C3S Energy Webinar

Unlocking Climate Data for Energy – Case Studies on Seasonal Forecasts and Climate Projections

Climate Change

20 November 2024

Case study 2

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A g e n d a

- Presentation of Everoze
- Project finance and the role of a technical advisor
- Focus on the energy yield assessment
- Presentation of the work
- Conclusion

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Presentation of Everoze

An employee-owned technical and commercial consultancy, specialising in renewables, storage, hydrogen and wider energy flexibility.

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Technologies and services

OFFSHORE WIND

SOLAR

ENERGY STORAGE

HYDROGEN

OSW SUPPLY CHAIN STRATEGY SUPPORT

CLEAN-TECH

ONSHORE WIND

BIODIVERSITY

SUSTAINABLE FINANCE

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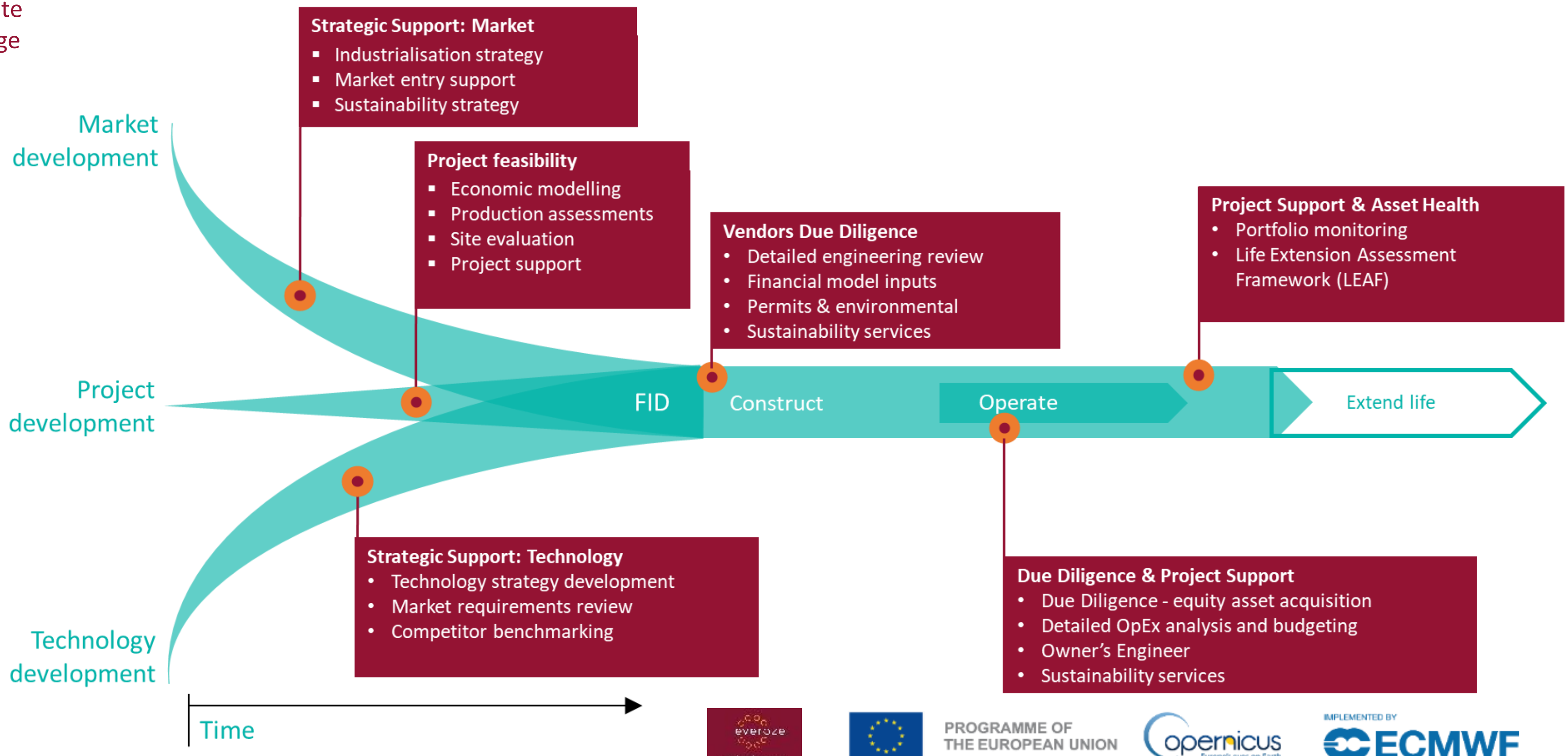
Tailored scope through the value cycle



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Project finance

And the role of a technical advisor

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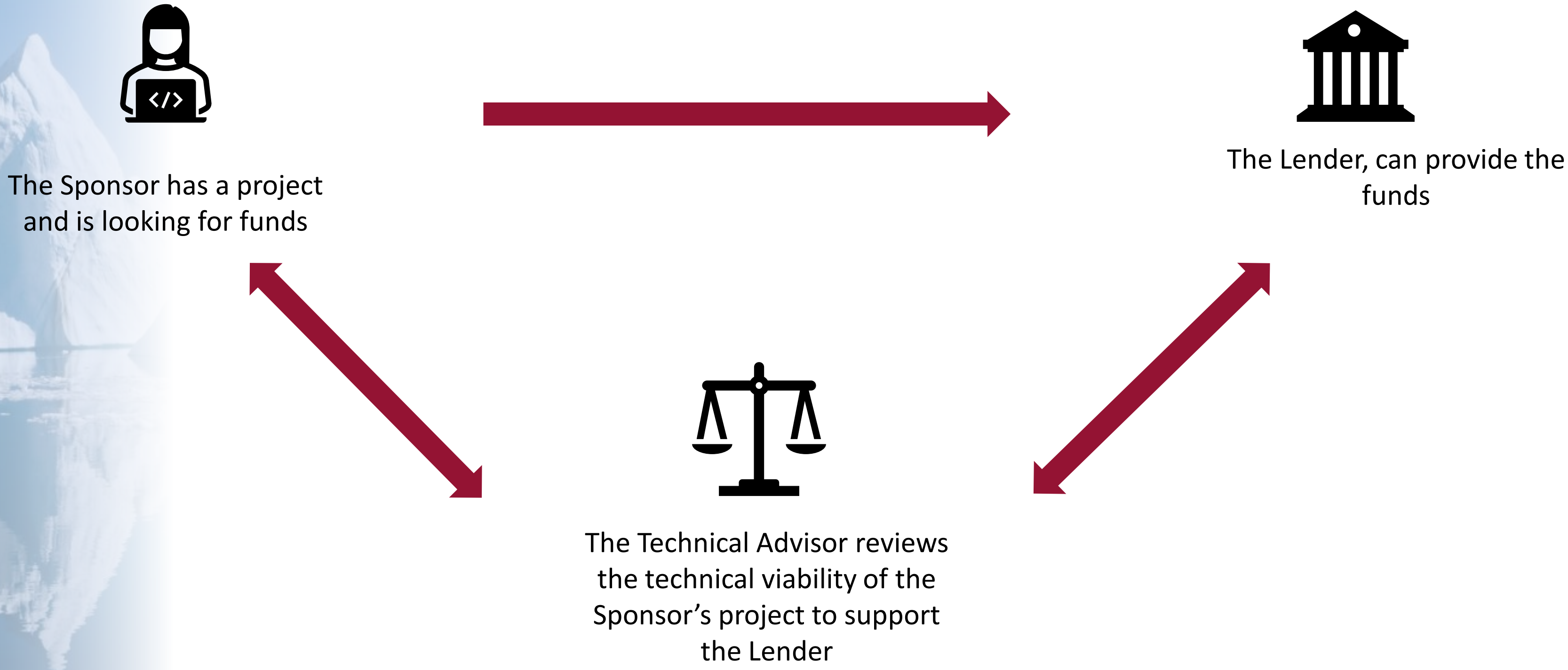
Project's stakeholders

