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# Neo-Carbon Energy Market designs for a 100% renewable energy system

LUT School of Energy Systems

Samuli Honkapuro

Kaisa Salovaara

Mari Makkonen

Olga Gore

Dmitry Bogdanov

[Samuli.Honkapuro@lut.fi](mailto:Samuli.Honkapuro@lut.fi)



NEO  
CARBON  
**ENERGY**



# Electricity market studies in NCE WP 1

## 1. Electricity market framework in Neo-Carbon Energy Scenarios

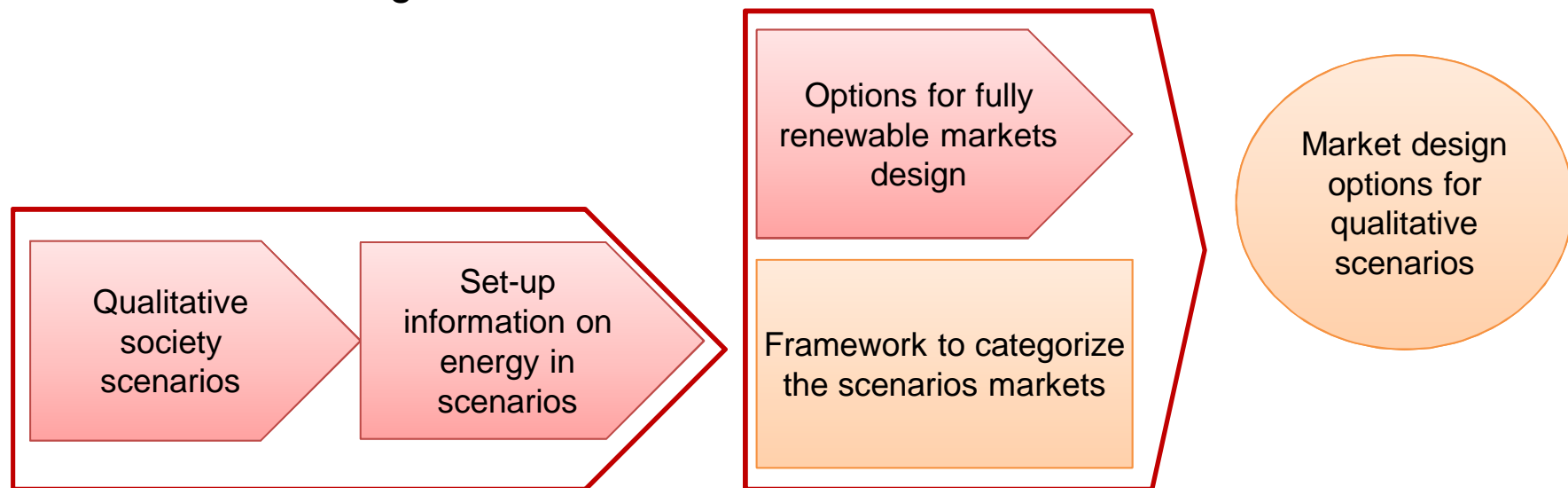
- Salovaara, K., Makkonen, M., Gore, O., Honkapuro, S. *Electricity Markets Framework in Neo-Carbon Energy 2050 Scenarios*. Neo-Carbon Energy WP 1 working paper 3/2016. ISBN 978-952-249-419-1. Lappeenranta University of Technology 2016.
- Salovaara, K., Makkonen, M., Honkapuro, S. *100 % Renewable Energy System - Challenges and Opportunities for Electricity Market Design*. Proceedings of 13th International Conference on the European Energy Market, EEM 2016

## 2. Agent-based simulations of market designs in 100 % RES system

- Gore, O., Bogdanov, D., Salovaara, K., Honkapuro, S. *Market designs for a 100% renewable energy system*. LUT Scientific and Expertise Publications 56. ISBN 978-952-265-973-6. Lappeenranta University of Technology 2016.

# Electricity market framework in Neo-Carbon Energy scenarios

- We have looked at the 100 % renewable energy systems in year 2050 through society scenario descriptions
- We described a framework for electricity market designs in four transformative, qualitative scenarios
  - Analyses of the feasible energy markets designs in four transformative neo-carbon scenarios.
  - Identifying the required elements of the market design that enable each scenario.
  - In the process, we highlight the key issues in determining applicable market designs.

