DEVELOPMENT OF TRANSITIONAL METHODS

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European Commission

Transitional Methods

….. where certain aspects essential to the implementation of Ecodesign, Ecolabel, Energy Label & GPP are not covered by existing standards, the Commission may choose to specify transitional methods, that are implemented as regulations until suitable standards are adopted.

1st stakeholder meeting, 29 June 2018
- Task 1 Report
- Dedicated report on standards (including gap analysis)

Expert Workshop on Transitional Methods Ispra 31 Oct. 2018

2nd Stakeholder Meeting, 19 December 2018
Draft report on proposed transitional methods

3rd Stakeholder Meeting mid-2019
Finalised report on transitional methods

Contents

- Inverter performance
- PV system energy yield
- Durability: degradation and failure rate
- Other materials efficiency aspects

Inverter performance

Proposed **functional parameter:**

> *"1 kWh of AC power output from a reference photovoltaic system (incorporating the efficiency of a specific inverter) under predefined climatic and installation conditions as defined for a typical year and for a service life of 10 years".*

Proposed methodology

Input data:

- European efficiency (EN 50530), η_{EUR}
- DC energy yield of a nominal 1 kWp PV array (IEC 61853), EY_{DC} (kWh/year)

Note:

- ➢ Assumes the PV array always works at its maximum power point
- ➢ Not sensitive to the sizing of the inverter (AC capacity) to the PV array (DC nominal power)
- ➢ Possible temperature dependence of inverter efficiency (so-called derating) not considered
- ➢ No other system losses considered

See report Annex A for sensitivity studies

Proposed methodology

- Calculate the AC energy output from 1 kWp reference PV array over a year, EY_{AC} (kWh/year per installed kWp)

$$EY_{AC} = \eta_{EUR} \cdot EY_{DC}$$

- Functional parameter:

$$FP_{Inverter} = \frac{1\ (kWh\ of\ AC/year) \cdot 1\ (kWp\ PV\ array)}{EY_{AC}\ (kWh\ of\ AC/year)}$$

Inverter example

Data from five commercial inverter datasheets with a hypothetical residential PV system

	Nominal power, $P_{AC,r}$ (W)	European Efficiency, η_{EUR}	EY_{AC} (kWh/yr · installed kWp)	Functional parameter $FP_{inverter}$
1	1500	94.5	1917.457	$5.21 \cdot 10^{-4}$
2	2750	93.6	1899.195	$5.27 \cdot 10^{-4}$
3	2300	93.2	1891.079	$5.29 \cdot 10^{-4}$
4	1550	91.8	1862.672	$5.37 \cdot 10^{-4}$
5	1200	90.9	1844.411	$5.42 \cdot 10^{-4}$