- How to make a project happen



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Energy assessment is important

- But it is not the only element of project development

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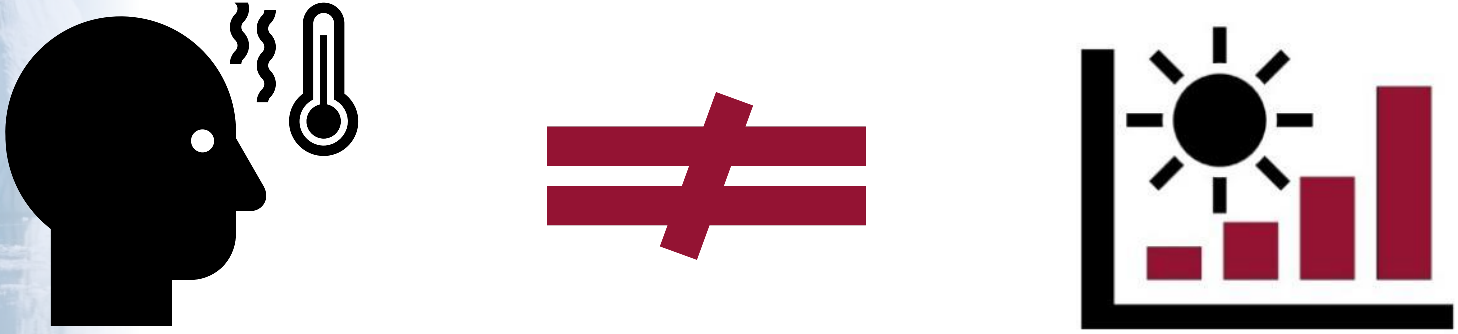
Perception of climate change

- Summer is good for PV, so summer all year round is a good thing, right?



Focus on energy yield assessment

P50 and P90

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Importance of the energy yield assessment

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Development → Construction → Operation

Development

Yield assessment using bankable tools and dataset to define a model of the future PV project and establish yield scenarios:

- P50 (sponsor)
- P90 (lender)

Construction

The model used to generate the P50 and P90 scenarios is used to assess the system performance at commissioning

Operation

The model can be used as a reference to assess the asset's performance over its lifetime

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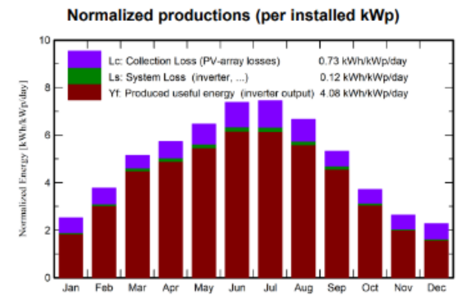
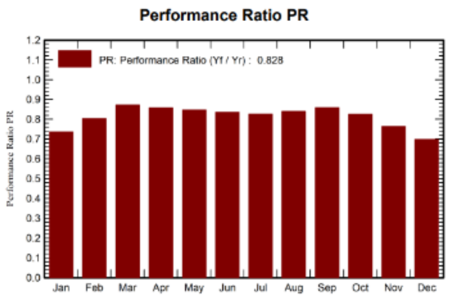
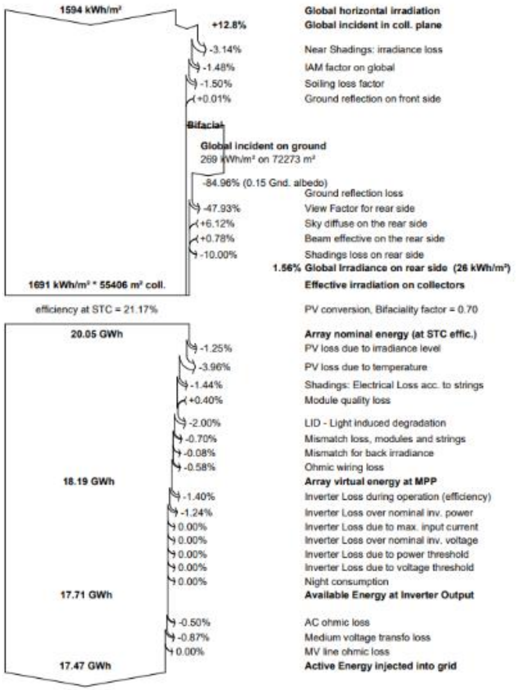
Simulation tool: PVsyst

- Has been validated by most players in the PV industry
- Provides a realistic and accurate model of a PV system
- It is bankable and the industry standard







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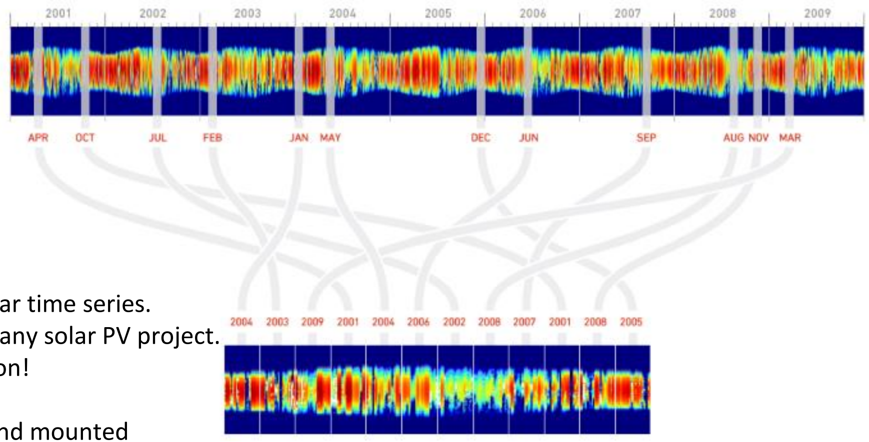
Solar resource

- The reference weather data (irradiance, temperature, wind speed) is supplied by a data provider
- There are a few active companies that are recognized as bankable data provider
- The simulation uses a Typical Meteorological Year (TMY) based on historic data



A solution from the past that will last in the foreseeable future
A Typical Meteorological Year (TMY) dataset is derived from a multi-year time series.
It is based on past data and is the reference for future performance of any solar PV project.
How representative past data will be of future resource is a key question!
The model can be reused with actual yearly data
Data are bankable because they have been benchmarked against ground mounted measurements.

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P50 and P90

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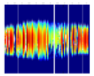
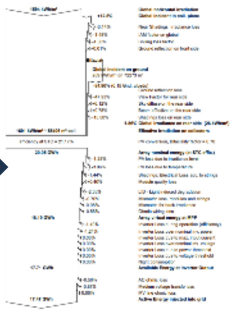
Impact on P50?