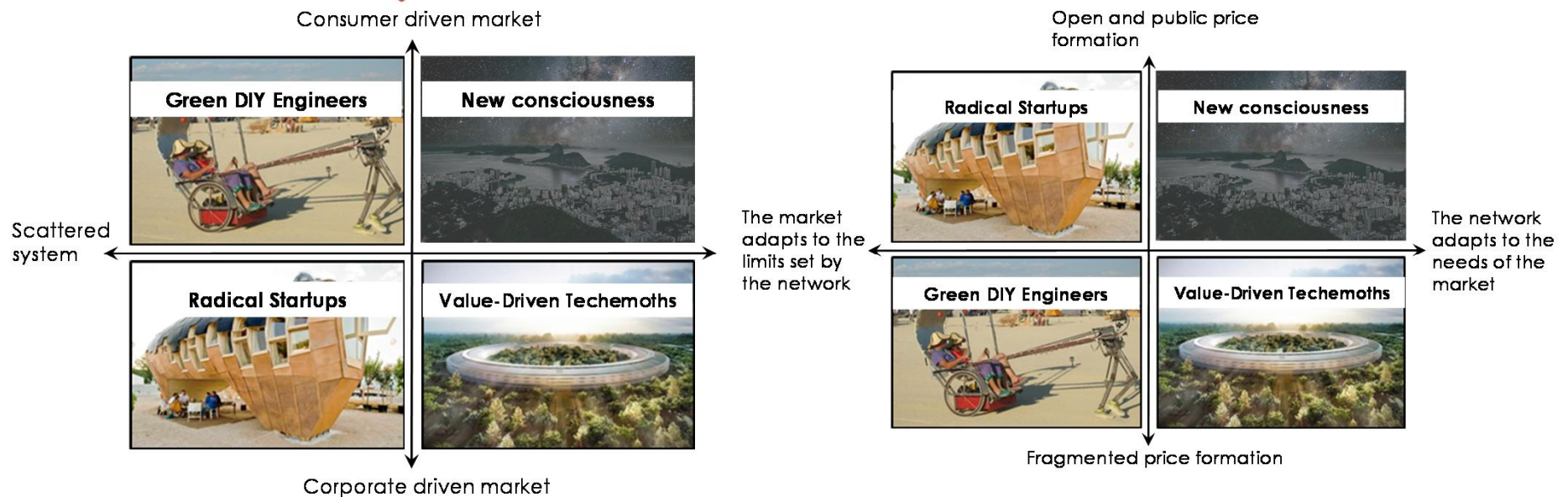


TRANSFORMATIVE SCENARIOS 2050 FOR NEO-CARBON ENERGY

























Deep ecology	<p><b>Radical startups</b></p> <p>Society is business-oriented, but economy is driven by a multitude of small-scale startups known for their "radical" values and approaches.</p> <p>Environmental problems are solved commercially. Businesses are drivers of new, ecologically oriented lifestyles.</p>	<p><b>New consciousness</b></p> <p>Deep ecological values and distributed models have led to altogether new kind of consciousness and worldview.</p> <p>Environmental problems are not seen as practical issues but calling for deeper changes in values and mindsets.</p>
Ecological awareness	<p><b>Value-driven "Techemoths"</b></p> <p>Peer-to-peer approaches are common, but they are practiced in more or less traditional organisations.</p> <p>Markets take care of environmental issues.</p>	<p><b>Green DIY Engineers</b></p> <p>Engineer-oriented citizens have organized themselves as local communities to survive ecological collapse.</p> <p>Environmental problems are solved locally, with a practical mindset.</p>

Corporate ("Centralized" peer-to-peer) ← Peer-to-peer → Neo-Communal (Distributed peer-to-peer)

