# SOLARX final Workshop

## WP5: Economic, environmental and social assessment

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# Agenda

SOLAR X

- Presentation of key results from the different WP5 tasks
- **Task 5.1: Economic impact in 2030/2050 power grid and power mix—electricity and H2**
  - *Lead: EMD (contact: Anders Andersen)*
  - *Co-lead: DTU (contact: Matti Koivisto, Sumanth Yamujala)*
- **Task 5.2: Environmental assessment including LCA**
  - *Lead: DTU (contact: Alexis Laurent, Hannah Marie Huth, Aude Bechu)*
- **Task 5.3: Stakeholders mapping and value proposition analysis**
  - *Lead: CNRS (contact: Céline Verchère)*
- **Task 5.4: Social acceptance and recommendation for integration of SOLARX system**
  - *Lead: CNRS (contact: Céline Verchère)*

# Task 5.1: Economic impact in 2030/2050 power grid and power mix: electricity and H2

# Overview of workflow

SOLAR X

- Decarbonisation pathways towards 2050, technology-wise dispatch and electricity prices

CorRES → Balmorel → Scenarios

**CorRES**

- Gives the VRE time series and capacity factors
- Uses 40 years of historical weather data from ERA5 and GWA
- Only one weather year is used for Balmorel studies at this point (computational complexity)

https://corres.windenergy.dtu.dk/

**Balmorel**

- Open-source energy system optimization model
- Bottom-up and deterministic approach
- Optimizes energy system investments while accounting for CAPEX, OPEX, and energy-specific constraints

**Scenarios**

- Represents diverse outlooks and perspectives
- Each scenario describes a pathway under the restrictions/assumptions under study
- Hourly schedules, electricity and $H_2$ prices