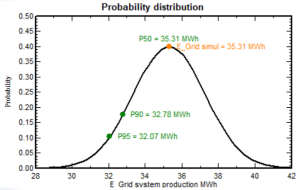




P50 scenario

- Uncertainty on the model (design, software)
- **Uncertainty on weather data**
- **Year on year variability vs TMY data**

Impact on P90?



Investment in renewable energy technologies are long term (20-40 years) and the Energy Production Assessment (EPA) is a key element of project development and finance. Currently, the EPA is based on historical satellite imagery derived irradiation data.
There is growing concern among our clients regarding the potential negative impact of climate change (average global temperature rise) on the energy yield.
Can we bridge the gap between the state of the art of climate research and industry practice?

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Presentation of the work

Methodology

Results of phase 1

Results of phase 2

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Methodology

- The case study was built in three phases
  1. we picked 1 asset in Spain, and tested different data sources to run multiple simulations,
  2. we expanded the analysis to 2 more sites, outside of Europe (Egypt and Senegal),
  3. We completed the analysis for Spain with higher data resolution
- Metrics used:
  - Energy yield in kWh/kWp
  - Performance Ratio (PR) as a %,

$$PR = \frac{Actual\ Energy\ Output}{Theoretical\ Max\ Energy\ Output}$$

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Site selection

We picked on purpose real assets, so we could potentially compare the simulation with the weather data provided by ICS with our previous work.
In the future, we could potentially use operational data to calibrate the different models. This was not investigated further for this case study.

Country	Spain	Senegal	Egypt
Size	63 MWp	35 MWp	64 MWp
Module capacity	395 Wp/module	340 Wp/module	330 Wp/module
Cell technology	Si-mono	Si-poly	Si-poly
Tracking system	Tracking N-S	Fixed 10°	Tracking N-S

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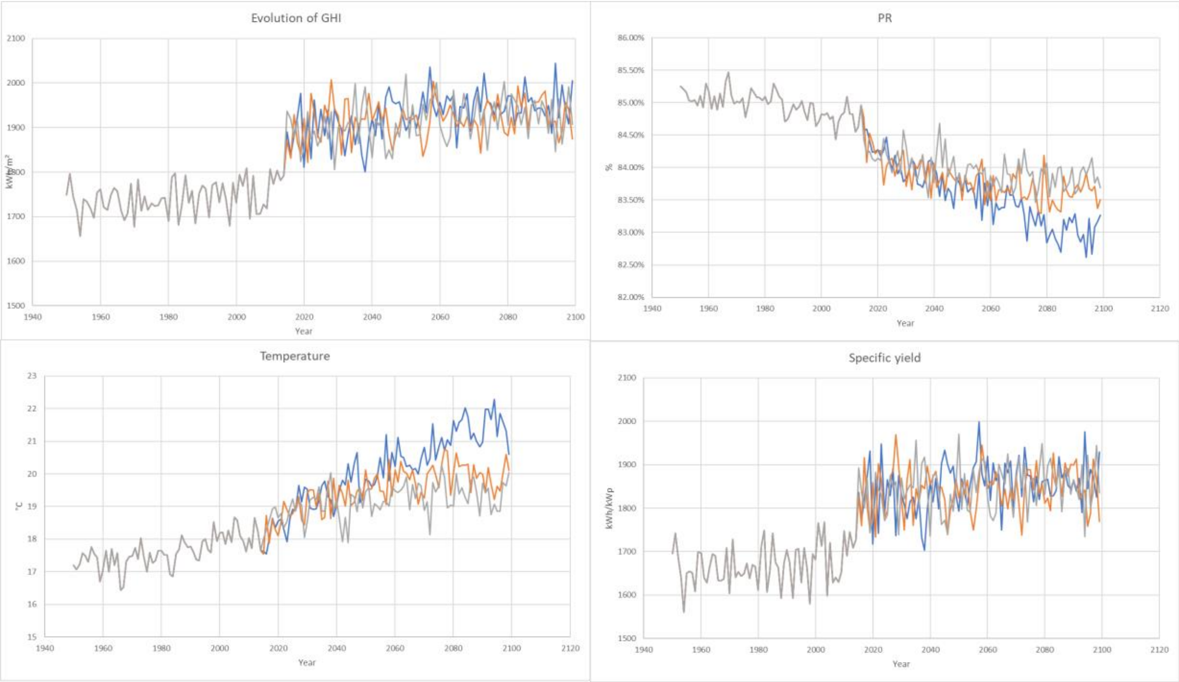
Synthesis of stage one

- Data formatting for PVsyst

This initial work allowed us to redefine further steps.
The amount of available data was important, we picked one model and the three scenarios to run our initial analysis.
An important effort was dedicated to data checking and formatting to be able to work with PVsyst.

The results showed that the potential impact of climate change seemed limited when compared with other factors: aging, downtime.



Model used CAMS

SP585

SP245

SP126

– Some discrepancies in the model between historical and future data.

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Synthesis of stage two

- The work focused on future data only
- Simulations were run from 2015 to 2065 using 4 models (BCCS, CMRS, ECE3 and MEHR) and 2 scenarios (SSP2-4.5 and SSP3-7.0)
- Additional analysis with hourly data for Spain
- The outputs:
  - Expected impact on P50 limited:
    - Reduction of PR for all locations
    - Energy generation stable for Spain, slight decrease for the other sites
  - P90:
    - The interannual variability may be impacted by climate change

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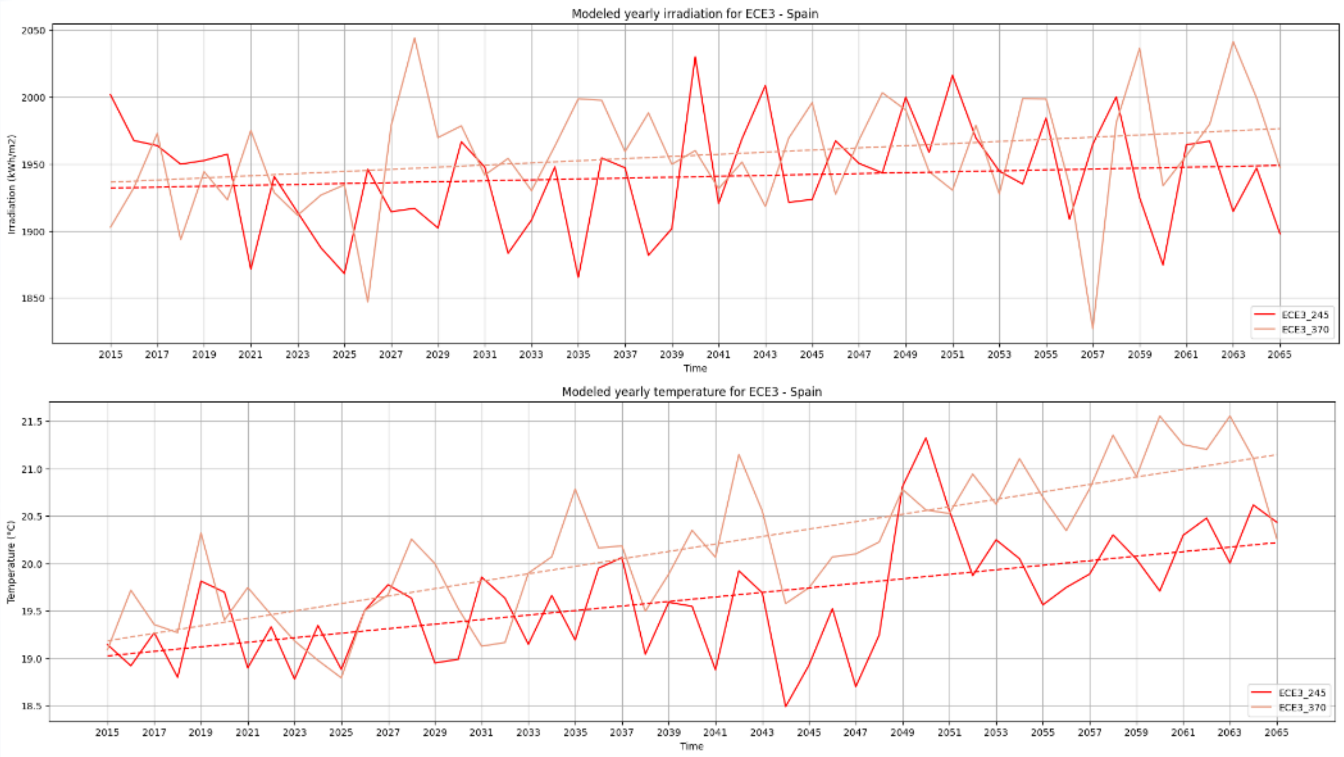
ECE3 data for Spain