# Framework for market design



# The estimates of the applicability of the market designs to different scenarios

PRICING MECHANISM/SCENARIO	RADICAL STARTUPS	TECHEMOTHS	DIY ENGINEERS	NEW CONSCIOUSNESS
MARGINAL PRICING WITH ZONAL				
MARGINAL PRICING WITH NODAL				
PAY-AS-BID				
MARGINAL COST BASED DISPATCH AND PRICING ON LCOE				
COST OF SERVICE				
OVER THE COUNTER TRADING				



Extremely suitable



Moderate suitable



Very suitable



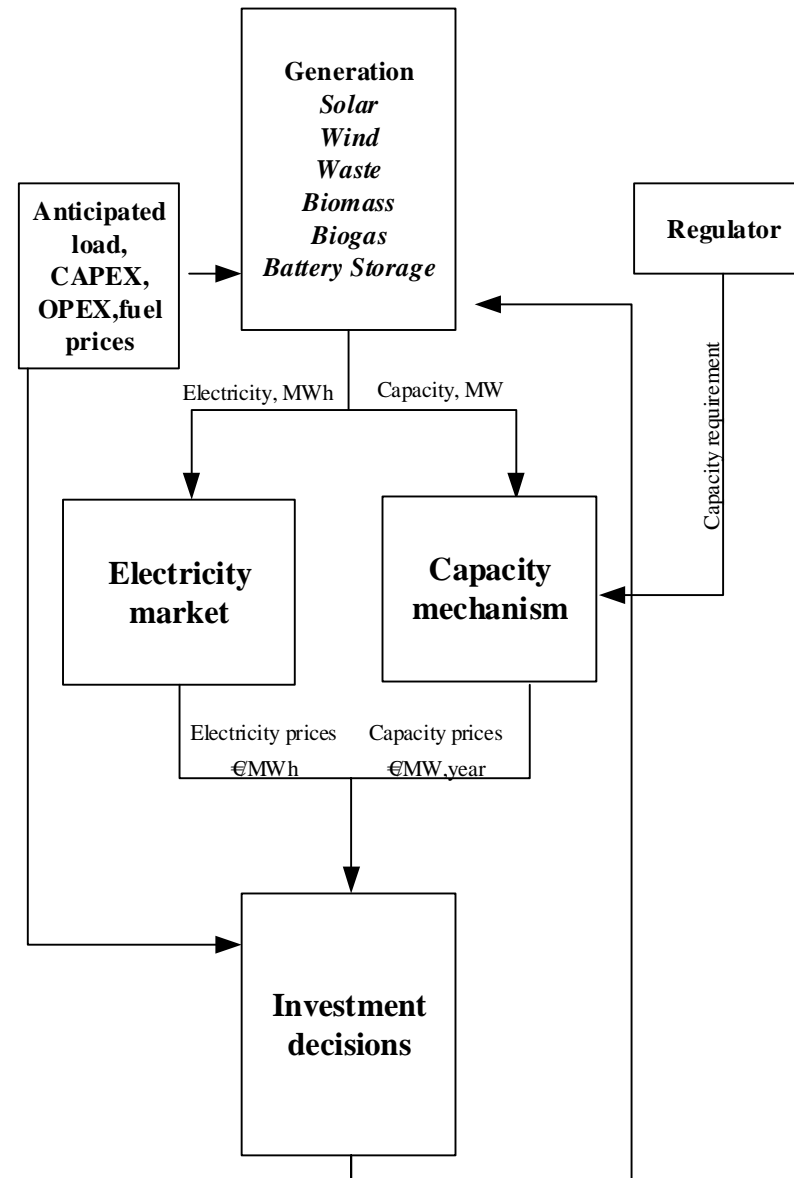
Slightly suitable



Not at all suitable

# Market designs for a 100% renewable energy system

- Testing the feasibility of different market design models in the 100% RES.
- Behavioral simulations
- Studying the impacts of market design on short-term operation (hourly resolution) and long-term investment decisions (yearly resolution)