https://www.balmorel.com/

# Scenarios and Geographic Scope


Regions in Balmorel Energy System Model

**Level of Sector Coupling**

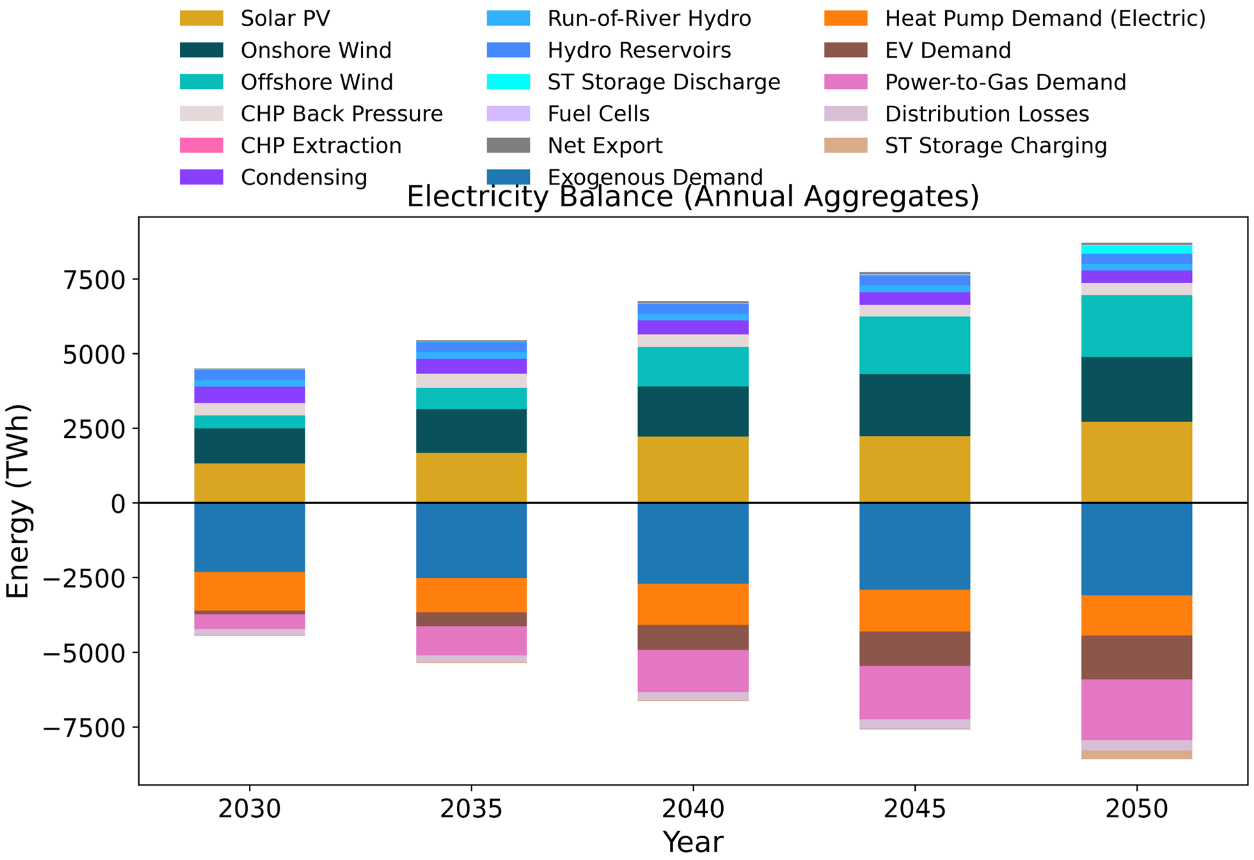
Scenarios

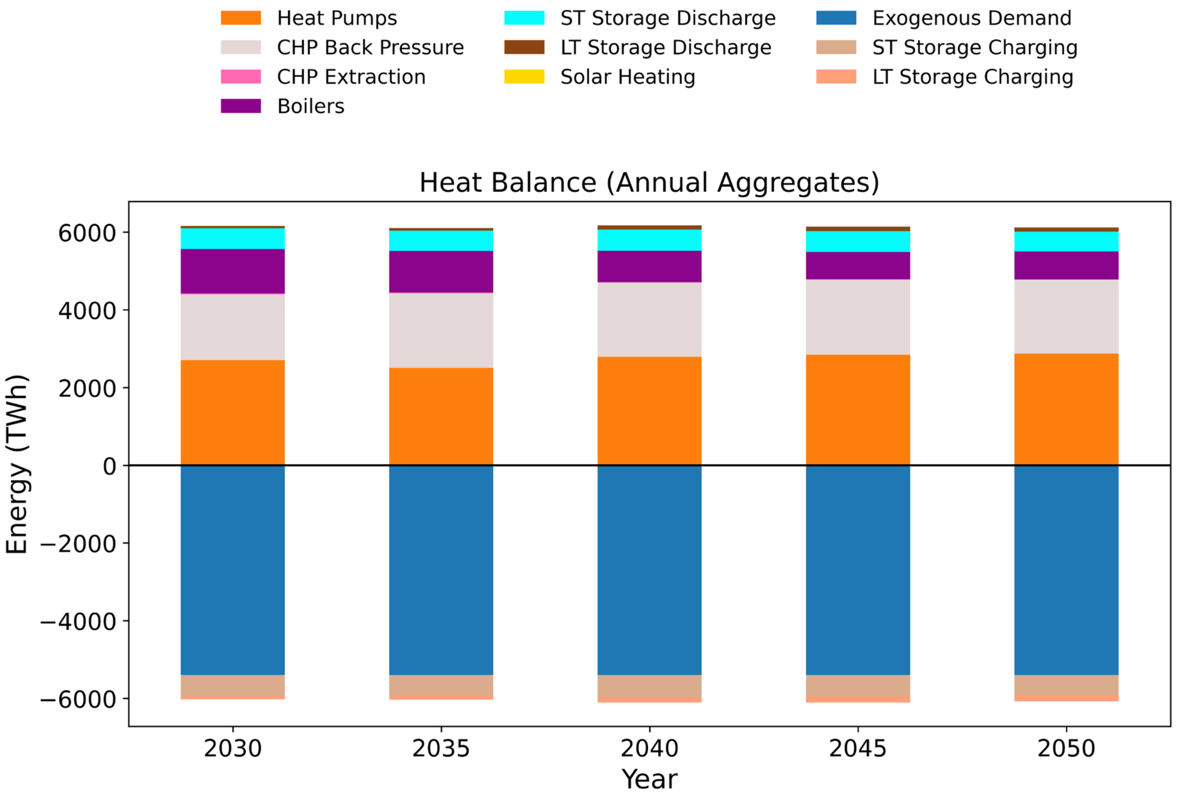
- Electricity and Heat (EH)
- Electricity Heat and Transport (EHT)
- Full Sector Coupling (FullSC)

Base | LC-Wind and HC-Solar | HC-Wind and LC-Solar | High NGP | High Storcost (x5)

| Sub Scenario | Wind Tech cost | Solar Tech cost | Natural gas prices | Energy storage cost |
|---|---|---|---|---|
| Base | 1 | 1 | 1 | 1 |
| LC-Wind and HC-Solar | 0.7 | 1.3 | 1 | 1 |
| HC-Wind and LC-Solar | 1.3 | 0.7 | 1 | 1 |
| High NGP | 1 | 1 | 5 | 1 |
| High Storcost (x5) | 1 | 1 | 1 | 5 |

