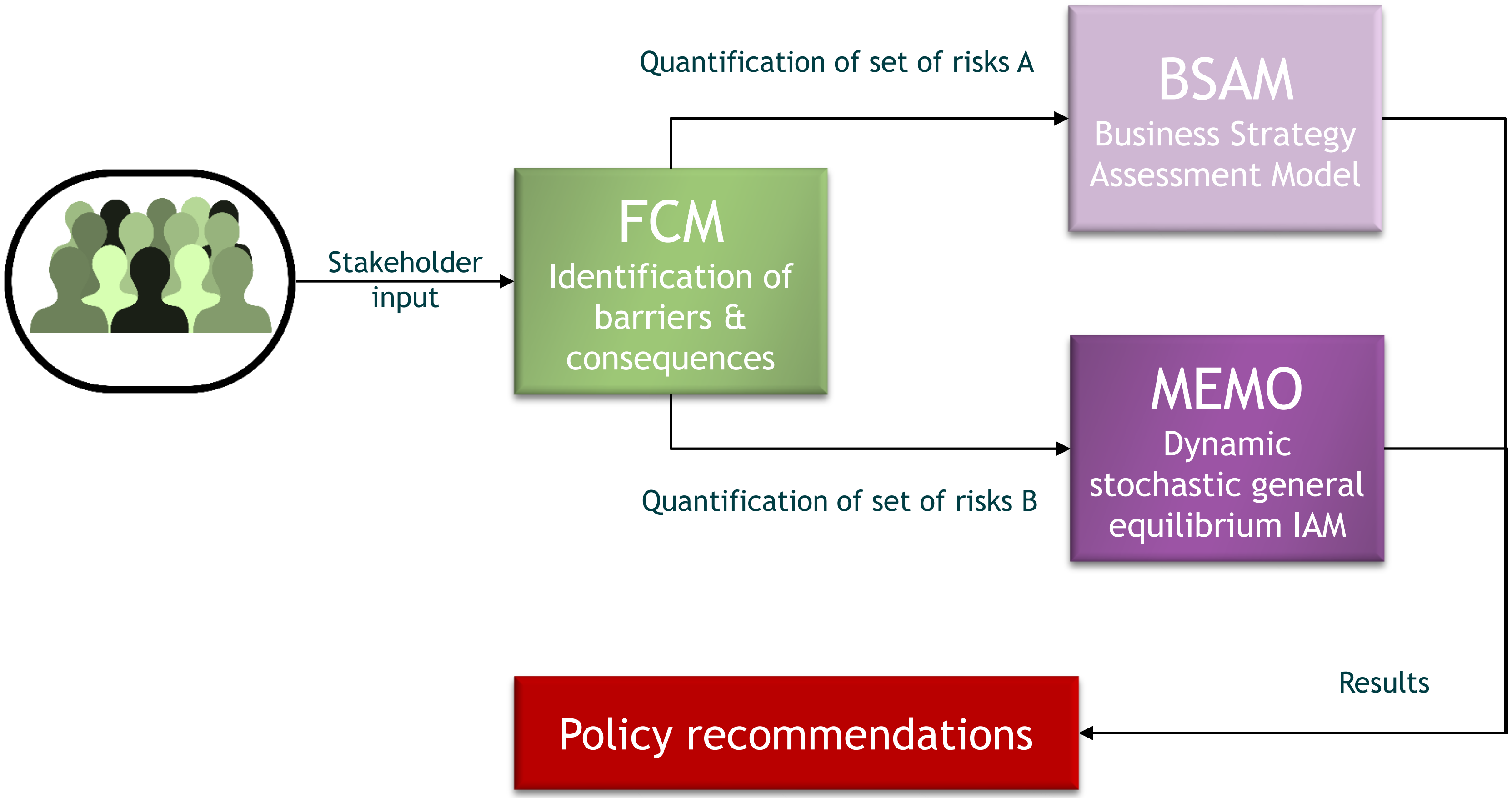
Research questions

- What are the potential barriers to and consequences of such a transition?
- Can they be quantified, in terms of impact?
- How can science respond to actual policy demand?
- Can we bridge the infamous science-policy interface?