3%

0.4%

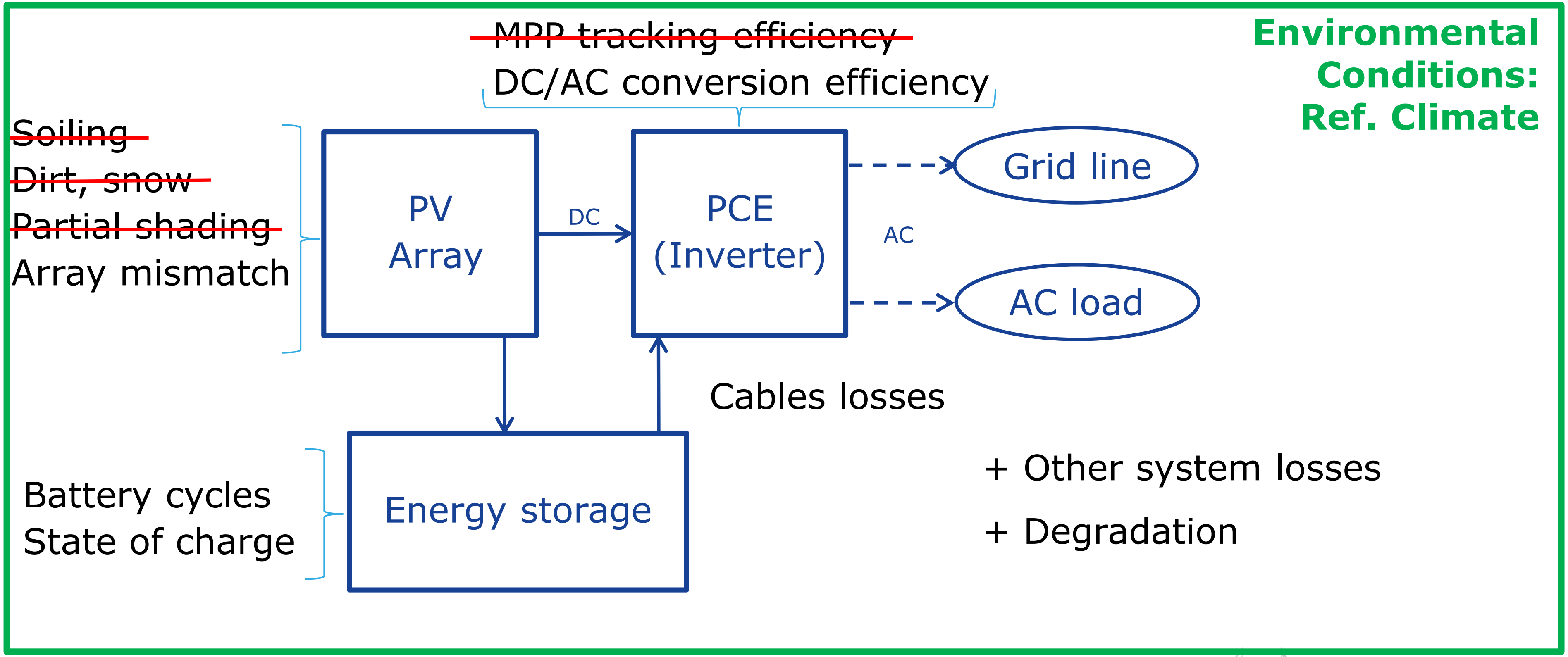
4%

Photovoltaic System Energy Yield

Proposed PV system **functional parameter:**

> *"1 kWh of AC power output supplied under fixed climatic and installation conditions as defined for a typical year (with reference to IEC 61853-4) and for a service life of 30 years".*

Factors influencing PV system energy yield



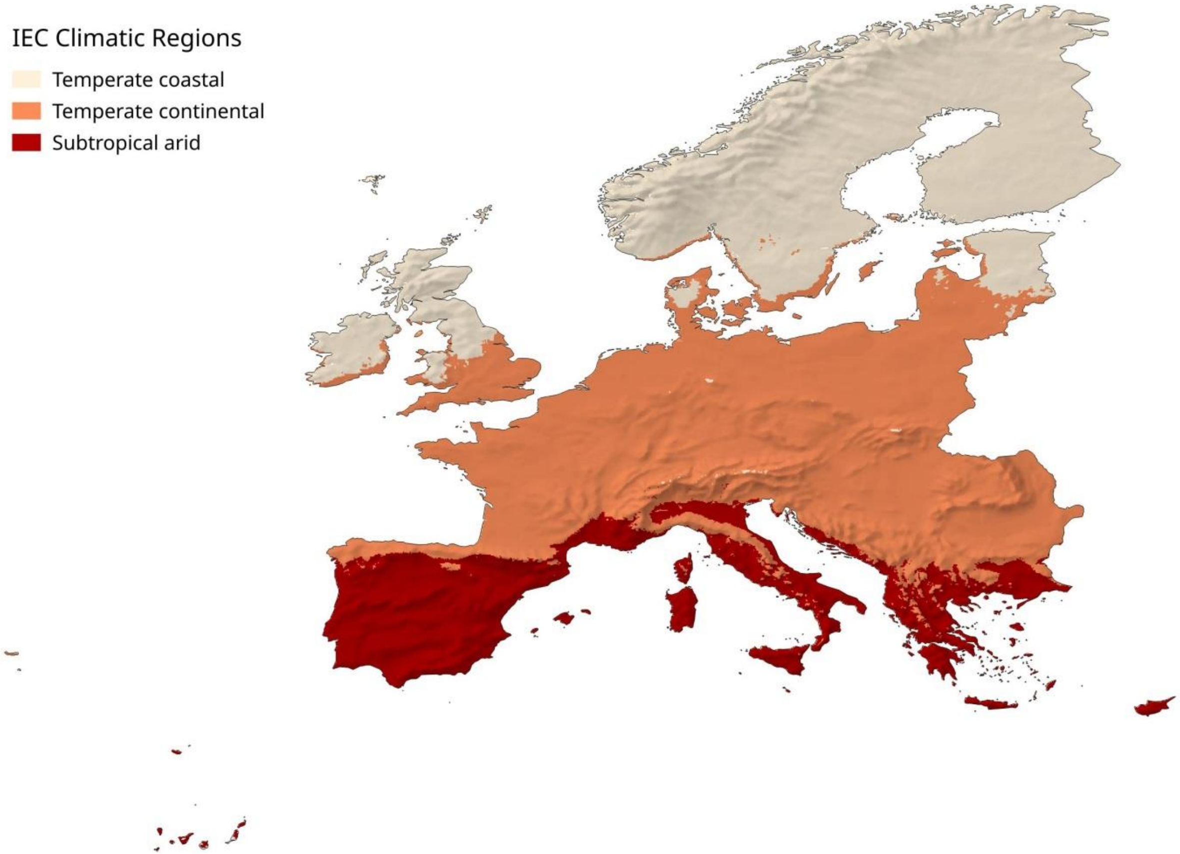
EN IEC 61853-4 *"Photovoltaic (PV) module performance testing and energy rating – Part 4: Standard reference climatic profiles"*

