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Preparatory study for solar photovoltaic modules, inverters and systems

(Draft) Task 8 Report:
Policy recommendations

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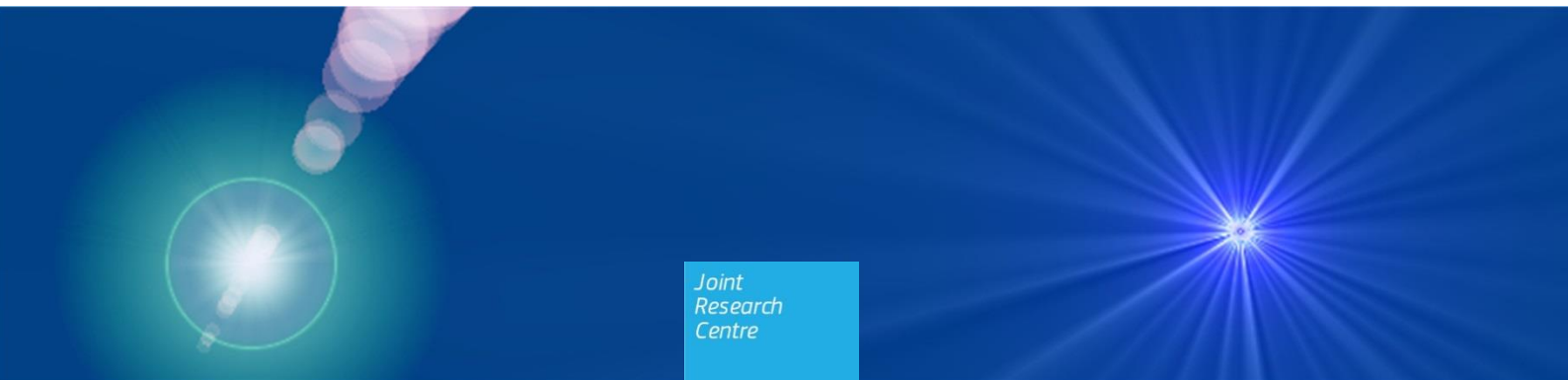

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8. Task 8: Policy recommendations

This task provides policy recommendations based on the results of policy analysis in Task 7, in particular in terms of the feasibility of proposing Ecodesign, Energy labelling, EU Ecolabel and GPP requirements, and bearing in mind the specificities of the different policy processes. In this context, the added value brought by each scheme and the potential synergies is considered as well the relevance and feasibility of potentially having the product(s) covered by one or several schemes.

The task report is structured according to the four policy instruments under study. For each policy instrument the recommended approach and package of requirements is put forward. The preferred options for combinations of policy instruments are then put forward, with identification of the package of requirements and the potential synergies.

8.1 Recommendation 1: Ecodesign requirements for modules and inverters

In this first recommendation, requirements are proposed to be set that would apply to individual modules and inverter products placed on the EU market and intended for use in photovoltaic systems for grid-connected electricity generation. Specifically excluded from the scope would be:

For modules

- Module level power electronics, containing micro-inverters and power optimisers
- Modules with a DC output power of less than 50 Watts under Standard Test Conditions (STC)
- Building Integrated Photovoltaic (BIPV) products that incorporate solar photovoltaic cells
- Modules intended for mobile applications or integration into consumer electronic products.

For inverters

- Central inverters that are packaged with transformers (sometimes referred to as central solutions) as defined in Commission Regulation (EU) No 548/2014 on Ecodesign requirements for small, medium and large power transformers.

The aim of this market intervention would be to:

- foster module and inverter designs that have improved long term energy yield, circularity and smart readiness;
- take products off the market that are of a low quality and that have higher life cycle costs whilst also introducing a requirement for transparency on the life cycle Gross Energy Requirement (GER) and Global Warming Potential (GWP) of modules.