Carried out by

NTUA UPRC/TEES IBS

Transdisciplinary Approach

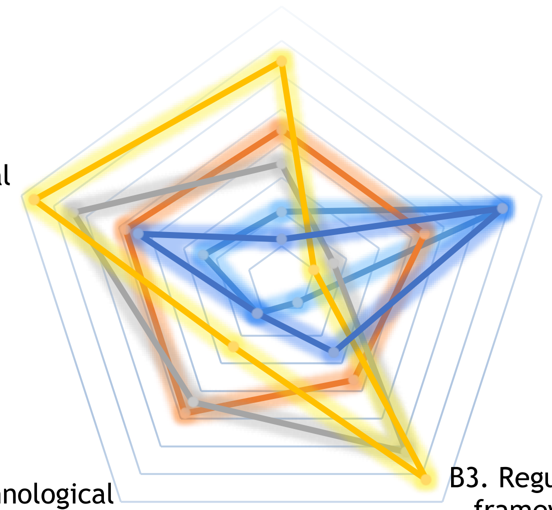


UNDERSTANDING BARRIERS

IMPLEMENTATION RISKS

- **B1**. Ongoing recession
- **B2**. Poor public acceptance
- **B3**. Unstable regulatory framework
- **B4**. High technological costs
- **B5**. Poor political prioritisation

SCENARIOS



IDENTIFYING POTENTIAL CONSEQUENCES

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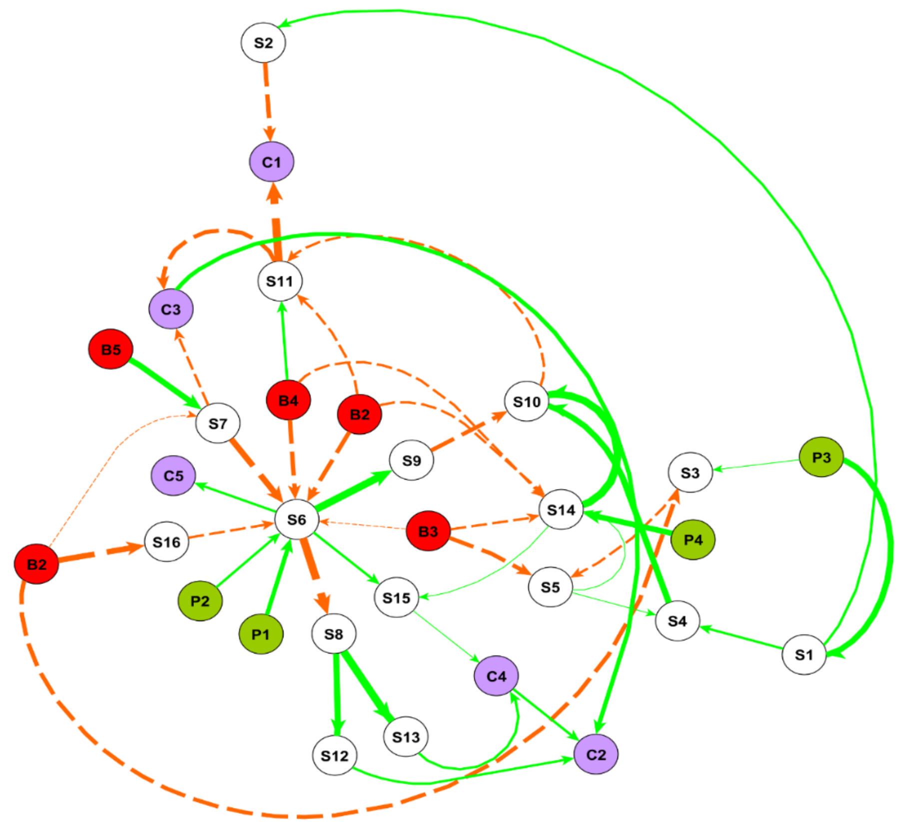
CONSEQUENTIAL RISKS

- **C1.** Costs for end users
- **C2.** Poor economic growth
- **C3.** Investments
- **C4.** Unemployment
- **C5.** Tariff deficits (again)



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Key Stakeholder Findings

- A **prosuming-oriented strategy** perceived to have **positive** socioeconomic impacts along the envisaged transition. Especially in a **high adaptation challenges** scenario.
- A **centralised generation-based pathway** perceived to have **negligible** socioeconomic benefits, unless our **future's trends do not shift from historical patterns**.

More importantly:

- Potential impact of **energy storage** and demand flexibility on **wholesale electricity prices** and, in turn, electricity costs for end users.
- Potential impact of a **wide-scale RES deployment** on socioeconomic indices (**economic growth**, **investments**, **employment**).

