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# Agent-based modeling for ex-ante policy evaluation: The establishment of Renewable Energy Communities

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# Renewable Energy Communities

- Renewable Energy Communities (RECs) (Van Der Schoor et al., 2016)
  - Collective innovation action
  - Drive the energy system transformation from the **bottom-up**
  - Entails new roles for local communities in the **ownership** and **governance** of the energy system
- Renewable Energy Directive (REDII)
  - Empowers RECs to **produce, consume, store, and sell** renewable energy (RE)
- RECs benefits (IRENA, 2021)
  - Easier to attract **private investments**
  - Support **RE deployment** and **acceptance**
  - Increasing the **flexibility** and **security** of the market
  - Create **socio-economic** and **environmental** benefits for the community
- RECs challenges (Flor et al., 2014)
  - More vulnerable to **regulatory risks** due to **ineffective** and **uncertain policy** support schemes
  - **Profitability** affected by the electricity market related characteristics
- Enabling policy mechanisms should
  - Account for the specific requirements for **local participation**
  - Design ad-hoc **regulatory, financing** and **administrative** solutions

# Complex System Approach to Policy Design

- Socio-technical systems (RECs)
  - People and technologies **interact** through physical and social **networks** governed by institutional and political structures
  - Entail complex system dynamics: self-organisation, path dependency, emergence, co-evolution, adaptation (Bale et al. 2015)
- Policy challenges
  - Systemic interactions
  - Decision-making under uncertainty
- Modelling approaches
  - Agent-based models
  - Dynamic network models
- Complex systems modelling used in policy design to
  - Highlight the uncertainties related to **human behaviors** (Arthur, 2021)
  - Make **uncertainty** more rigorously **explicit** (Stirling, 2010)
  - **Probabilistic** statement about the **trajectories** the system might follow (Jager and Edmonds, 2015)
- Models for ex-ante policy assessment
  - Shed light on the **dynamics** and **uncertainties** involved (Van Daalen et al., 2002)
  - Explore different policies in **virtual 'laboratories'** to generate an understanding of the policy domain (Gilbert et al., 2018)

# The Agent-Based Model

- Features of the model
  - **Heterogeneous** agents (households)
  - **Bounded** rationality
  - Local **interaction**
- It simulate the establishment of a RECs -- energy cooperatives --
  - Joint investment and ownership of PV plant: local **production** and **consumption** of the produced electricity
  - **Sharing** of costs, risks and responsibilities of capital-intensive RE projects (Caramizaru and Uihlein, 2020)
- Theoretical framework
  - **Network theory**: word-of-mouth information sharing drives the dynamic network formation – eco-innovators as driving forces (Sperling, 2017)
  - **Coalition formation theory**: setting up of a strong coalition interested in jointly invest in a community-owned energy infrastructure - higher utility and a cost reduction (Pasimeni and Ciarli, 2018)
  - **Diffusion theory**: agents' behavior is affected by other decisions (Rogers, 2010)
  - **Value creation**: fair allocation rule to ensure long-term stability of REC - increasing self-consumption levels creates more value for the community (Tounquet, 2019)

# Why Useful for Policy Design

- Representation of key dynamic **mechanisms** in the system evolution
- Explicit **representation** of one or more policy interventions in the different REC development stages
  - **Behavioural interventions**
    - Social norms marketing campaigns as a tool for advancing communication (Acosta et al. 2018)
  - **Regulatory intervention** -- shift to market incentives --
    - Feed-in-Tariffs (FIT)
    - Feed-in-Premiums (FIP)
    - Sliding Feed-in-Premiums (Sliding FIP)
- **Calibration** of the model for ex-ante policy evaluation
  - Issues and opportunities of new **data** availability (Fontana and Guerzoni, 2021)
  - **Context dependent** heterogeneity of the socio-economic and cultural conditions (Massey et al., 2018)
  - **Model replicability** using different empirical variables (Van Daalen et al., 2002)
- Sound **modeling principles** of adequate calibration and validation techniques to ensure model replicability (Grimm et al., 2005)

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## Thank you for your attention!

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