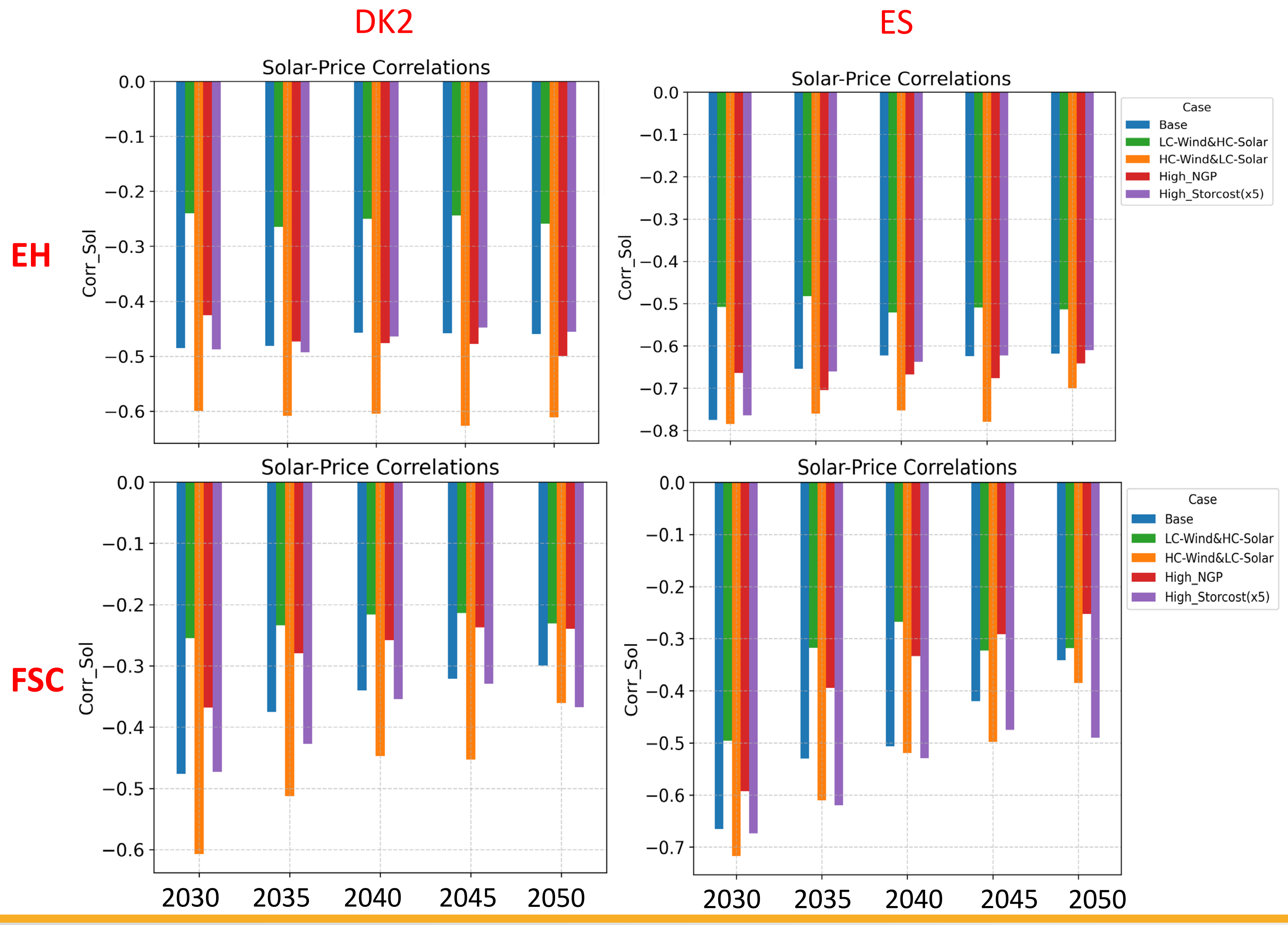
# Supply -Demand Balance towards 2050




- Electricity demand is expected to double between 2030 and 2050
- Electrification of heat, transport, and H2 contributes to it
- VRE sources meet at least 60% of electricity needs starting in 2030
- Heat pumps play a significant role in the heat sector

# Correlation between Solar and Prices

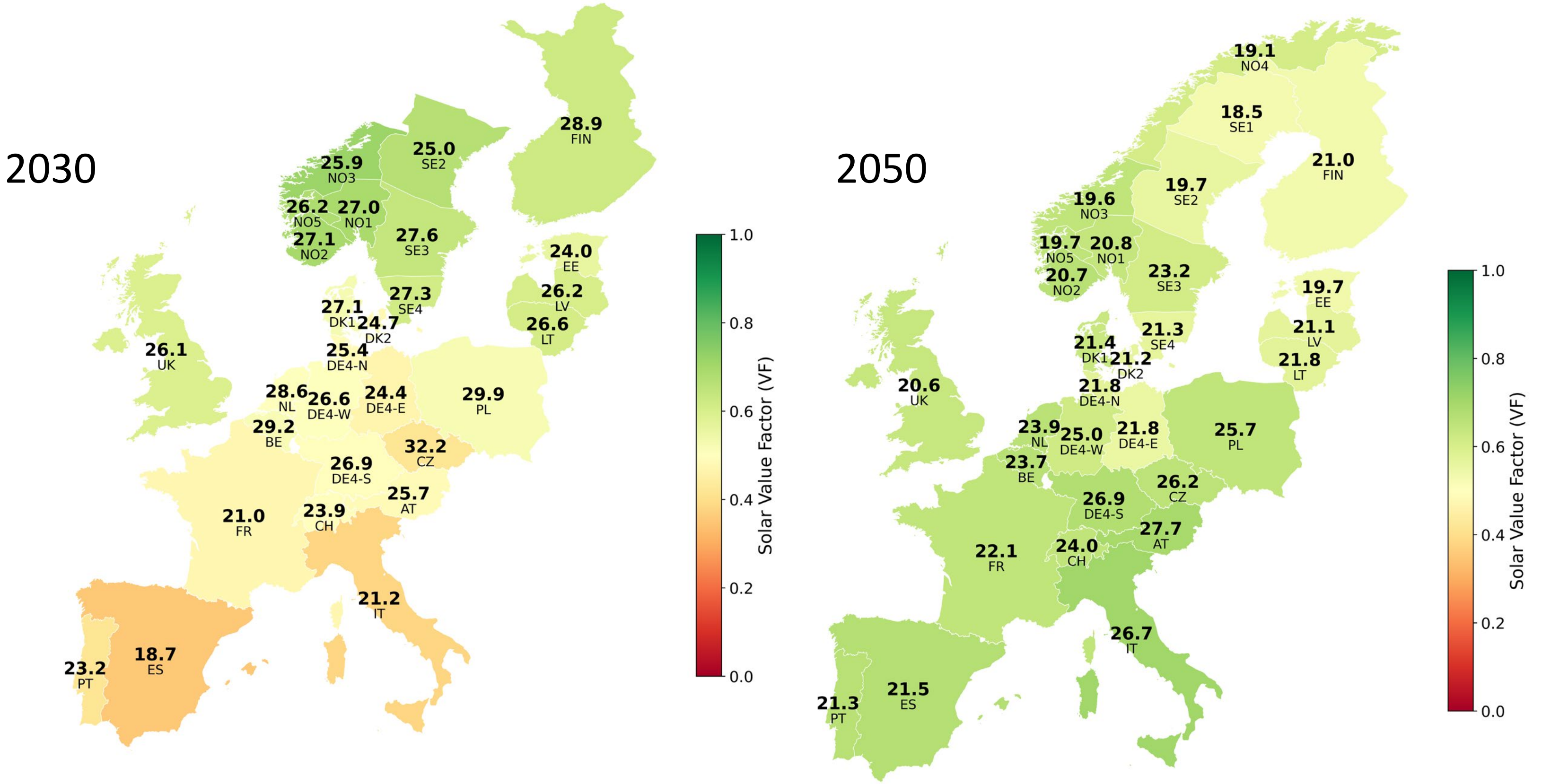



- Under low levels of sector coupling, **Solar shows a strong negative correlation to electricity prices towards 2050**
- **More pronounced in southern regions**

- As the level of sector coupling increases, Solar-Price correlations improves, but remains negative
- Due to sectoral alignment – EV charging and H2 production

# Solar Economics towards 2050

- VRE, due to their lower operating costs, cause the Merit-order effect and self-cannibalisation
- **Market value** - average price that a generator is capturing (Euro/MWh)
- **Value Factor** – Ratio of Market value to average wholesale prices (capture rate)




Market value (text) and Value factor (colour) of solar in the Fully Sector-coupled Scenario

