# DEVELOPMENT OF TRANSITIONAL METHODS

## Determination of the Energy Yield of PV systems

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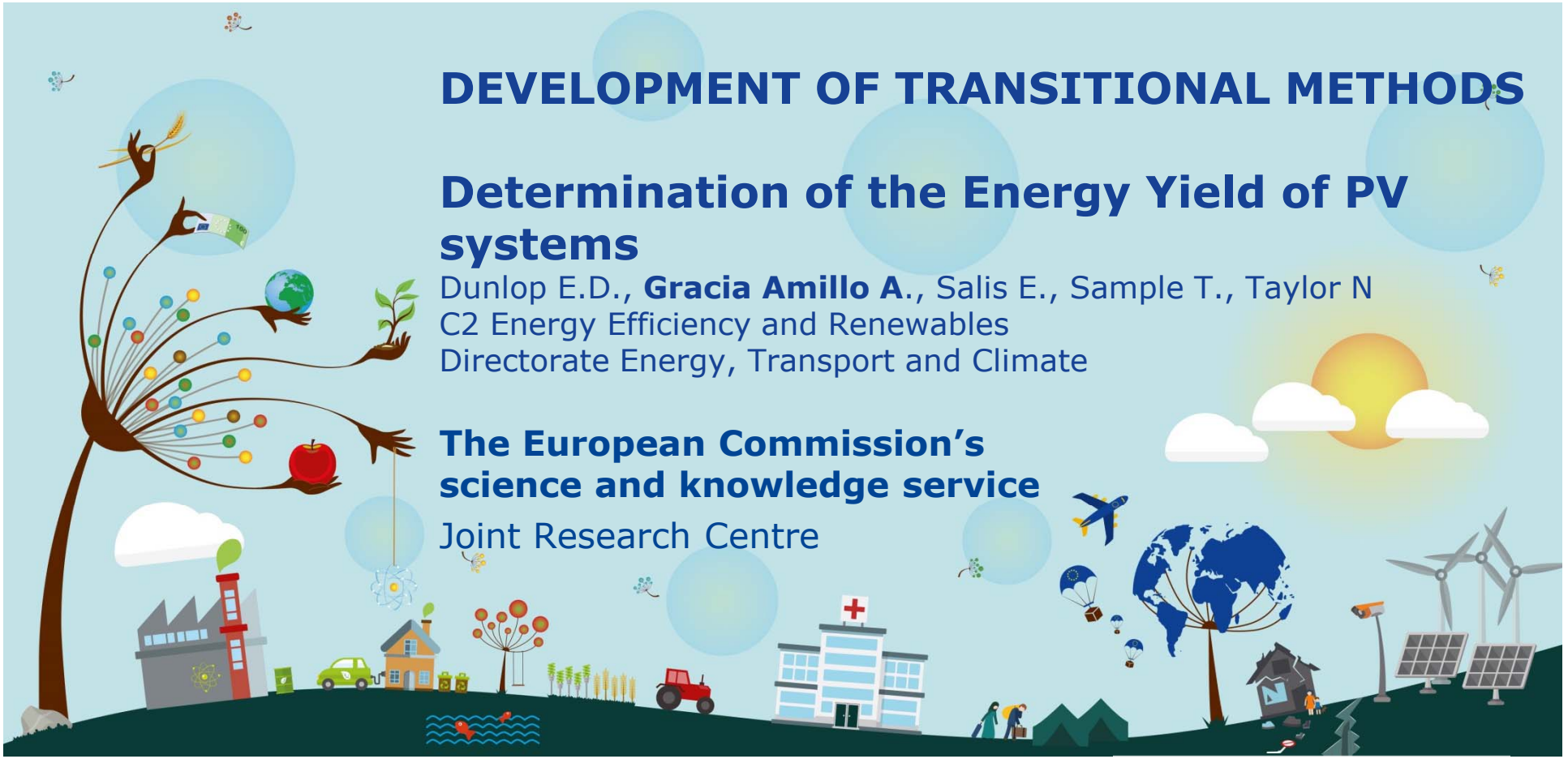