ECE3 SP245

ECE3 SP370

Illustration of the results for ECE3 model and 2 different scenarios

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Modeled yield and PR for Spain (ECE3)

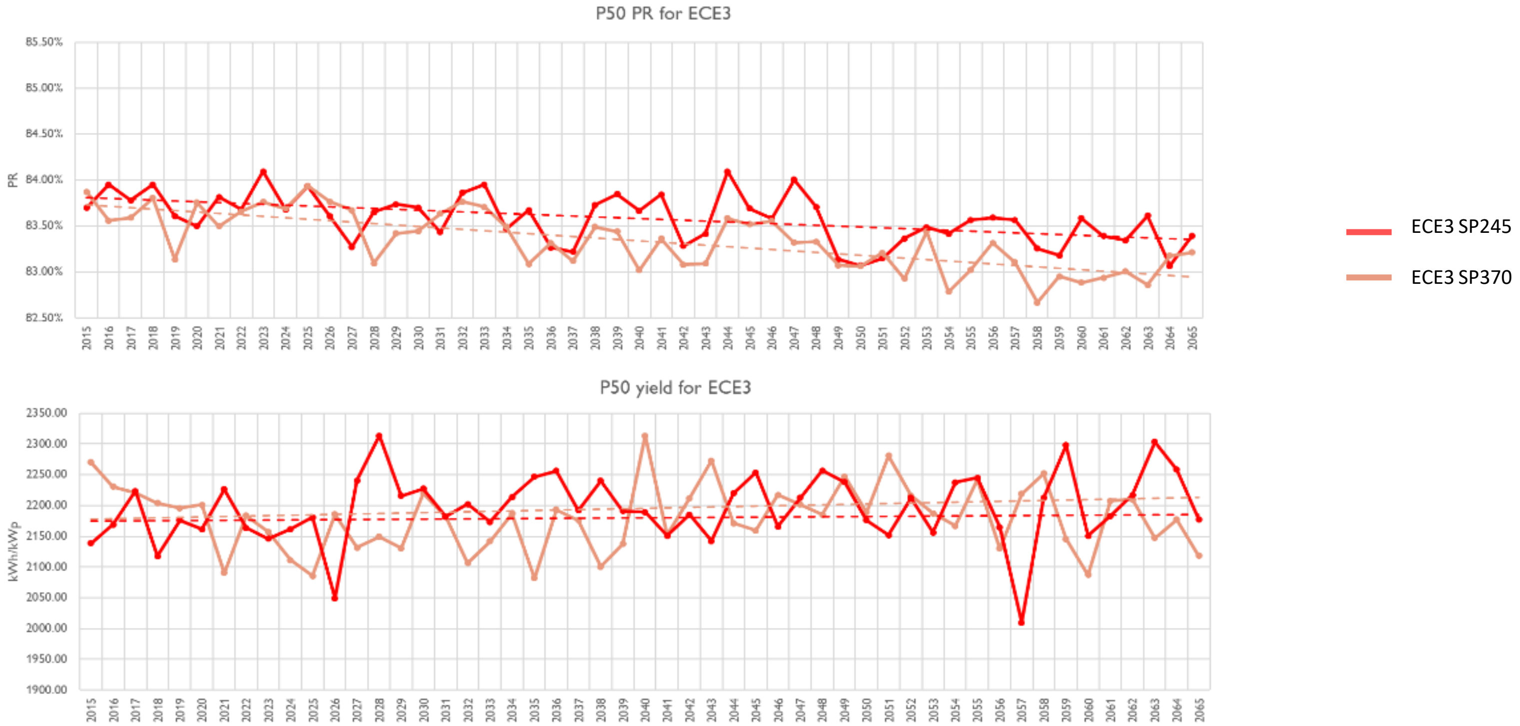

Illustration of the results for ECE3 model and 2 different scenarios

Further analysis for Spain- hourly data

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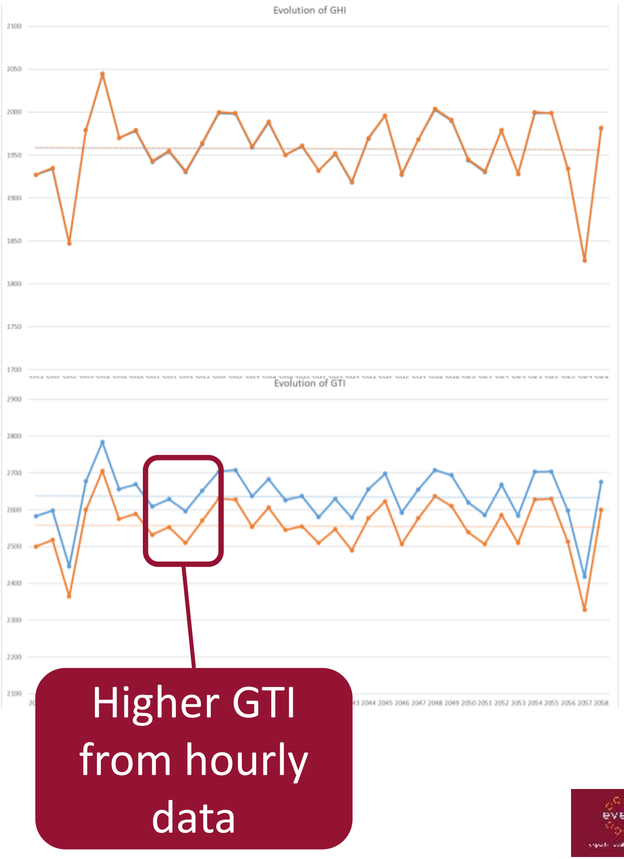
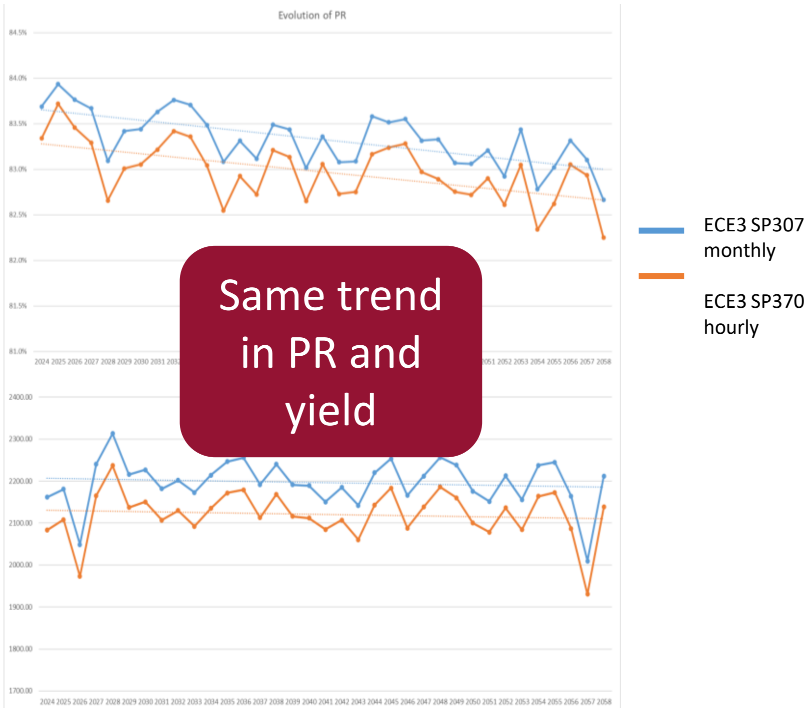
Data for phase 2 were provided as daily values of mean irradiance and temperature. Those were averaged into monthly data and incorporated to PVsyst. The hourly data was generated by PVsyst