- By 2030, solar technologies, especially in Southern Europe, **can only capture as low as 20% of average electricity prices**
- With stronger sector coupling, the VF increases to at least 50%, with greater improvements in the South
- **MV decreases towards 2050**, especially due to declining average wholesale electricity prices

# Applying the scenario data to analyse SOLAR business case

SOLAR X

| Parameters (Units) | Usecase 2: Electricity and H2 Market | | | Usecase 1: only Electricity Market | | |
|---|---|---|---|---|---|---|
| | Denmark | Germany | Spain | Denmark | Germany | Spain |
| Performance Metrics – Financial and Technical | | | | | | |
| NPV/CAPEX | 0.53 | 0.19 | 2.87 | -0.52 | -0.57 | 0.05 |
| NPV [M€] | 32.75 | 12.22 | 162 | -43.45 | -52.37 | 5.71 |

- The economic viability of SOLARX is the strongest when it **can generate hydrogen, switching optimally between producing electricity and hydrogen**
- **Spain showed the strongest business case for SOLARX**, offering higher NPV/CAPEX, revenues, electricity and hydrogen production

SOLARX Deliverable D6.9

# Task 5.2: Environmental assessment including life cycle assessment (LCA)

## The Goal of LCA

- **identify environmental benefits** and **potential environmental trade-offs** of scaled systems compared to existing technologies.

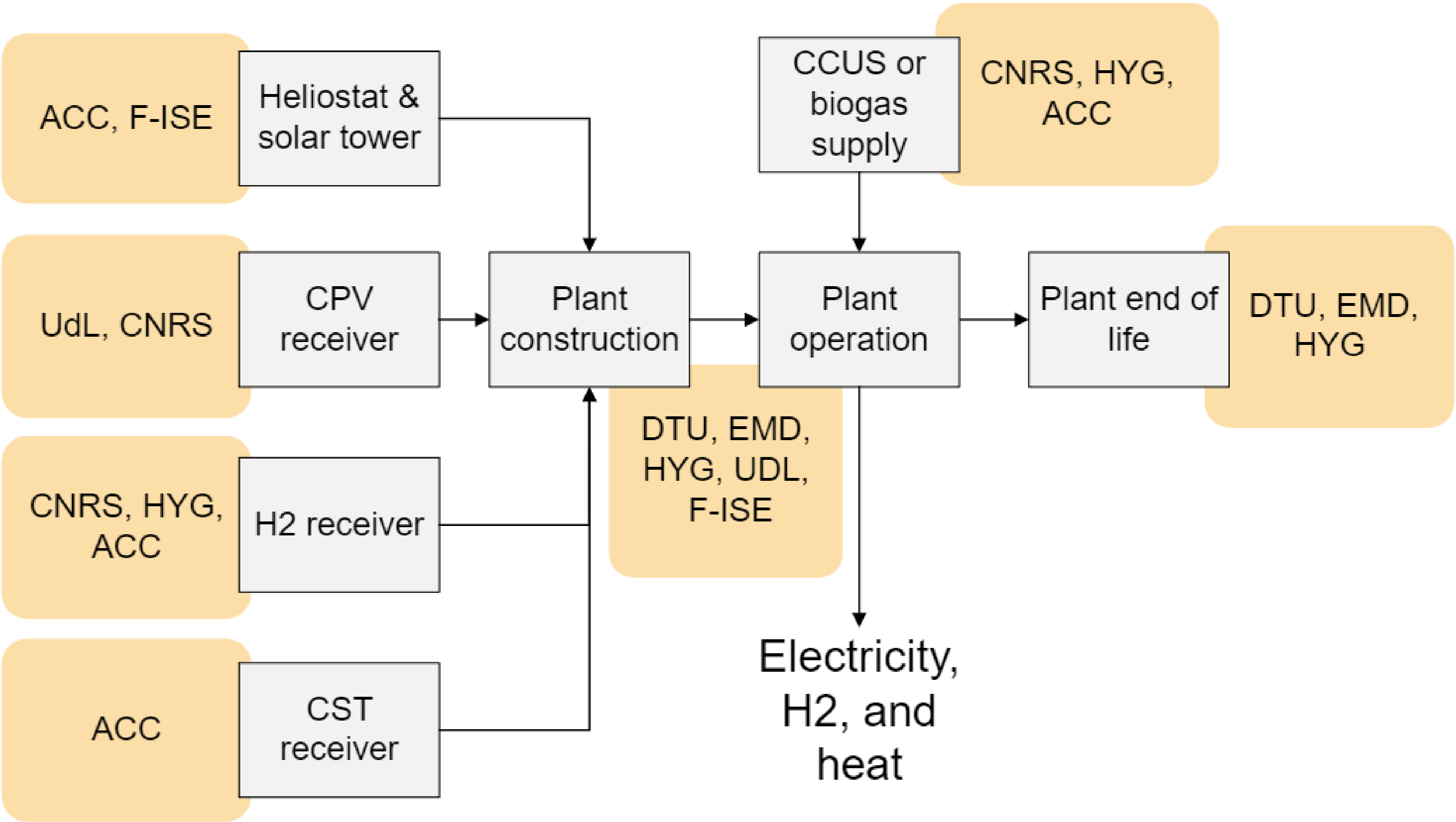
## Actions

1. Collection of **life cycle inventory (LCI) data** (e.g. materials requirements, energy requirements, waste amounts, efficiencies, lifetimes, etc.) from the other WPs → development of prospective LCI datasets
2. Prospective LCI modelling & LCA applied to **technologies in the project** (incl. different alternatives, if relevant, e.g., different materials) → LCA for optimized SolarX systems defined by Task 4.2
3. **Market implemented assessment of Solar-X** & **comparison with functionally-equivalent systems** to identify potential benefits compared to existing alternatives

→ **Deliverable D5.2 (DTU, M36): Life cycle assessment report on benefits/challenges and strengths/weaknesses of SolarX (hotspot analysis & comparison with other systems)**