## *Studied market designs*

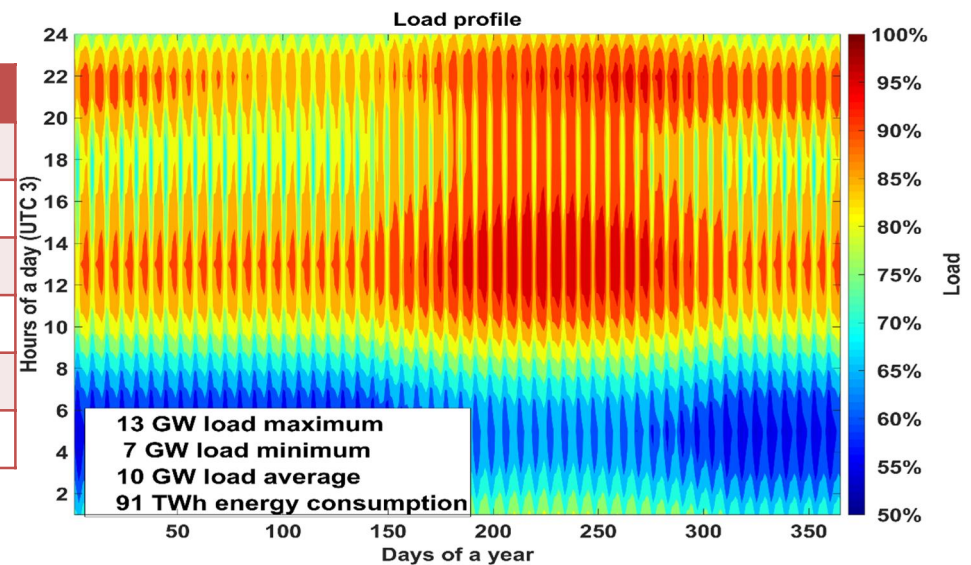
	MARKET DESIGN	ELECTRICITY MARKET	CAPACITY MECHANISMS
EO	"ENERGY ONLY" MARKET	POOL WITH Marginal pricing	No
EO-CA	"ENERGY-PLUS-CAPACITY" MARKET	POOL WITH Marginal pricing	Pay-as-bid Capacity Auction
EO-SR	"ENERGY-PLUS-STRATEGIC RESERVE" MARKET	POOL WITH Marginal pricing	Strategic reserve



# Case study with Israel input data

- Simulated time-frame 2030 – 2050
- Assumption of 100 % RES generation with optimal (least cost) generation mix for year 2030