algorithm before simulation. This approach did not allow to capture potential extreme daily irradiance and temperature figures. An additional series of simulation was undertaken for the Spanish asset, based on hourly data to see if the more precise time resolution would modify the conclusions





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B C C S d a t a f o r S e n e g a l

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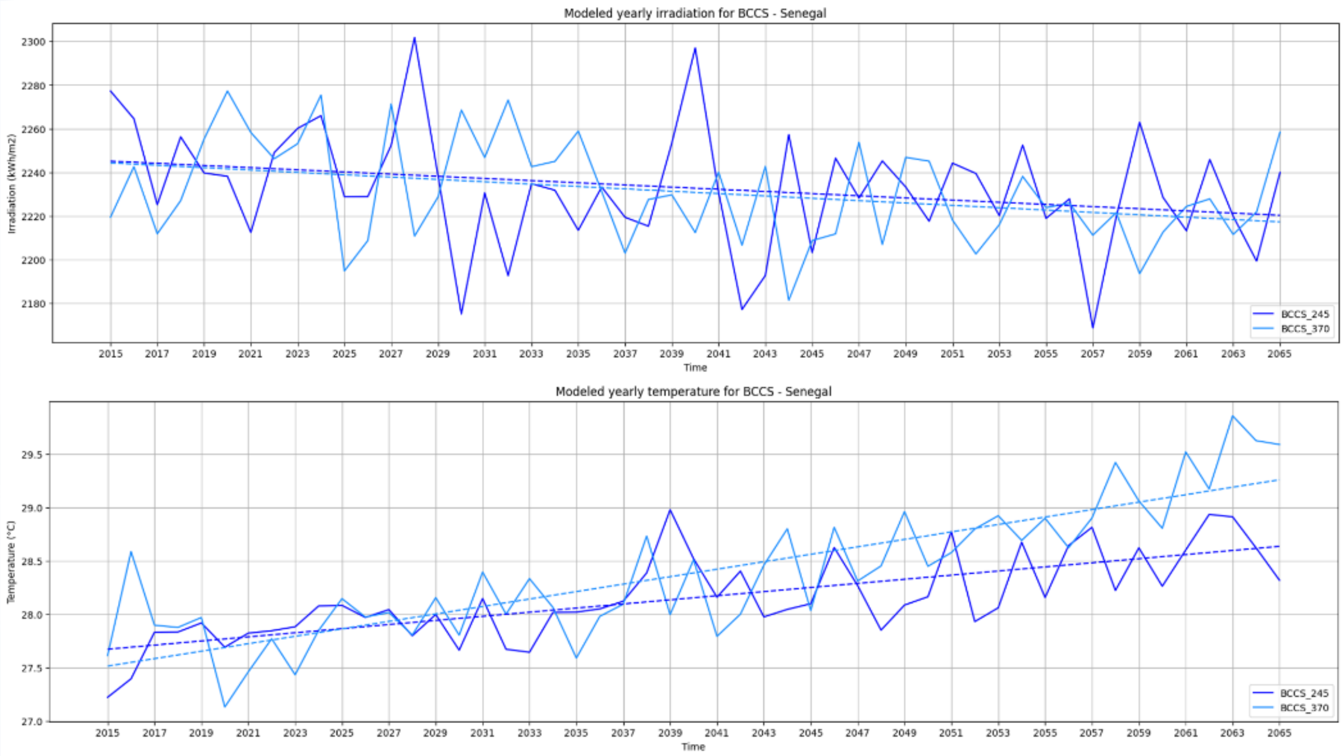

BCCS SP245

BCCS SP370

Illustration of the results for BCCS model and 2 different scenarios

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Modeled yield and PR for Senegal (BCCS)