# Task 5.2: Collection of life cycle inventory (LCI) data

Collection of **life cycle inventory (LCI) data**



# Task 5.2: Environmental assessment including life cycle assessment (LCA)

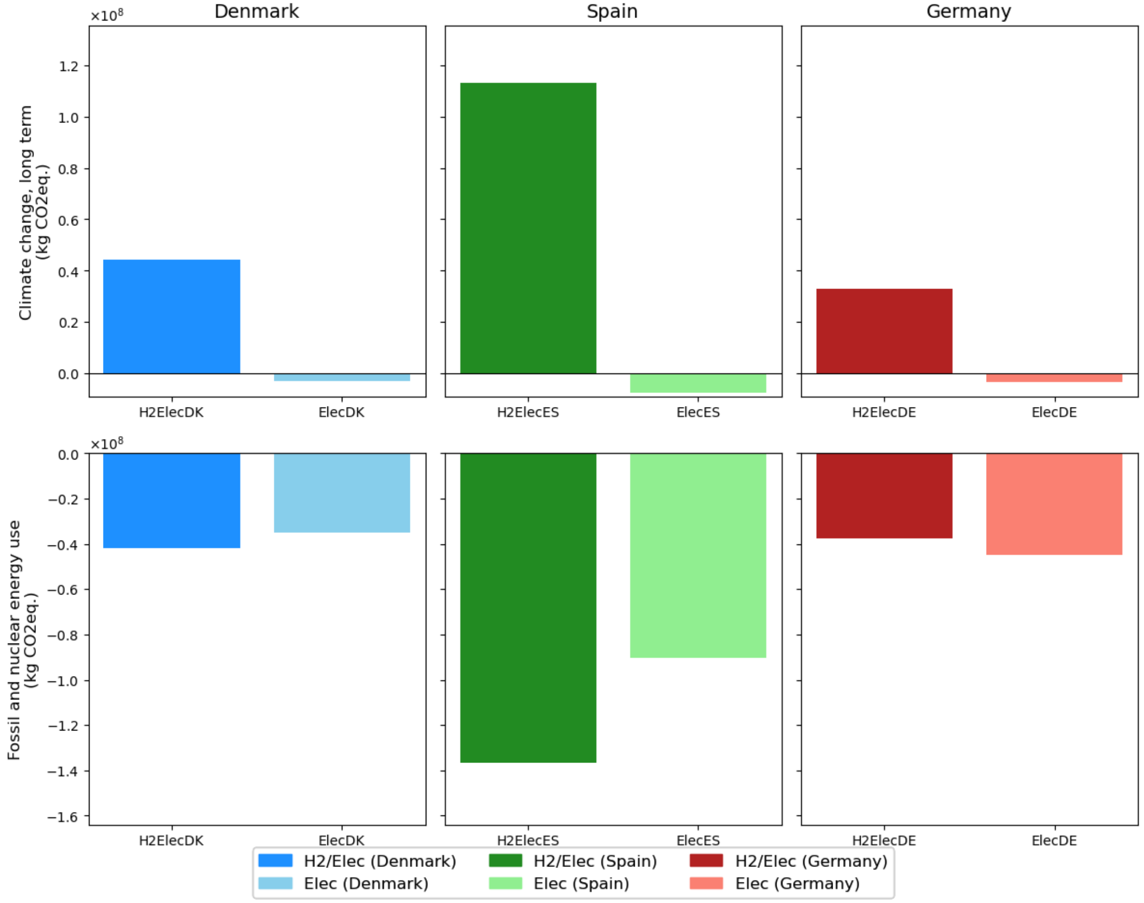



*Figure: Environmental midpoint assessment results for SolarX for climate change and land transformation*

## Findings

- Climate change impacts of the system increase with the implementation of SOLARX with hydrogen
  - The impact comes mainly from the the Steam Methane Reforming (SMR) reaction (related to hydrogen production)
- **SolarX without hydrogen slightly decreases** the system's climate change impact
- **Fossil fuel** (as an example of another midpoint impact category) is positively influenced by SOLARX
- Other categories were analyzed. For example, **water scarcity** is increased through SOLARX -> trade off
- For these impact categories, the impact or benefit comes from the **use phase** mainly