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# Photovoltaic Systems

Proposed **functional parameter:**

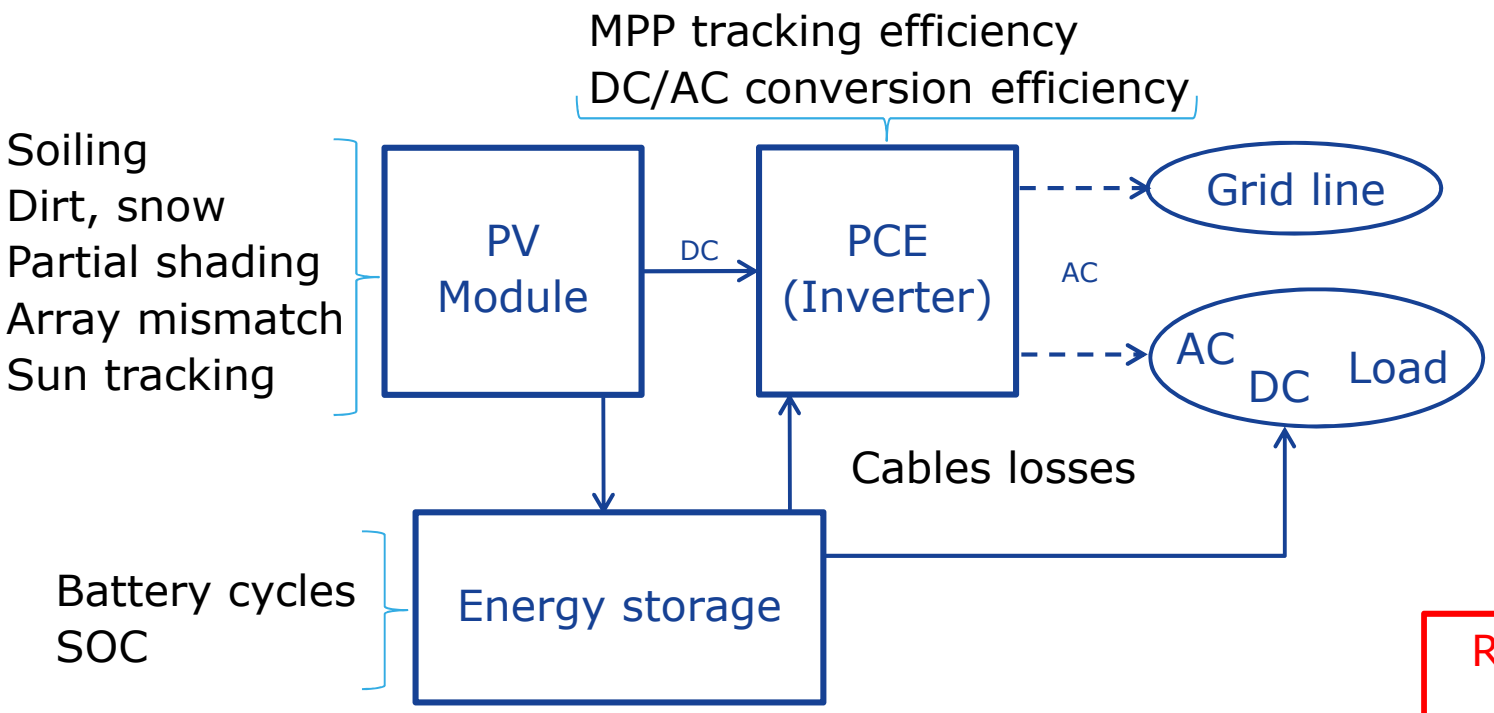
> *"1 kWh of AC power output supplied under fixed climatic conditions for 1 year (with reference to IEC 61853-4) and assuming a service life of 25 years".*

How to estimate the AC power output of any PV system?