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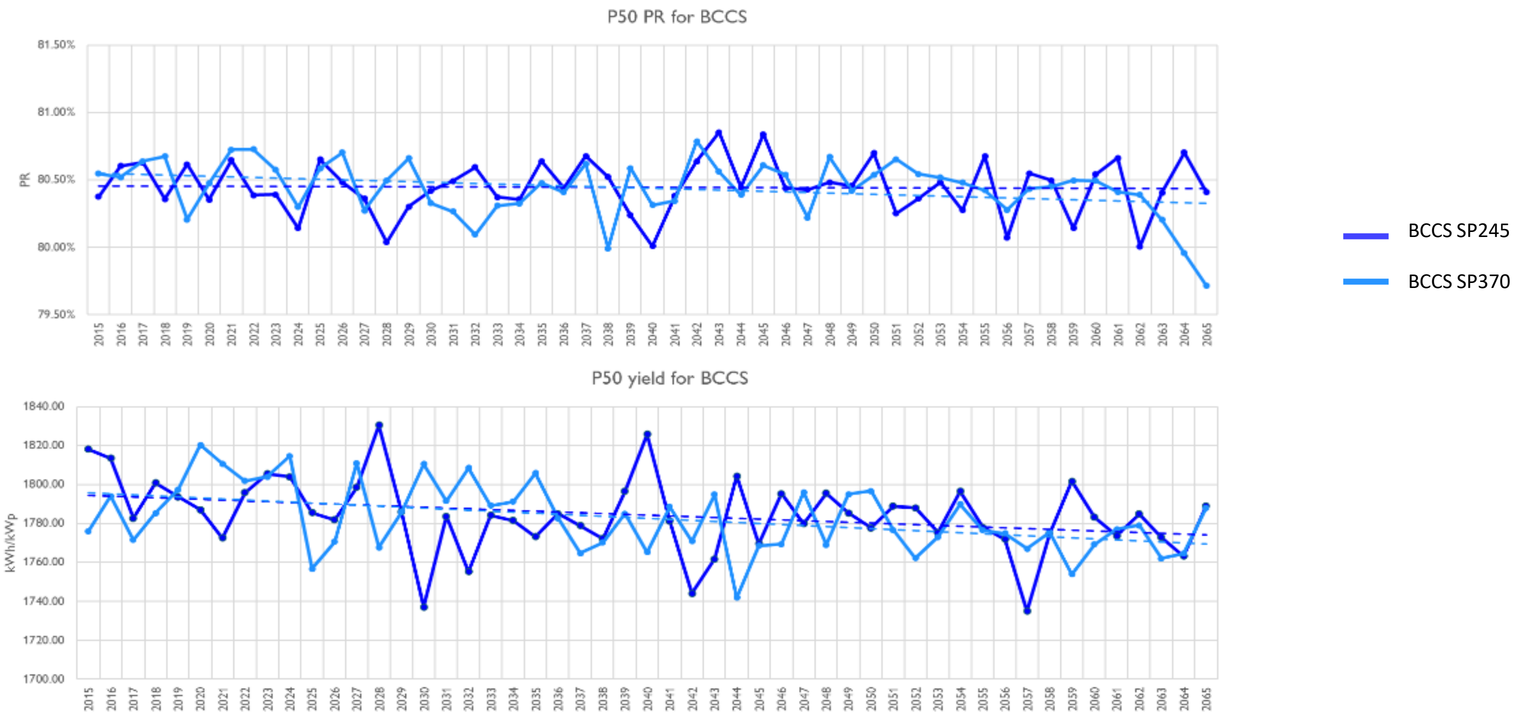

Illustration of the results for BCCS model and 2 different scenarios

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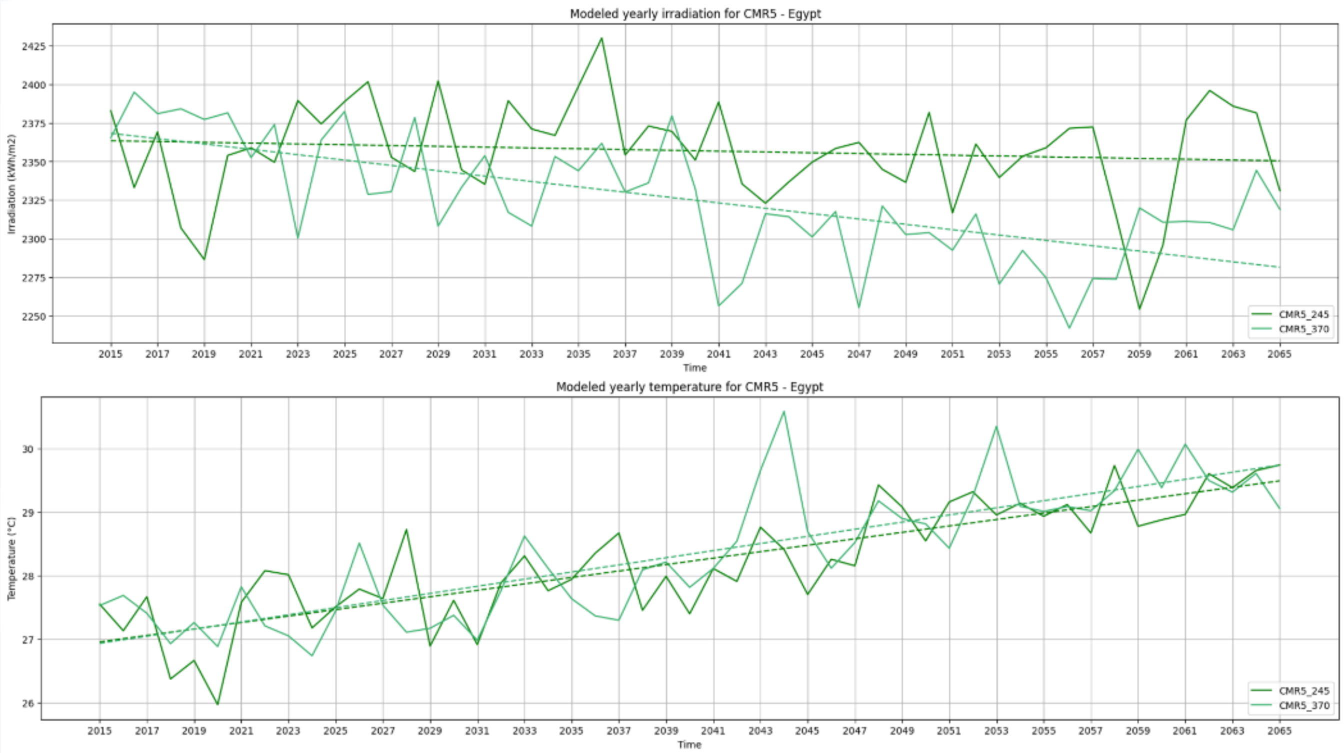
CMR5 data for Egypt



CMR5 SP245

CMR5 SP370

Illustration of the results for CMR5 model and 2 different scenarios

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Modeled yield and PR for Egypt(CMR5)