Risk Quantification

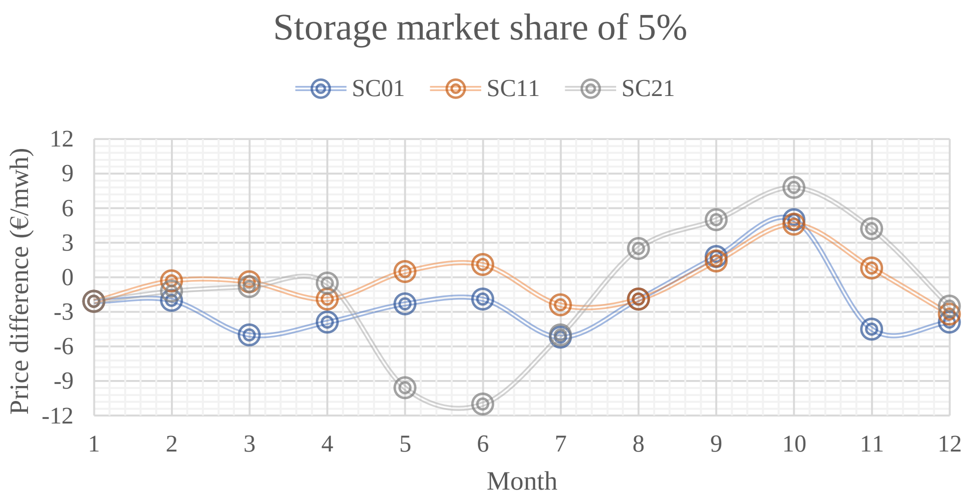
- *Energy storage*
- **Wholesale electricity prices**

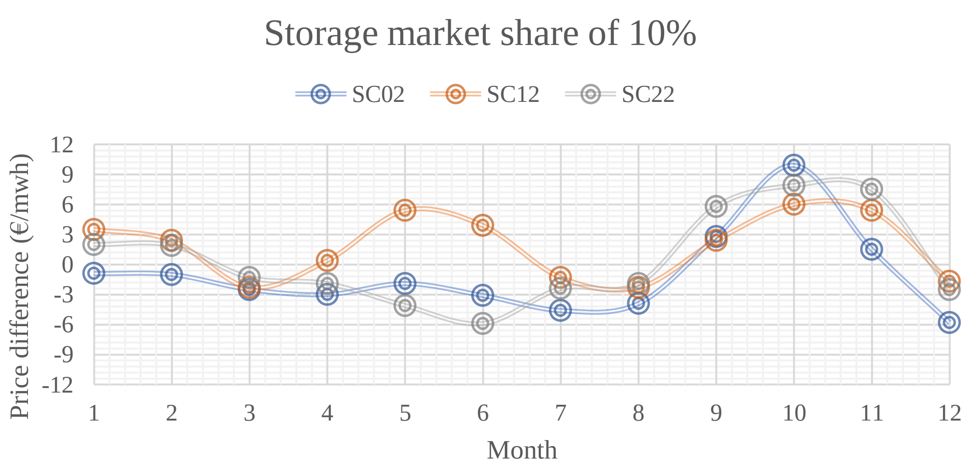
→ **BSAM**
Business Strategy Assessment Model

- *Wide-scale RES deployment*
- *Technological costs*
- **Economic growth**
- **Investments**
- **Employment**

→ **MEMO**
Dynamic stochastic general equilibrium IAM

ECONOMIC RISKS (BSAM)