The following technical justifications for the recommendation can be given:

- There is the need to ensure comparability in the market between claims relating to module yield, long term performance degradation and life cycle GER and GWP. By driving the use of new and existing methods, and by requiring reporting for all products the quality of data available as input to other calculations will increase.
- Module and inverter manufacturers require greater encouragement to ensure that designs are easier to repair and recycle. A voluntary intervention is not deemed sufficient because as solar PV industry moves towards mass deployment the scale of the challenge will increase rapidly and substantially.

- The material complexity and long term exposure in the field of module products means that it is difficult to specify individual durability tests. Instead a carefully specified series of test sequences is required that address priority areas identified from observations of failure modes in the field.
- Solar inverters have a key role to play in the smart readiness of homes but this is not currently a standardised feature. Intervention is therefore needed to ensure a minimum functionality across all inverters.

Moreover, an approach focussed on both modules and inverters is considered to be justified because they are business to business (B2B) components of all PV systems. The market intervention does not rely on consumer visibility as such and would act to cut off products at the point of being placed on the market to distributors, retailers, installers and consumers. This approach could, in turn, support a labelling instrument at package or system level.

8.1.1 Preferred module option 2.1: Requirements on life time electricity yield

The preferred option is for an Ecodesign requirement based on a declaration or threshold for the yield calculated according to IEC 61581-Part 3 and with reference to the climatic zones in part 4. The reason for selecting this option is that it is more representative of performance under real life conditions. In addition to the power rating it takes into account PV module performance characteristics such as coefficients for spectral response under low light conditions and the potential loss of performance at high temperatures.

Given that this is a relatively new performance measurement, having been first introduced as a standard in 2018, it is not yet considered possible to establish thresholds that could form the basis for mandatory minimum requirements. Instead as the initial proposal is for an information requirement in order to stimulate its adoption as a standard metric to be reported on module product datasheets.

If a yield threshold were to be pursued as the basis for a minimum requirement, further data gathering would be required in order to determine the market spread of yield, as this information is not yet readily available. Consideration would also need to be given as to how new technologies that initially enter the market with lower yields should be treated. This would be with the aim of not dissuading innovation.

Table 8-1. Preferred module policy option 2.1: Yield information requirement

Performance aspect	**Detailed proposed requirements**
Preferred option: Module energy yield	The module energy output (yield) expressed in kWh/kWp and calculated according to IEC 61853-3 for each of the three reference EU climate zones shall be declared by the manufacturer.

8.1.2 Preferred module option 2.2: Performance requirements on quality, durability and circularity

This further Ecodesign option would introduce a more stringent set of quality and durability tests for module products. The design qualification of modules according to test sequence set out in IEC 61215 is proposed as a Minimum Requirement. Although the test sequence is costly and has a long duration it is understood to already be considered as a market entry requirement by major manufacturers. It is also considered difficult to separate the test sequences and/or to introduce new aspects (such as encapsulant browning or inspections for cell cracking).

Customers in the commercial and large-scale solar PV system market segments currently request this design type approval as standard. Moreover, all feed-in tariff schemes to date reviewed as part of this study have requested this standard for residential contracts, so it can be seen to have been established in the residential market segment as an entry requirement.

Requiring such a design type approval would, however require further legal analysis because, although there are some enabling provisions with the Ecodesign Directive 2009/125/EC, they have to date not been used. Moreover, from the point of view of minimising regulatory burden some of the testing within the overall sequence is already mandatory for CE marking, as mandated by the Low Voltage Directive 2014/35/EU.

In order to ensure factory (mass production) conformity with the design type approval it is also considered important to request factory quality controls and auditing according to IEC TS 62941. However, this is not as suitable to be considered as an Ecodesign requirement given that it would not relate to the testing of specific product characteristics as such.

Long-term performance degradation of modules can have a significant impact on life time electricity generation. Claims made by manufacturers for their products' degradation rate or, linked this, the power guarantee, currently don't have a standardised basis and are not usually backed up by an explanation of the method by which they have been derived. A transitional method has therefore been developed by the JRC, specifying the need for claims to be based on field observations over a minimum period of time. 'Unvalidated' claims that are not supported by field observations would still be permitted as long as their experimental basis was explained, if not prescribed values should be used.