Climate Change

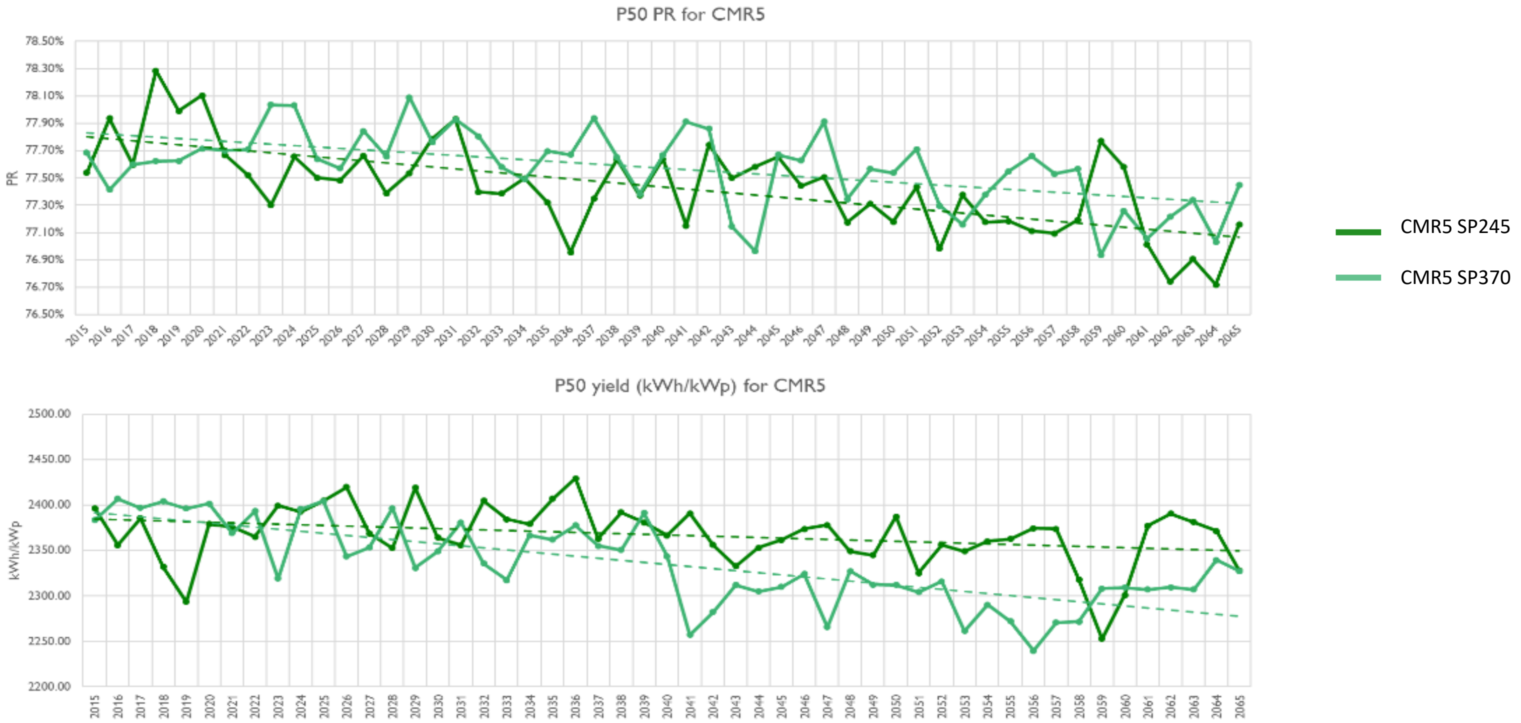

Illustration of the results for BCCS model and 2 different scenarios

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Egypt- Combination of factor impacting PR

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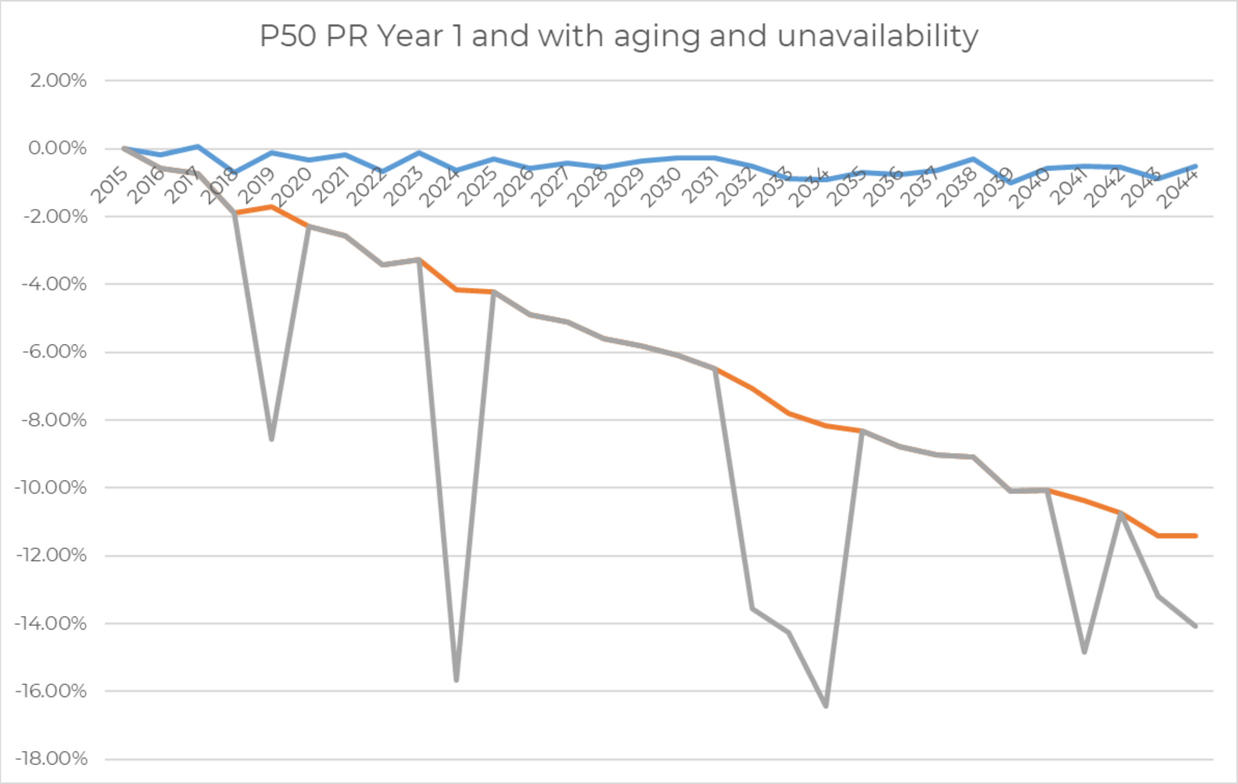
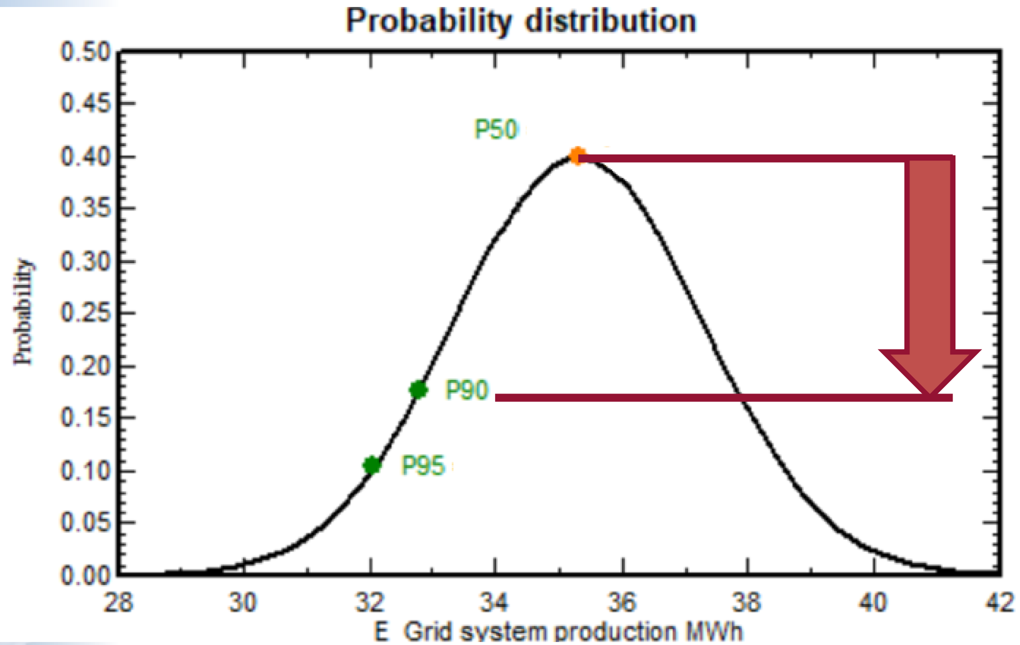


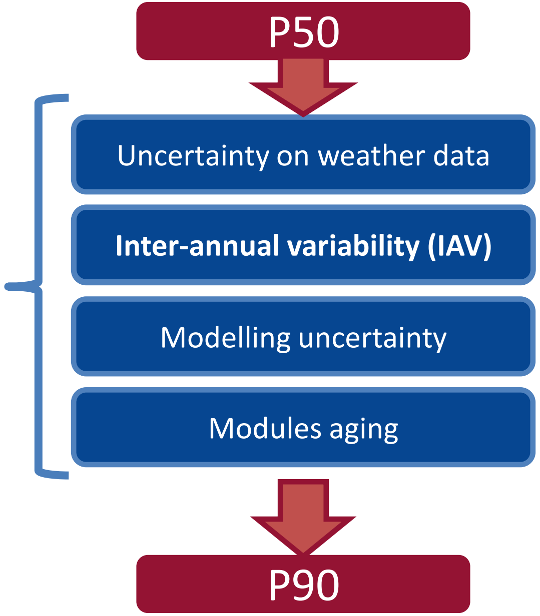
Impact on P50 is limited

1st graph, “climate change evolution only”
2nd graph “climate change + aging”
3rd graph, adding some random unavailability

Impact on uncertainty - P90

P90 is impacted by several sources of uncertainty applied to the P50 yield.