- Representative of the major climatic conditions
- Six datasets with hourly values for one year
- Fixed open rack, equator-facing, inclination angle 20°

Year	Sun incidence angle to the normal of the module, θ (°)
Month	Global horizontal irradiance, Gh ($W{\cdot}m^{-2}$)
Day	Direct horizontal irradiance, Bh ($W{\cdot}m^{-2}$)
Local solar time	Global in-plane irradiance, G ($W{\cdot}m^{-2}$)
Ambient temperature, T_{amb} (°C)	Direct in-plane irradiance, B ($W{\cdot}m^{-2}$)
Wind speed at the module height, v ($m{\cdot}s^{-1}$)	Spectrally resolved global in-plane irradiance integrated in 32 spectral bands, R ($W{\cdot}m^{-2}$)
Sun elevation (°)	

Satellite-retrieved

EN IEC 61853-4 *Standard reference climatic profiles*



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

Proposed methodology – input data

- PV array size and module performance characteristics (IEC 61853)
  - DC energy yield (EY_{DC}) of 1 kWp PV array over a year (kWh/year)
  - 3 reference climatic datasets
- Power Conditioning Equipment - Inverter
  - EN 50530. European efficiency, η_{EUR}
- PV system losses (default values or system specific values)
  - Cables losses
  - Diodes and connectors
  - Mismatch
  - …

} η_{system_loss}

Losses	Typical (%)	Range (%)
DC cabling	2	1 - 3
Connectors	0.5	0.3 – 1
Mismatch	2	1.5 - 3

Proposed methodology - calculation

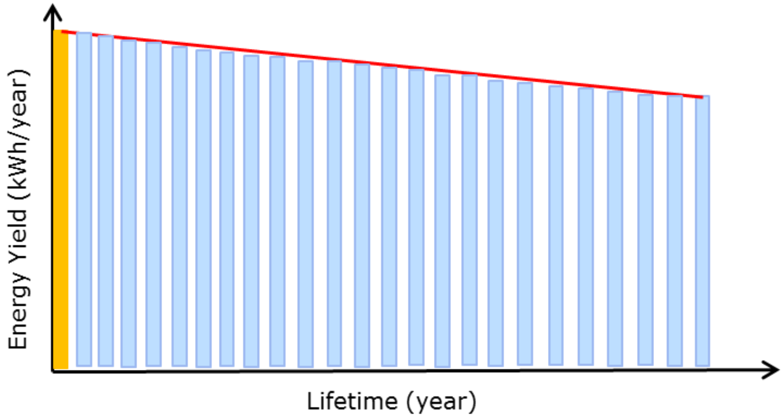
- Estimation of the AC energy yield, *System* $EY_{AC\_year\ 0}$

$$System\ EY_{AC\_year\ 0} = \eta_{EUR} \cdot (1 - \eta_{system\_loss}) \cdot EY_{DC}$$

For every reference climate

- Lifetime AC energy yield for each reference climate

$$System\ EY_{AC\_lifetime} = System\ EY_{AC\ year\ 0} \cdot T_{lifetime} \cdot \left(1 - \tau_{deg} \cdot \frac{T_{lifetime}}{2}\right)$$