# Task 5.2: Environmental assessment including life cycle assessment (LCA)

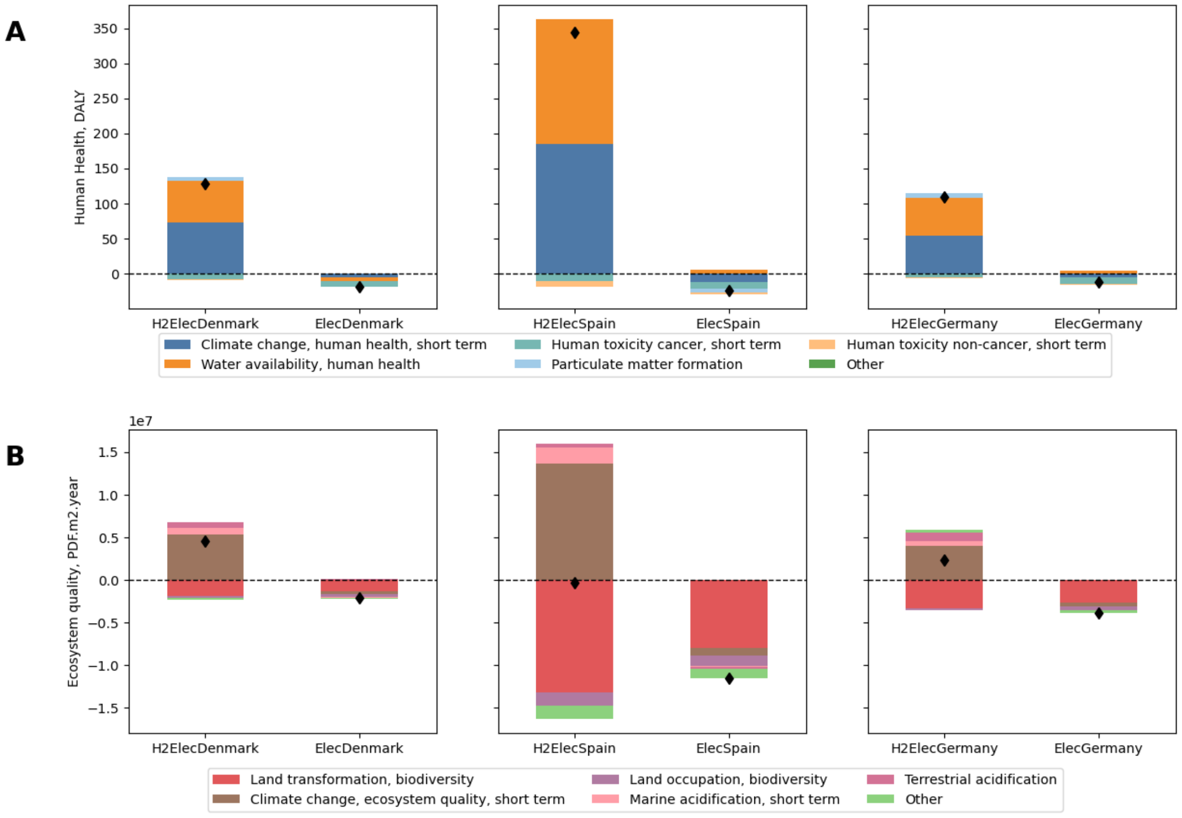



*Figure: Environmental damage assessment results for SolarX for damage to human health (A) and ecosystem quality (~ biodiversity loss) (B).*

## Findings

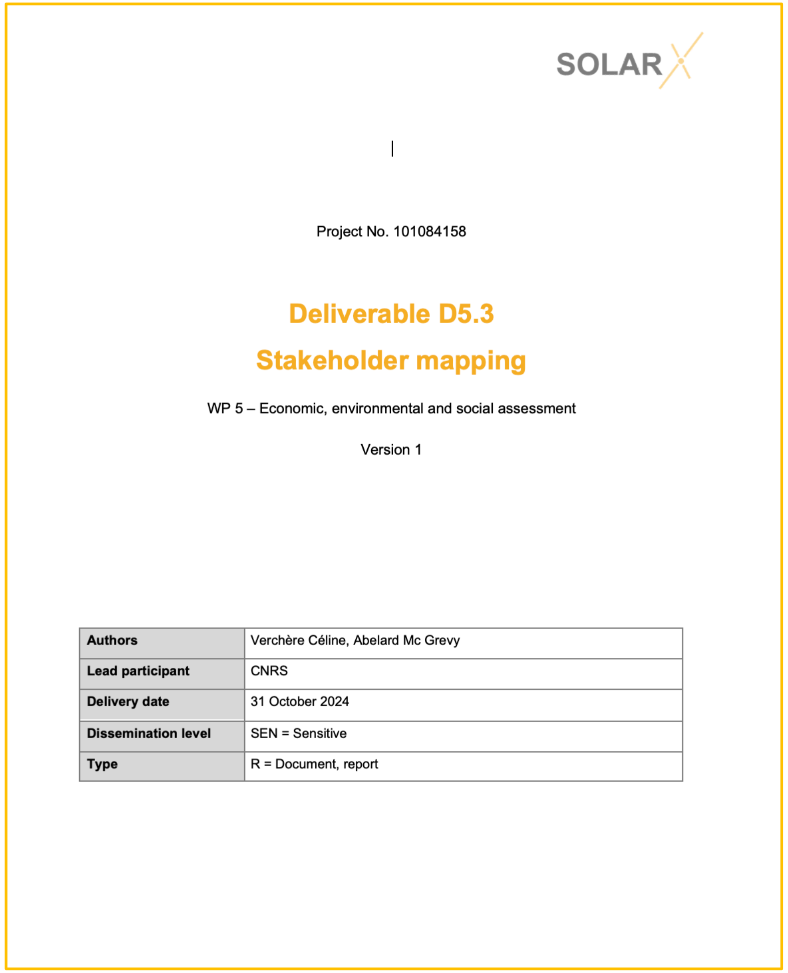
- System with **hydrogen production is not advisable** from a life cycle perspective (= does not bring benefits)
- **The use phase** is a critical hotspot due to the solar receiver: reduce the impacts of water and biogas use could improve the performance

## Further research

- While the H2Elec configuration may offer **increased system flexibility**, it simultaneously introduces **higher environmental impacts**. This duality highlights the need for further explorations of reliable **and** sustainable future energy systems (identifying situations or contexts, where this may not be the case).