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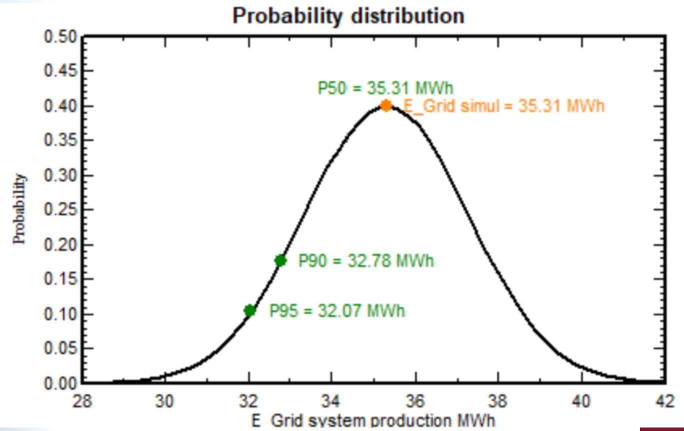
Impact on uncertainty - P90

P50 yield
(e.g. 1350 kWh/kWp) :

Weather data | PV Model



Uncertainties

Data accuracy	IAV	PV Model
+/- 3-6% of P50	+:- x % of TMY P50 (site dependent)	Exact cable, inverter losses, shading +/- 3-4% of the P50 Modules aging, etc.+/- 1-2% of the P50

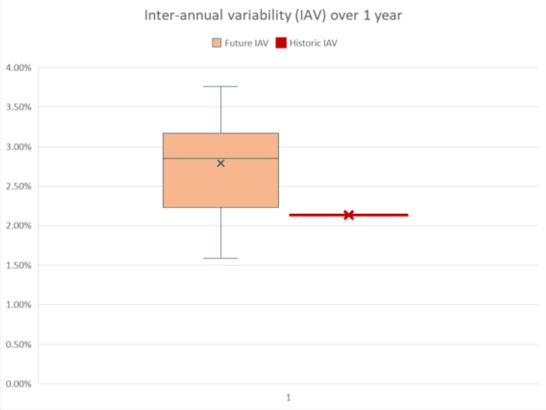
Combined uncertainties: 5.0 – 7.9%

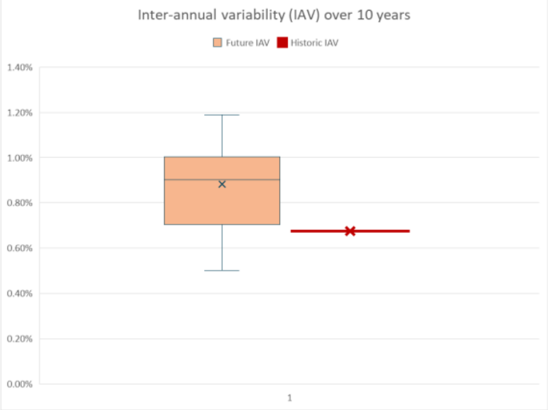
P90 yield would then be
1214 – 1264 kWh/kWp

Illustration of the impact on P90

Impact on P90 is limited

- Evolution of inter-annual variability – example of Spain





	Historic IAV	**Projections of IAV**
Combined uncertainty over a single year	5.59%	**5.41% - 6.41%**
Combined uncertainty over 10 years	5.22%	**5.20% - 5.31%**

Historic data, IAV of 20 years from 2004 to 2023
Future IAV, all models and scenarios (12 datasets), 2024 to 2043

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Conclusions

And suggestion of future developments

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Take-aways and future developments

- The expected evolution of climate **does not lead to higher energy generation** of solar PV systems
- Climate change impact on the yield would have minor impact compared to other factors
- A simple parametric approach could be sufficient to provide a climate change coefficient for energy yield assessment:
  - Evolution of P50
  - New uncertainty factors, leading to different P90
- More work would be needed to make forecasted data bankable

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It's not all about yield

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Back-up

Source data

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Data used in Year 1

- **9 DIFFERENT METEOROLOGICAL MODELS**
  - AWI-CM
  - CAMS
  - CESM2-WACCM
  - CESM2-WACCM
  - EC-Earth consortium
  - FIO
  - MRI-ESM
  - NorESM
  - Taiwan Earth System

- **HISTORICAL AND PREDICTED DATA**
  - Historical : 1950 – 2014
  - Predicted : 2015 – 2099
  - Monthly data
  - Irradiation in W/m²
  - Temperature in °C
  - Wind speed in m/s

- **3 DIFFERENT SOCIO-ECONOMIC PATHWAYS**
  - Ssp126 : Sustainability (2.6W/m² 2100 radiative forcing)
  - Ssp245 : Medium challenges to mitigation and adaptation (4.5 W/m² 2100 radiative forcing)
  - Ssp585 : Fossil-fuel development (8.5 W/m² 2100 radiative forcing)

Data used in Year 2

- **4 DIFFERENT METEOROLOGICAL MODELS**
  - BCCS
  - CMR5
  - ECE3
  - MEHR

- **PREDICTED DATA**
  - Projections : 2015 – 2065
  - Daily data
  - Irradiation in W/m²
  - Temperature in K
  - Wind speed in m/s

- **2 DIFFERENT SOCIO-ECONOMIC PATHWAYS**
  - Ssp245 : Medium challenges to mitigation and adaptation (4.5 W/m² 2100 radiative forcing)
  - Ssp370 : global issues pushed into the background (7.0 W/m² 2100 radiative forcing)

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Data used in Year 2 – hourly analysis Spain

- **4 DIFFERENT METEOROLOGICAL MODELS**
  - BCCS
  - CMR5
  - ECE3
  - MEHR

- **HISTORICAL AND PREDICTED DATA**
  - Historical : 1950 – 2023
  - Predicted : 2024 – 2065
  - hourly data
  - Irradiation in W/m²
  - Temperature in °C

- **3 DIFFERENT SOCIO-ECONOMIC PATHWAYS**
  - Ssp126 : Sustainability (2.6W/m² 2100 radiative forcing)
  - Ssp245 : Medium challenges to mitigation and adaptation (4.5 W/m² 2100 radiative forcing)
  - Ssp370 : global issues pushed into the background (7.0 W/m² 2100 radiative forcing)
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