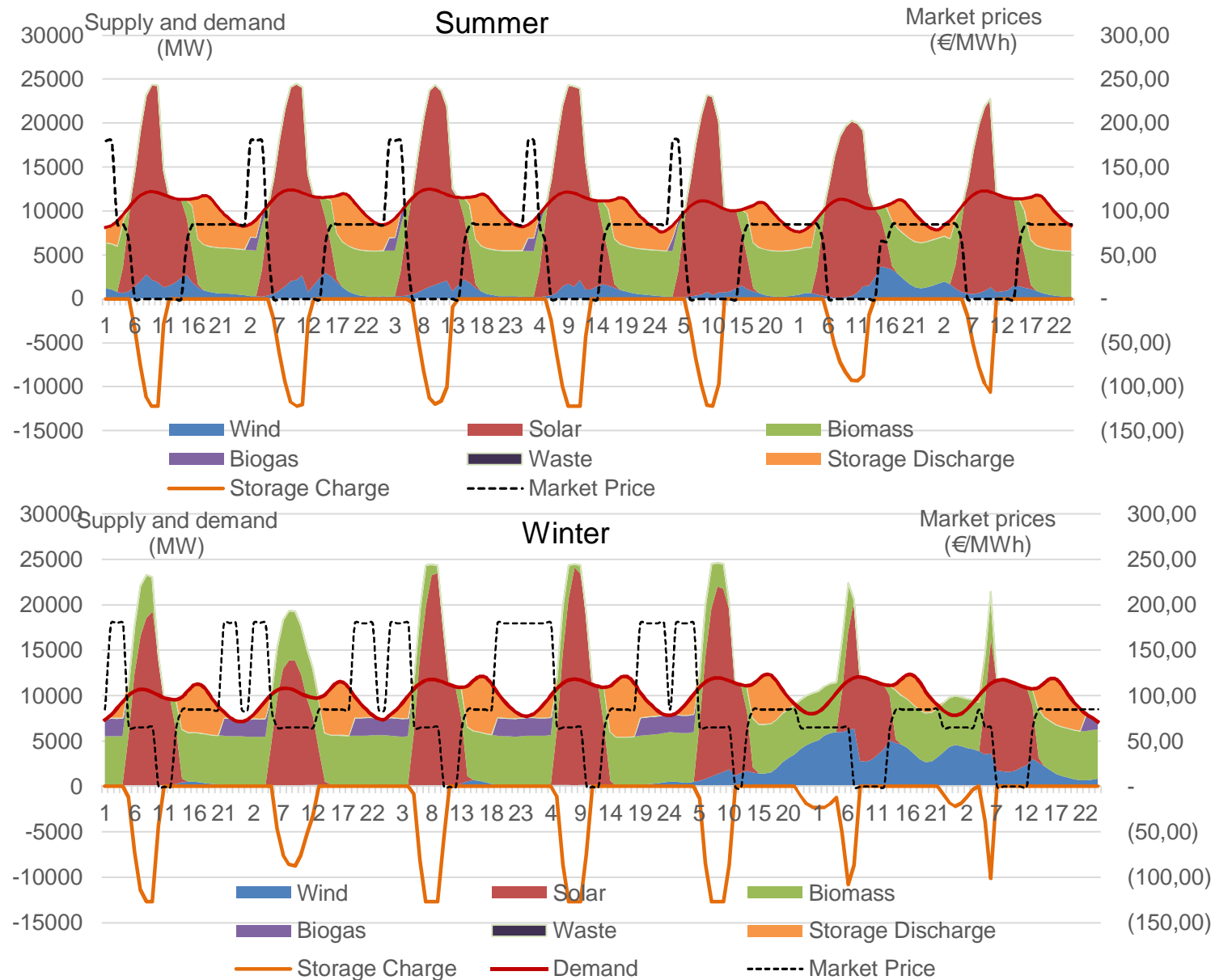
Technology	Baseline generation mix [MW]
PV	32997
Wind onshore	6978
Biomass	5222
Biogas	1512
Waste	28