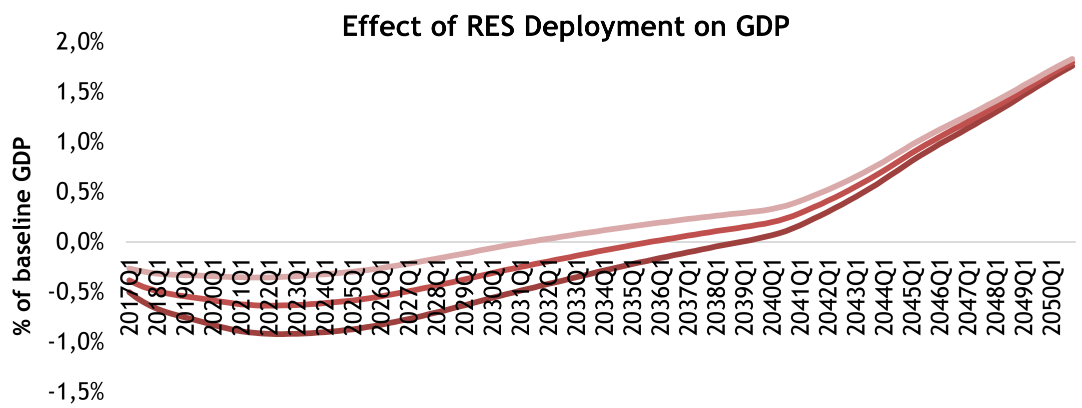


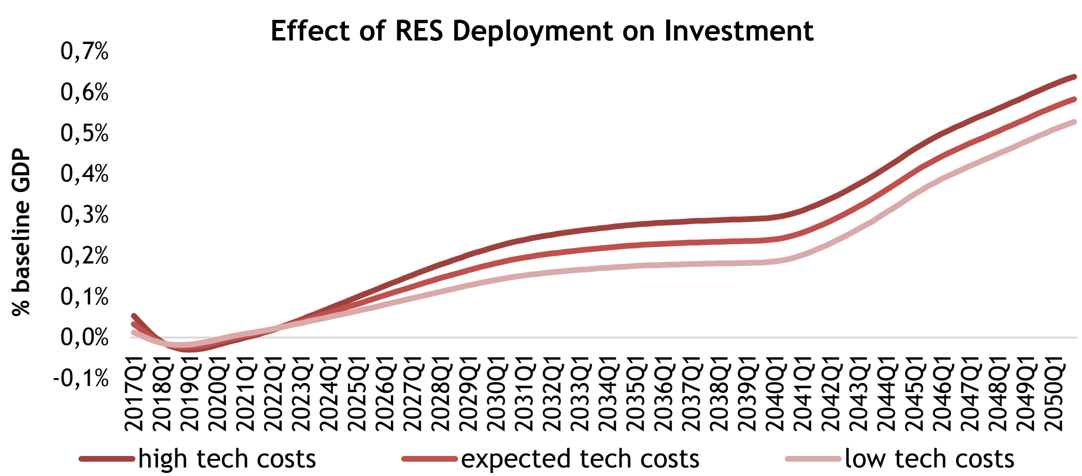


- Self-consumption **favours prosumers:** they offset the energy produced with energy consumed at different times (abolishing the grid's role).
- Combined with the **limited flexibility** of the Greek power system, increasing self-consumption could "force" generators to bid higher.
- Increasing self-consumption will **increase**, for some months of the year, the **price that everybody else pays.**

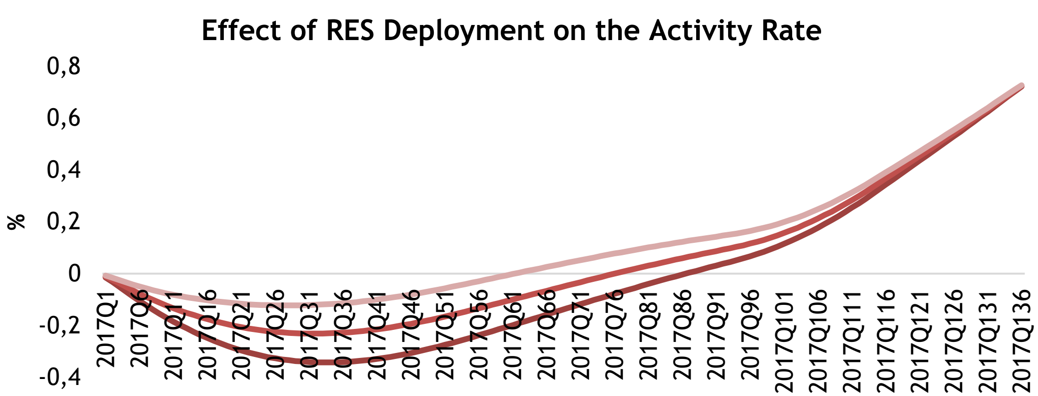
Economic Risks (MEMO)