- Size
- Location, set up
- Application
- Configuration

Model the performance of every single component

# Energy Yield of PV systems




System losses

Degradation

Lifetime

(1 year)

Environmental conditions

G, Tamb, Ws

Reference climate
Location specific



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# 1. PV module

## IEC 61853 series. *Photovoltaic (PV) module performance testing and energy rating*

- Defines the methodology to estimate the hourly DC power output values, for a year, from a 1 kWp array of the PV modules under analysis (IEC 61853-3).
- Describes the tests to be performed on the analyzed modules to obtain the parameters used in the modelling part (IEC 61853-1&2).
- Contains the 6 reference climatic datasets (IEC 61853-4).
- Fixed configuration of the modules:

  free standing rack, equator facing, inclined 20 .

Considered effects:
- AOI
- Spectral response
- Module Temp
- Low irrad. perform.

# 2. Power Conditioning Equipment

- Present components in the PV system
  - Inverter
  - Transformers or converters
  - Battery charge regulators
  - etc.
- Size of the various components
  - Inverter: Pnom Ratio (Pnom_Array / Pnom_inv)
    - 1.25 – 1.3 for most well oriented systems
    - > 2 for PV in façades
- Efficiency

PVSyst

# 2.1. Inverter efficiency

**IEC 61683 *Photovoltaic systems – Power conditioners – Procedure for measuring efficiency***

**EN 50530 *Overall efficiency of grid connected inverters***

- Overall efficiency, weighted efficiency

  $P_{AC} = h_{conv}$ $P_{DC} = h_{conv}$ $h_{MPPT}$ $P_{MPP}$

  $h_{EUR}$ or similar

- Efficiency curve

  Interpolation procedure need to be defined

# 3. Energy storage

- Type of battery used
- The model used to simulate the performance should consider:
  - State of charge
  - Charging/discharging current rate
  - Temperature (capacity)
  - Loads, working patterns
  - Ageing: static longevity and deterioration due to use
  - Number of cycles and depth of discharge
  - Battery efficiency

# 4. PV system losses

- PV module array
  - Soiling (1-4%)
  - Dirt, snow (up to 10%)
  - Partial shading
  - Array mismatch (2.5%)
  - Real module performance, MPPT
- Power conditioning equipment
  - MPP tracking losses
  - Transformer (2%)
- Wiring losses (1-6%)
- Others (availability losses 5%)

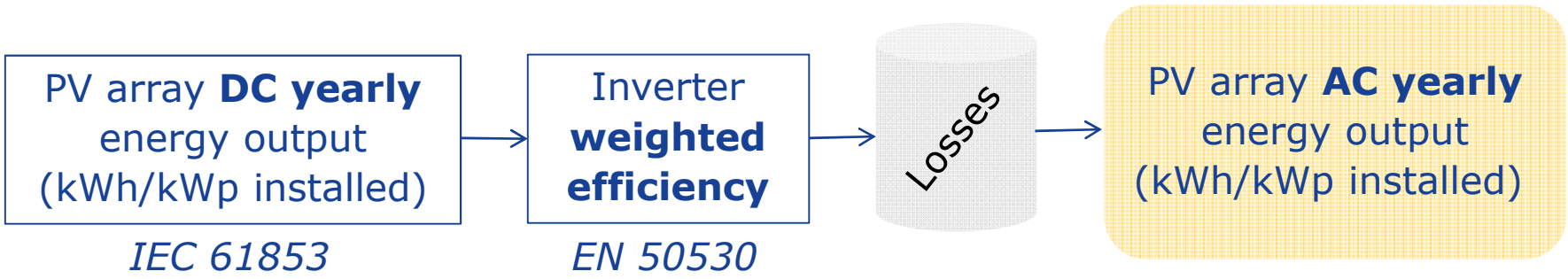
OPTIONS:

1. Modelled values
2. Empirical factors
3. Not applicable losses

PV system size dependent

# Estimation of Energy Yield of PV systems

Approach A.