# Task 5.3: Stakeholders mapping and value proposition analysis

SOLAR X


SOLAR X

Project No. 101084158

**Deliverable D5.3**

**Stakeholder mapping**

WP 5 – Economic, environmental and social assessment

Version 1

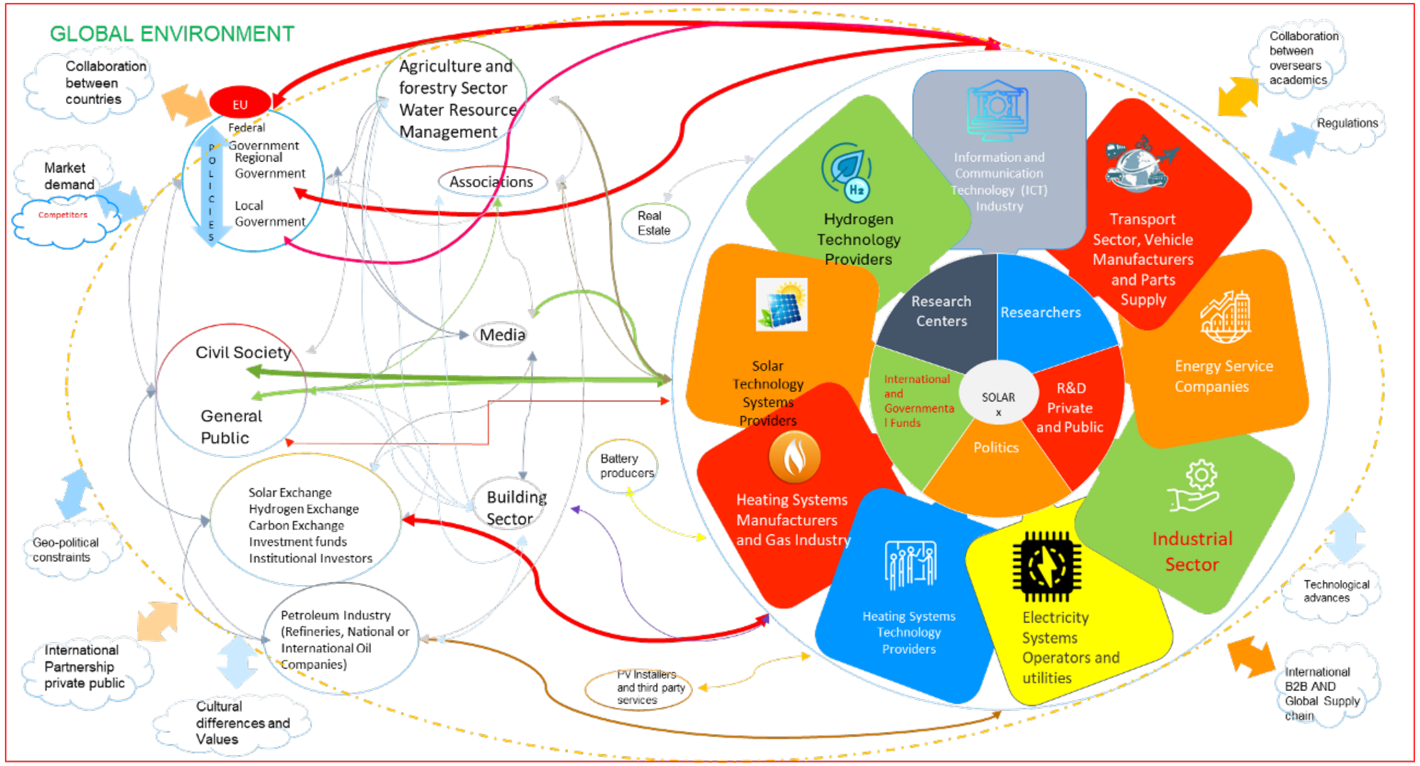
| | |
|---|---|
| **Authors** | Verchère Céline, Abelard Mc Grevy |
| **Lead participant** | CNRS |
| **Delivery date** | 31 October 2024 |
| **Dissemination level** | SEN = Sensitive |
| **Type** | R = Document, report |

Done – M24 (september24)

✓ Based on a literature review about the following concepts: Sustainable infrastructure, Eco-design and Benefit management realization.

✓ Based on a fieldwork done in April24, in Julich, Germany ; in Arnhem, Netherlands ; in Valencia, Spain ; in Nicosia, Cyprus and videoconferences (from May to July 24).

# The Stakeholders' Network Map




Note. Read from the center to the exterior circles. SOLARX is at the center and may rise if driven by the first circle of stakeholders. The second circle is important to the project for applied research and to go quicker to market. This connectivity is essential to go further. This is the heart of the project.
Color and thickness- The more important inner connection lines are those in red and green. The thickness of lines indicates the importance of the links. In red, mostly funding and political. In green, mostly societal issues. For the outer connection fleches: Blue trends, mostly for constraints. Yellow trends, for partnership.

The Stakeholders' Network Map serves as a strategic tool for:

- **Identifying key stakeholders relevant to a project**
- Understanding the dynamics of interactions within the network.
- Visualizing opportunities for **collaboration and engagement**
- Assessing potential **risks and barriers based on stakeholder relationships**

This map ultimately helps organizations navigate complex stakeholder landscapes, facilitating better decision-making and enhancing project outcomes.

# Task 5.4: Social acceptance and recommendation for integration of SOLARX

SOLAR X

| Social acceptance and recommendation for integration of SOLARX system | Status |
|---|---|
| Literature review | Done |
| Fiedwork about the legal, ethical, social and environmental impacts of developing SOLARx project (from solar power/ concentrated solar power to synergic production of heat, electricity and hydrogen from solar energy) | Done |
| Fiedwork analysis | Done |
| Determine relevant criteria for identifying SOLARx impacts and challenges crossing the littérature review and the fieldwork feedback: different scenarios emerging | Done |
| Deepening development of criteria concerning different scenarios - Analysis and recommendations | Done |
| Final report | End of Sept.25 |

Due to M36

# Three scenarios to be analysed

SOLAR X

**Scenario 1**: 100% Industrial (B2B) Solar Power Tower System (3-Receiver CSP Technology)

In that scenario, a Concentrated Solar Power (CSP) tower system with three receivers sends all of its energy—thermal energy, electricity, and hydrogen—directly to **local industrial sites**. This arrangement only works for **Business-to-Business (B2B) delivery**; it doesn't work with networks for homes or public utilities.

**Scenario 2:** Scenario 2 depicts a fairly ambitious strategy for a **dual-market CSP implementation** that tries to balance localized energy distribution to enterprises with **planned integration into public infrastructure**. In this situation, thermal energy and electricity always go directly to nearby factories. Hydrogen, on the other hand, is transported to third-party recipients through a network.