Battery	10368



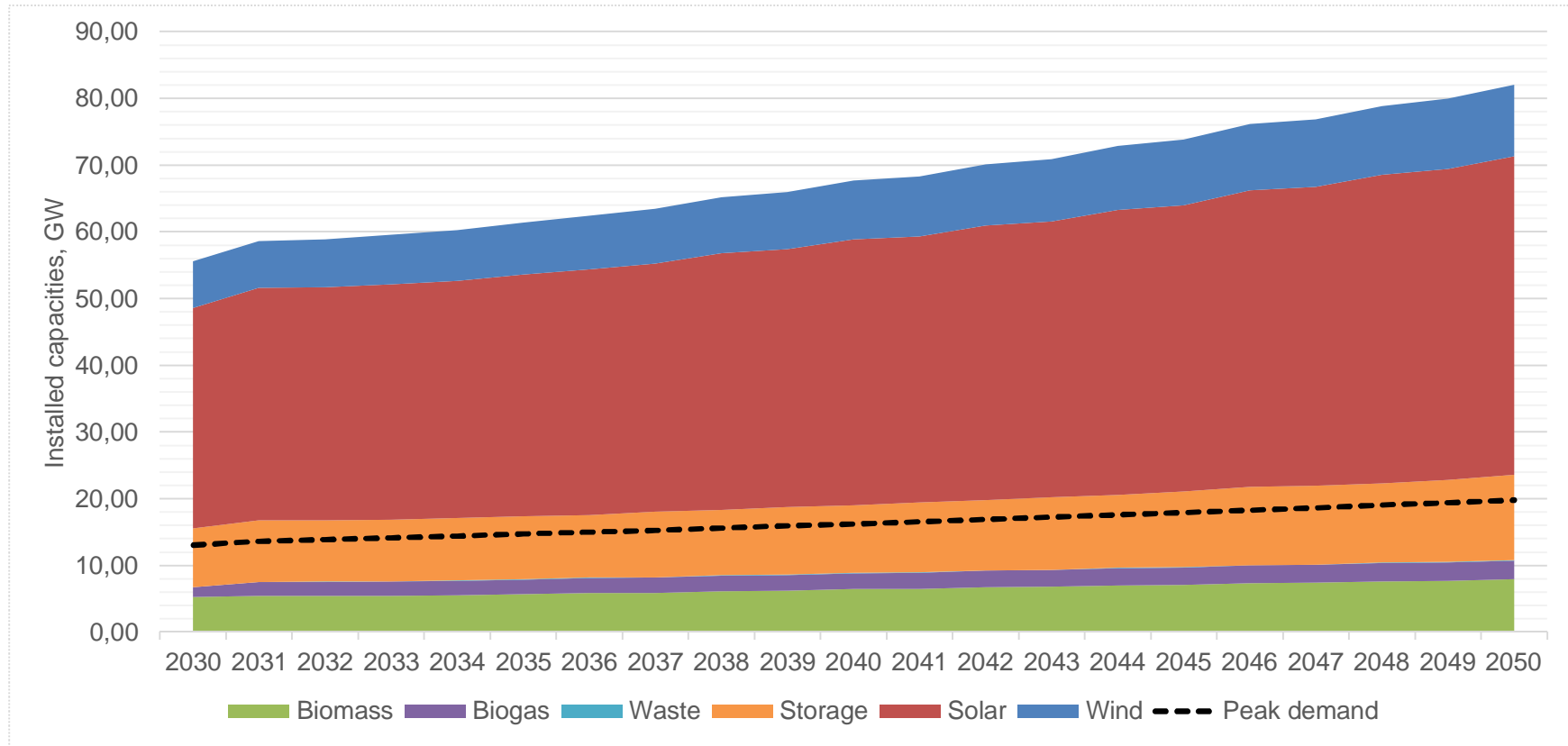
# *Case study with Israel input data – technical and financial assumptions*