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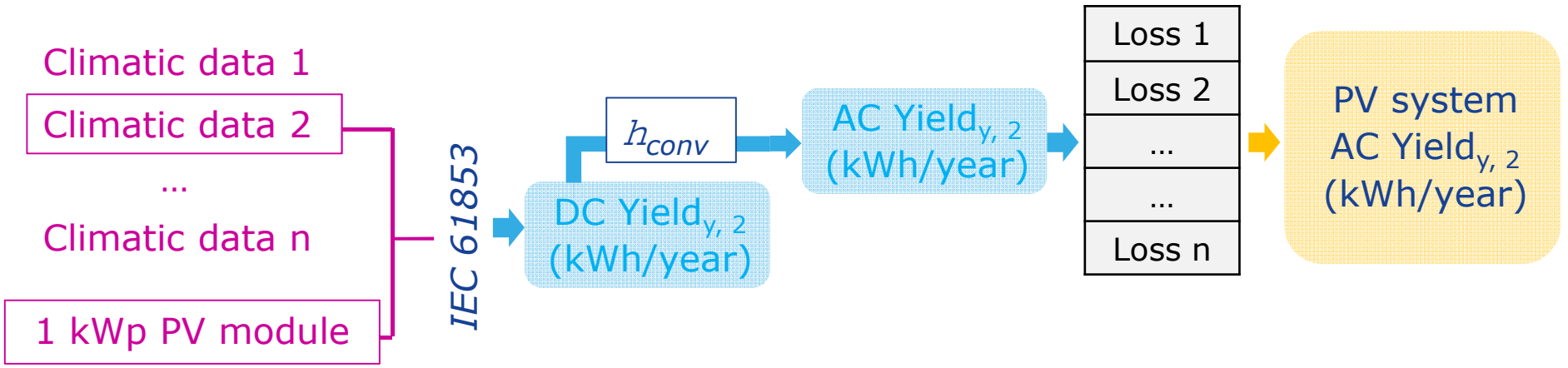
# Estimation of Energy Yield of PV systems

Approach A.



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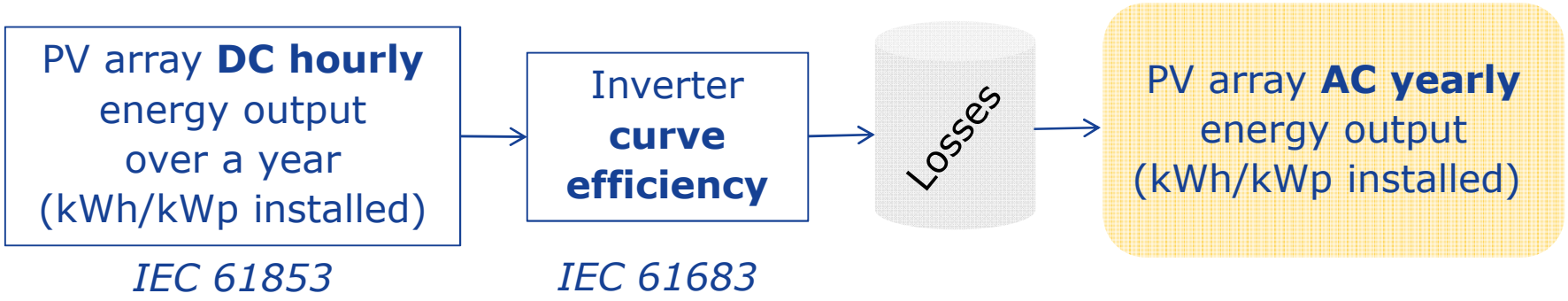
# Estimation of Energy Yield of PV systems