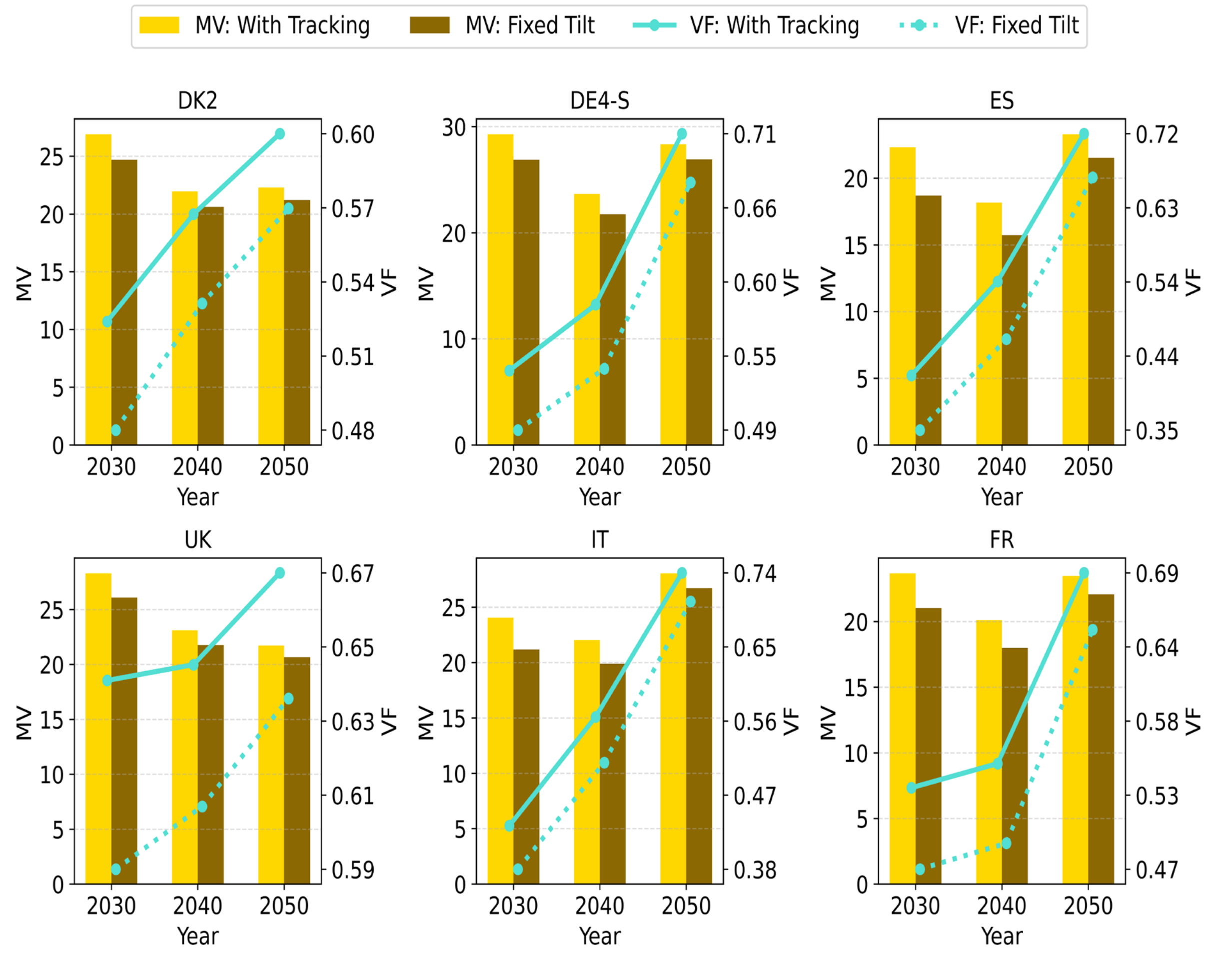
**Scenario 3:** Scenario 3 is a cornerstone of net-zero solutions, combining private-sector reliability and public-sector accessibility.

# Scenarios analysis framework (example sc.1)

| CONCENTRATED SOLAR POWER-SOLAR POWER TOWER: A 3-RECEIVERS TOWER | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lifecycle Assessment | “(From Cradle to Grave)” | | Extraction and Transportation Stage, Manufacturing and Construction Stage, Use stage, End of life Stage, Disposal and Re-use Stage | | | | | | | | | | | | | | | |
| Potential Business Case option | Targets and Issues | | Potential OUTCOMES | | Infrastructure Resilience | Potential Social Impacts and ethics issues | | Potential Environmental Impacts | | | | | | | | Policies and Regulation Constraints | | Potential Benefits and Dis-benefits |
| Exploitation | Market | Output Resource | Greenhouse gases reduction | | Operability | Local | Nonlocal | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Region or country |
| | Overall aspects | | Urban | Rural | Flood, Hurricane, Storm, Snowstorm, etc. | RSE and Social acceptance | Assessment of real RSE application to Supply chain | Land Use, Green spaces and Wetlands (5 to 10 acres per MWcap required for CSP) | | Water Use | | Wildlife | | Physical | | International-regional policies, public policies, norms and local regulations, etc. | | Net-zero industry, region, or country |
| SCENARIO 1 | 100% INDUSTRIAL (B2B) directly to Industrial nearby Companies | Thermal energy: (Technological issues due to the Thermal Energy Storage Type)<br>And<br>Electricity: (Technological issues due to the Thermal Energy Storage Type)<br>And<br>Hydrogen: (Technological issues due to the Thermal Energy Storage Type) | Heating and Cooling Industrial facilities (single or network) | Heating and Cooling Farms facilities (single or network)-small towns | | Local labour, Culture, expropriation, etc. | Raw materials origins: Child labor, ecological norms, fair salary, forced expropriation, human rights etc. | (scarcity of lrequired amount of land) | Loss of wetlands, loss of green spaces, erosion | Water waste for cooling and cleaning | Water waste for cooling and cleaning | | Loss of endangered species, wildlife habitat threat, management of new species habitat at or around facilities, | Fire, explosion due to chemical materials storage<br>Negative Visual impact<br>Noise | Fire, explosion due to chemical materials storage<br>Negative Visual impact | Tower height and Chemical Storage limitations | | |

# Extra slides

# Technology Improvements




- Ex-post analysis of MV and VF for Tracking and Fixed tilt
- The difference in MV is most pronounced in the near term (2030), PV tracking delivers an average gain of +2.6 €$_{2016}$/MWh.
- The largest benefit is observed in Spain with +3.63 €$_{2016}$/MWh, 19% higher than fixed tilt.
- By 2050, tracking will still provide +1.35 €$_{2016}$/MWh higher MV on average.

- Slight deviation from the standard solar generation profile can result in higher revenue and help the system manage morning and evening ramps.
- strong first-mover benefit for tracking systems/advanced solar technologies, particularly in solar-rich regions such as Spain.