Technology	Capex [€/kW]	Opex [€/kW]	MC [€/kWh]	Lifetime [a]
PV	550	8	0	30
Wind onshore	1000	20	0	25
Biomass CHP	2500	175	0.065	30
Biogas CHP	370	14.8	0.085	30
Waste incinerator	5240	235.8	-0.015	20
	Capex [€/kWh]	Opex [€/kWh]	MC [€/kWh]	Lifetime [a]
Battery	150	10	-	10

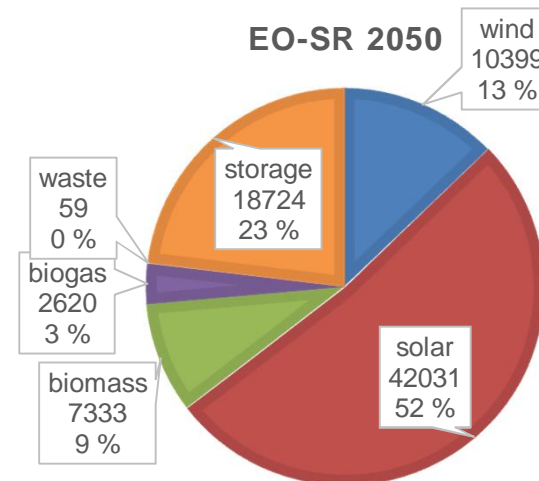
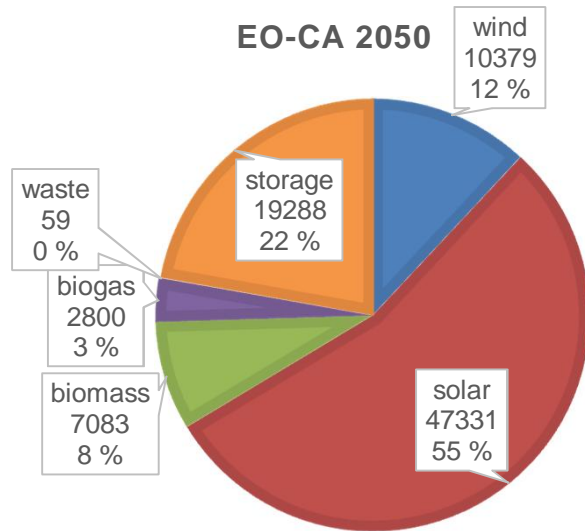
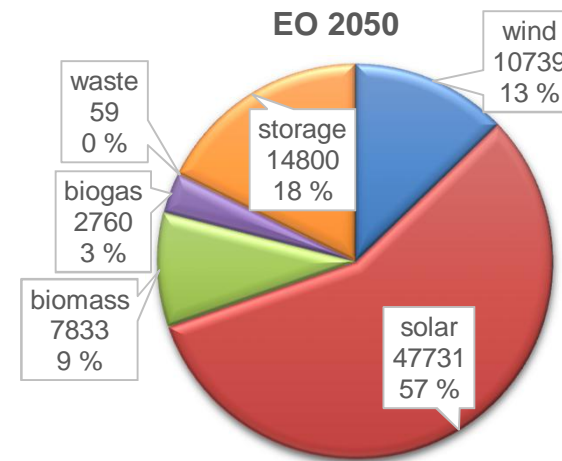
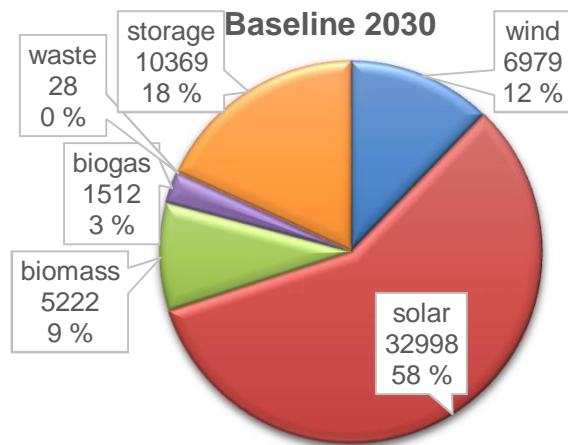
# Supply – demand profiles and prices