$T_{lifetime}$: 30 years

τ_{deg} : degradation rate

Proposed methodology

- Functional parameter:

$$FP_{System} = \frac{1\,(kWh\ of\ AC/year) \cdot 1\,(kWp\ PV\ system)}{EY_{av}\,(kWh\ of\ AC/year)}$$

EY_{av} : Average system's AC energy yield over its lifetime

$(EY_{AC\_lifetime} / T_{lifetime})$

Proposed methodology - Example

PV array: 5 kW of c-Si modules Inverter: η_{EUR} = 0.96 Other losses 4.5%	Three reference climates Subtropical arid Temperate coastal Temperate continental

To demonstrate the role of the various loss factors we use performance ratio (PR):

- *PR is the ratio of the system performance to the module name plate value*
- *Ideal PV system with NO losses would have a PR=1*

System performance example (1) sensitivity to reference climates

Ideal PR = 1

Climates	IEC 61853 PV module performance AOI (%)	λ (%)	Irrad & Temp (%)	Total losses (%)	Inverter Losses (%)	PV system Losses (%)	Theoretical PV System Performance Ratio
Subtrop. arid	-2.7	0.4	-8.7	-10.8	-4.0	-4.5	**0.816**
Temp. coastal	-3.9	1.8	-3.2	-5.3	-4.0	-4.5	**0.866**
Temp. cont	-3.1	1.3	-6.1	-7.8	-4.0	-4.5	**0.843**

System performance example (2) sensitivity to losses

PV system configuration. Residential	PR
Default installation	0.75
Optimised design and yield forecasting	0.80
Optimised monitoring and maintenance	0.85

Task 4. "*Technical analysis including end-of-life*".

Base case as an average system

Climates	PV System PR (module and inverter)	PV system losses		
		Final **PR 0.75**	Final **PR 0.80**	Final **PR 0.85**
Subtrop. arid	0.8562	11.91%	6.30%	0.70%
Temp. coastal	0.9091	16.80%	11.52%	6.24%
Temp. cont	0.8848	14.63%	9.20%	3.78%

Possible additional needs

- Extend to PV systems with different configuration to current IEC 61853 reference datasets (equator facing with 20° inclination angle)
  - Define the models to estimate the in-plane irradiation
  - Treatment of bifacial modules
  - Use of trackers
- Extend to PV systems at specific locations
  - Use PVGIS, or similar tools to obtain climatic datasets like those in IEC 61853-4
  - Existing typical meteorological year (TMY) datasets would need additional variables
- Building Integrated PV systems
  - Models to estimate the in-plane irradiation
  - Method to define the coefficients for the module temperature estimation (increased compared to free-standing rack situation)

Possible additional needs

- PV systems with battery storage
  - Models to simulate:
    - the battery's working cycles of charge and discharge
    - state of charge
    - efficiency (temperature and age dependent)
  - Consumption profiles
  - Hourly calculations to model the flow of energy between the different components (PV array, load, battery, inverter and grid)

Note

- *IEC 61853-3 already provides for hourly calculations of DC energy yield*
- *Need to also consider range of inverter efficiency values measured for different power loads (IEC 61683 and EN 50530)*

Durability

Transitional methods to:

- ✓ To establish a definition of the degradation rate for solar PV modules, inverters and PV systems.
- ✓ To establish one (or more equivalent) method(s) to enable quantitative evaluation of the degradation of PV modules, inverters, components and PV systems.

Degradation of PV Modules

Pre-requisites: conformity to all relevant design qualification and type approval (ex: EN 61215 series), safety tests (EN IEC 61730 under Low Voltage Directive).

Prescribed values:

- c-Si: between 0.7% per year (linear)
- Thin-film and heterojunction: 1% per year (linear)

Product-specific values - requirements for acceptance:

- Robust data from the measurement of field-deployed systems and made available (upon request) to the market surveillance authorities, covering all reference climatic profiles, with data from at least:
  - 5 consecutive years
  - 2 separate geographical locations in each climatic profile
  - 2 mounting options
- Assigned value shall be the average of the collected values

Measurement guidance:
EN 61724-1 and IEC 61724 series
(PV guidelines monitoring)

Degradation of Inverters

Pre-requisites: conformity to all relevant design qualification, type approval and safety tests: EN 62116 (islanding prevention), IEC TS 62910 (test for low voltage ride-through measurements), as well as IEC 61683 and EN 50530 (efficiency measurements).