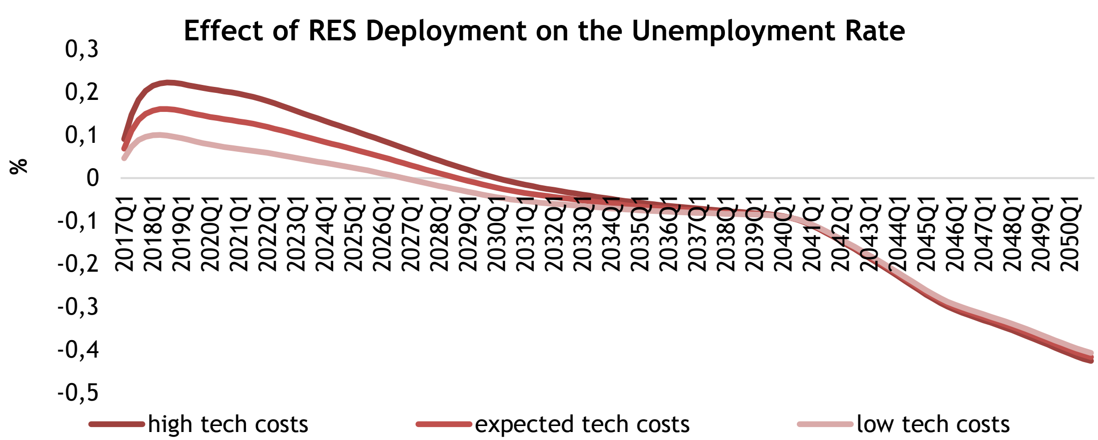
- Across all scenarios, the impact of **RES-E deployment** on the Greek economy becomes **positive by 2040**.
- In **2050**, the Greek **economy** would be **1.8% larger** in the RES scenario than in the BAU scenario; GDP loss never larger than 0.6% (-1% in high technological costs scenario)
- **Investment** goods **fuelled** by inflow of labour and capital.





Social Risks (MEMO)





- Larger wages and better job finding rates encourage activity and a **miners' shift** to other sectors.
- Increase in **demand** for goods, greater real **revenue** for firms, increases in real **wages**, increases in the **number of job vacancies** and higher **chances** of unemployed finding a job.
- **Temporary decrease** in **labour productivity**. Size and length depend on investments/costs.

Conclusions

Renewables can facilitate the country's economic recovery.

Optimising self-consumption is not always beneficial

(if optimality means decreasing the price that consumers without it must pay)

Self-consumption with storage must be evaluated with **decreasing costs for storage**, **new business models** and **regulatory frameworks** (fair allocation of benefits among all actors)

Acknowledging the limitations of modelling activities

Assumptions outdated or unrealistic (e.g. fresh 2030 RES targets for Greece)

Unit commitment problem, grid inflexibility and technical aspects

Rigidity of wages (sectoral level), barriers of entry, structural changes' effect to R&D

Thank You!

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Appendix
(modelling assumptions)

Scenario Assumptions

- Installed PV Capacity: {2016: **2,611** MWp}, {2025: **3,900** MWp}, {2035: **5,900** MWp}
- 3 energy storage (in small-scale PV) market share scenarios: **0%**, **5%**, and **10%**
- Large-scale PV **6 : 1** small-scale
- **Ceteris paribus** (total power demand, fossil fuel prices, water reservoir levels, etc.)
- **Elastic job search intensity** (small wage changes → many workers joining market)
- Electricity demand: **linear trend** {2020: 53 TWh} → {2030: 58.5 TWh}

Cost Assumptions

- For one 1 MW installation (large-scale solar projects): The average annual capacity factor is taken to be 22% and the annual efficiency decrease 0.5%. Furthermore, the operating and maintenance cost is assumed to be equal to 1% of the total investment cost per annum. Investment cost is 1 €/W.

- For small roof-mounted PV systems: The operating and maintenance cost is assumed to be equal to 2% of the total investment cost per annum. The average annual capacity factor for rooftop PV installations is 15%. The annual efficiency decrease has been assumed to be 0.5%. Investment cost is 1.3 €/W.

- The capital cost for onshore wind power systems in Greece is 1.2 €/W. The average annual capacity factor for interconnected wind RES-E farms is 25%.

Assumptions for PV/Wind Capacity

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Year	PV Capacity (MW)	Wind Capacity (MW)
2016	2,443	1,987
2020	2,900	2,831
2025	3,900	3,675
2030	4,900	4,519
2035	5,900	5,363
2040	6,900	6,207
2045	7,900	7,051
2050	8,900	7,900

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Assumptions for Other Technologies

Generation mix for residual demand (%)			
Year	**Lignite**	**Natural gas**	**Hydro**
2016	32	41	27
2020	25	45	30
2025	26	44	30
2030	25	42	32
2035	26	41	33
2040	28	37	35
2045	15	47	38
2050	9	53	38