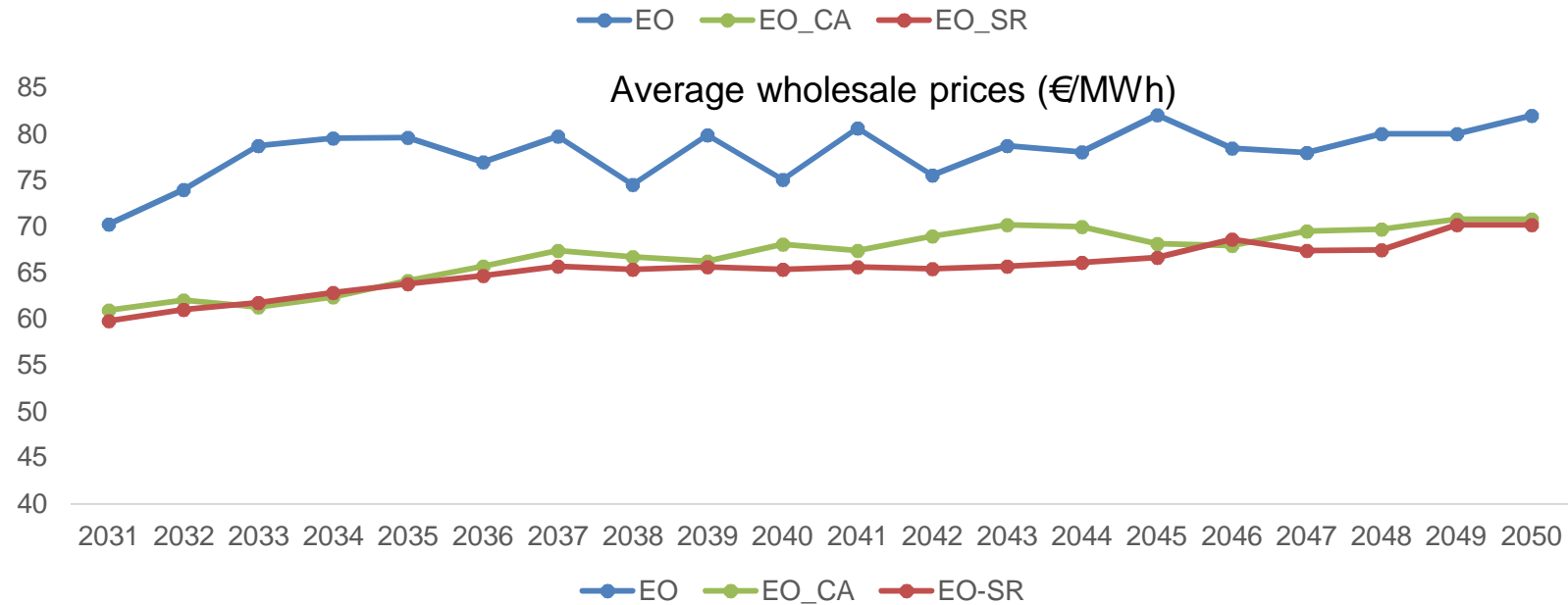
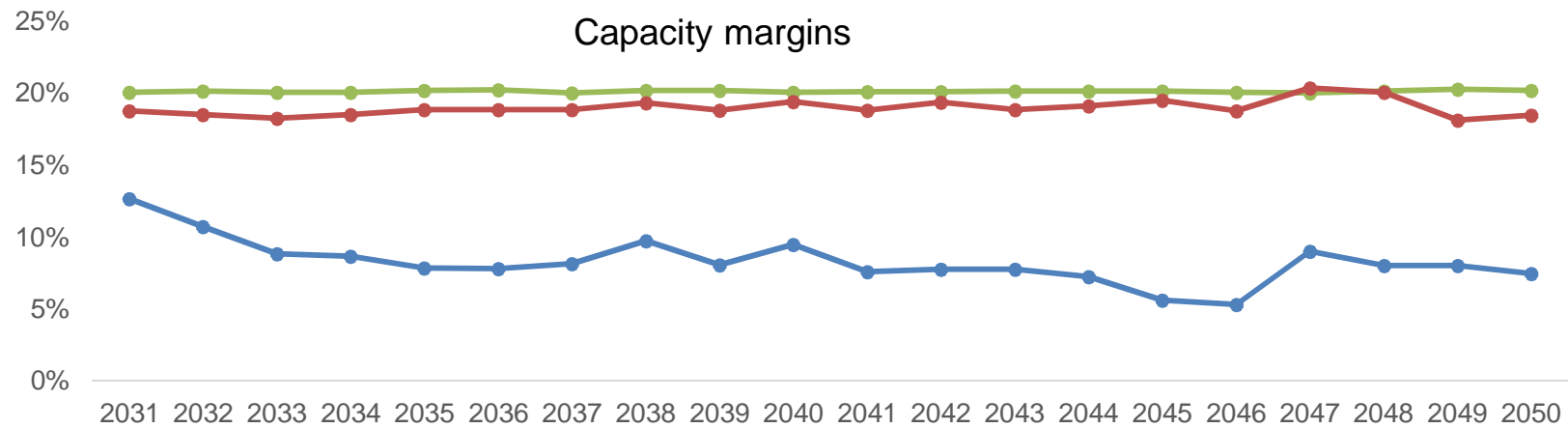
# *Evolution of installed capacity – EO market design*



# Evolution of installed capacities (MW and %)



# Capacity margin and average prices



# Summary of results

Market design	EO	EO-CA	EO-SR	
LOLE (h/year)	5.75	0	0	
RES curtailment in % of total production	15 16	17 25	18 27	wind solar
Average electricity price €/MWh	77.5	66.5	65.0	
Average capacity price €/MW,year		71,000		
Total bill of generation billion €per year (average over 20 years)	12.38	12.18	11.93	Total
	3.65	1.4 3.4	1.03 3.7	Capacity
	8.73	7.38	7.2	Solar surcharge Energy
Total system costs billion €per year (average over 20 years)	9.54	10.07	9.75	

# Publications



Gore, O., Bogdanov, D., Salovaara, K., Honkapuro, S. *Market designs for a 100% renewable energy system*. LUT Scientific and Expertise Publications 56. ISBN 978-952-265-973-6. Lappeenranta University of Technology 2016.

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