Prescribed values:

- Degradation rate: 0 %/year (no degradation)
- Failure rate: 10% per year

Product-specific values - requirements for acceptance:

- *To be defined*

Degradation of PV Systems

Pre-requisites: conformity to requirements for PV modules and inverters, and to those specifically related to PV systems relevant to safety tests, design qualification and type approval (ex: IEC 62548, HD 60364-7-712, EN 62124, IEC TS 62738, EN 62446-1, IEC 62446-2 (draft), IEC TS 62446-3, EN 50583 series (BIPV)).

Prescribed values:

- Wafer-based c-Si: 0.7% per year (linear)
- Thin-film and heterojunction: 1% per year (linear)

Product-specific values - requirements for acceptance:

- Robust data from the measurement of field-deployed systems and made available (upon request) to the market surveillance authorities, covering all reference climatic profiles, with data from at least:
  - 5 consecutive years
  - 2 separate geographical locations in each climatic profile
  - 2 mounting options
- Assigned value shall be the average of the collected values

Measurement guidance:
EN 61724-1 and IEC 61724 series
(PV guidelines monitoring)

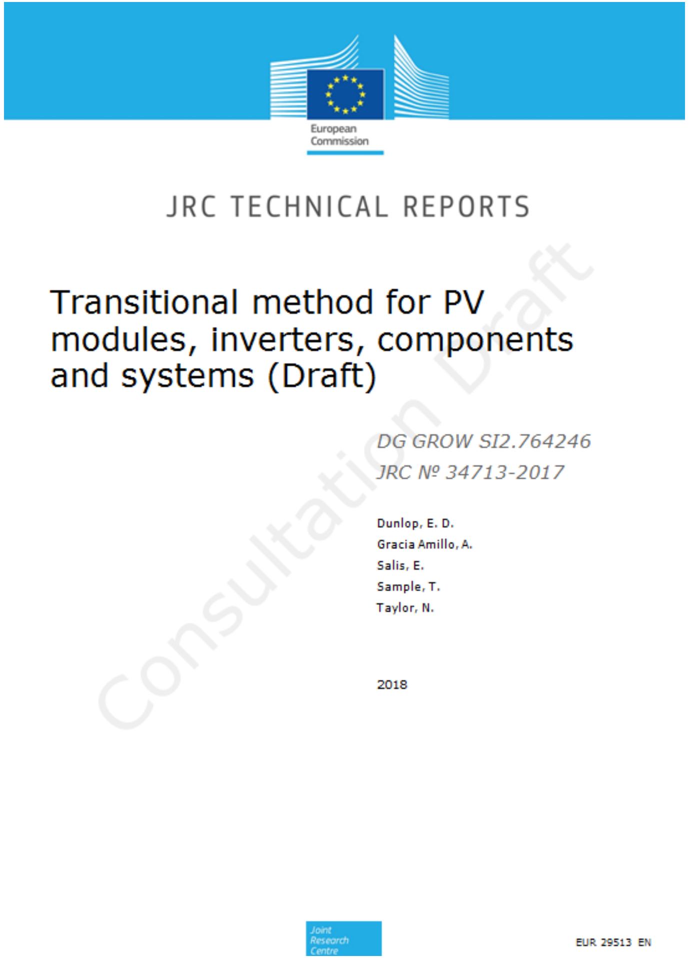
Other Materials Efficiency Aspects

- Dismantlability of PV Modules
- Disassemblability of PV Systems
- Remanufacturing of PV Systems

Pending the publication of the horizontal standards CEN/CENELEC JTC10 'Energy-related products – Material Efficiency Aspects for Eco-design under EC mandate M/543

Summary

- Procedures proposed for determining the performance of inverters and PV systems
- Need measures for identification of additional PV system losses, including quantification methods
- Approach proposed for durability parameters for components and systems
- Other material efficiency aspects are pending
- Draft report on transition methods available for review, with a finalised version planned for the 3rd stakeholder meeting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JRC TECHNICAL REPORTS

Transitional method for PV modules, inverters, components and systems (Draft)

DG GROW SI2.764246

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Thank you for your attention

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