Approach B. Hourly modelling



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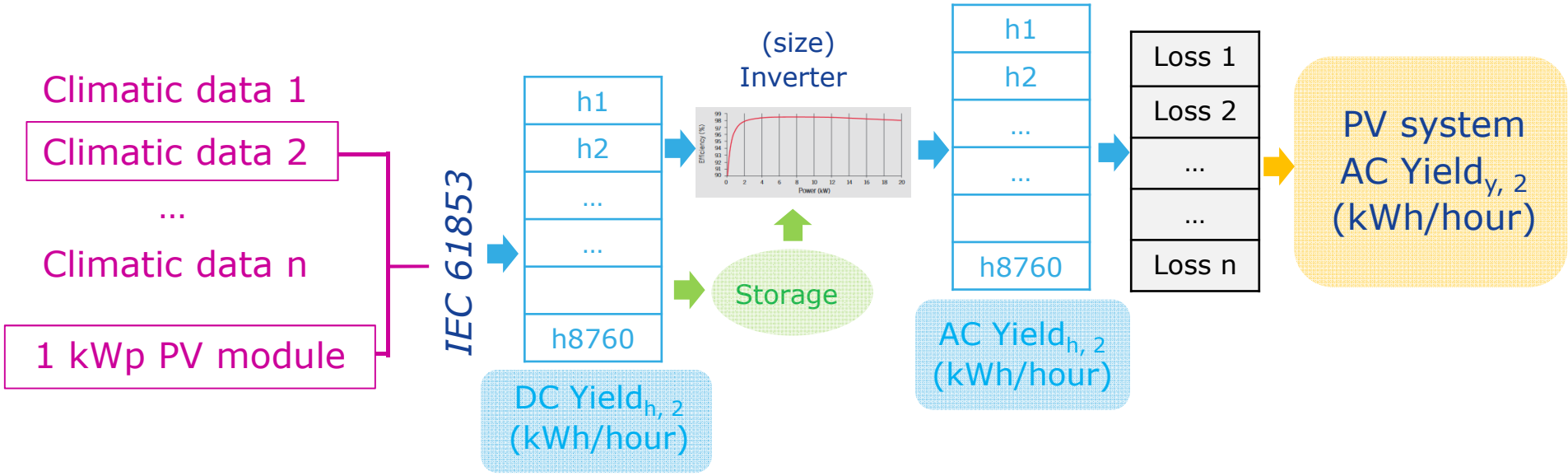
# Estimation of Energy Yield of PV systems

## Approach B. Hourly modelling



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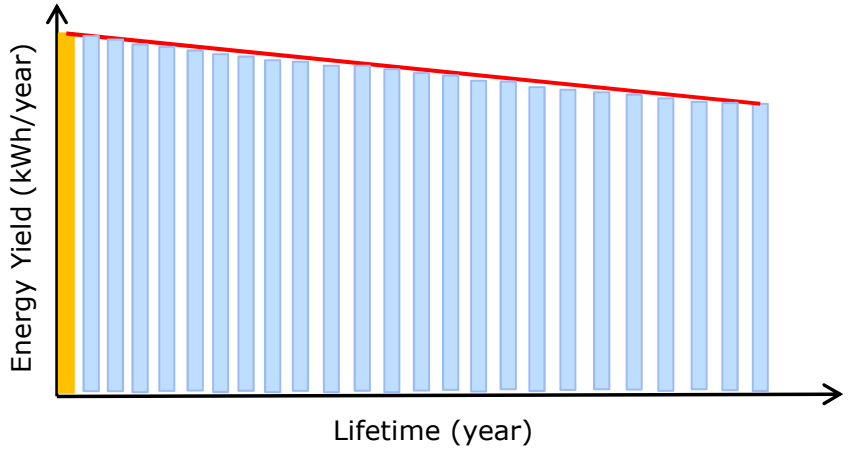
# Lifetime Energy Yield of PV systems estimation

## Linear constant degradation

$$EY_{lifetime} = EY_{annual(0)} \quad T_{lifetime} \quad (1 - \tau_{deg} \cdot \frac{T_{lifetime}}{2})$$



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# Climatic conditions for Europe

IEC 61853-4 *Standard Reference Climatic Profiles*

6 reference climatic datasets

- Subtropical arid
- Temperate coastal
- Temperate continental
- Tropical humid
- Subtropical coastal
- High elevation (above 3000 m)

European weather conditions

Specific location data for PV system analysis or policy tool retrieved from sources like PVGIS.