This market intervention would also seek to ensure that, via information requirements, modules were possible to disassemble and dismantle in order to facilitate repairing and recycling. The requirement signals where future design priorities should focus.

Table 8-2. Preferred module policy option 2.2: Quality, durability and circularity requirements

Performance aspect	**Detailed proposed requirements**
Performance requirements	
2.2.1 Durability product test sequency	Each model shall be certified to have passed the product test sequence required for qualification under IEC 61215. *This requirement could be further extended to require factory quality controls and auditing according to IEC TS 62941 and IECRE OD 405.*
Information requirements	
2.2.2 Lifetime performance degradation	The manufacturer shall declare the average linear degradation rate expected over a notional service lifetime of 30 years. This shall be the same rate that is used as the basis for the power warranty (if offered). The declaration shall be clearly identified as being either: – *Validated:* The manufacturer's claim shall be an average derived from a series of field observations made according to the Transitional Method, in regard to the number, geographical coverage and the time series. – *Unvalidated:* on the manufacturer shall report on the basis for their

	claimed rate with reference to accelerate life testing methods and modelling..
2.2.3 Repairability	The manufacturer shall report on: – the possibility to access and replace the bypass diodes in the junction box [1], – the possibility to replace the whole junction box of the module *Note: the possibility exists to include semi-quantitative criterion if a product specific standard is developed in accordance with the forthcoming horizontal standard for repairability prEN 45554.*
2.2.4 Dismantleability	The manufacturers shall report on the potential to separate and recover the semi-conductor from the frame, glass, encapsulants and backsheet. Design measures to prevent breakage and enable a clean separation of the glass, contacts and internal layers during the operations shall be detailed. *Note: the possibility exists to include semi-quantitative criterion if a product specific standard is developed in accordance with the forthcoming horizontal standard for recyclability prEN 45555.*
2.2.5 Material disclosure	The manufacturer shall declare the content in grams of the following materials in the product: – Antimony – Cadmium – Gallium – Indium – Lead – Silicon metal – Silver – Tellurium For the encapsulant and backsheet the manufacturer shall also declare the type of polymers used (including if it is fluorinated or contains fluorinated additives) and the content in grams.

8.1.3 Preferred inverter option 2.3: Performance requirements on efficiency

This preferred option is based on the EN 50350 method for calculating the 'Euro Efficiency' of an inverter. This is an important derating factor for the performance of a solar PV system, so the removal of the worst performing, sub 94% efficient inverters would contribute as a minimum requirements for the inverter derating factor. It is also considered important to request improved and more consistent additional information in the form of tabulated efficiency values and the inverter's temperature dependency.

The increasing role in the future of hybrid inverters incorporating battery storage introduces the possibility that such efficiency gains could be reversed in order to raise self-consumption so it is also considered important to have complementary requirements on the efficiency of hybrid systems. This would entail reference to the private

[1] This was identified as the main option available for the repair of a module in order to minimise yield loss during the lifetime of the product.

German Effizienzleitfaden standard [2], which may shortly be developed into a national DIN (Deutsches Institut für Normung) standard.

An additional requirement is proposed to facilitate the *'smart readiness'* of PV systems in support of the Commission's proposed overall initiative to develop a Smart Readiness Indicator (SRI) for buildings. For residential inverter applications a minimum functionality is proposed to be requested, based on both hardware and software. This functionality would facilitate the two best performing PV system design options in Task 6, which rely on monitoring and fault diagnosis to support repair response and maintenance. It would also support the proposed EU Ecolabel criteria relating to an on-site repair service for inverters.

Table 8-3. Preferred inverter policy option 2.3: Efficiency requirements

Performance aspect	**Detailed proposed requirements**
2.3.1 Euro Efficiency minimum requirement for PV inverters without storage	Require a minimum Euro efficiency at Tier 1 of 94% and Tier 2 at 96% measured according to EN 50530. *Allowances shall be provided for micro-inverters and hybrid inverters to offset for their other benefits.*
2.3.2 Euro Efficiency supporting information requirement	In addition the following supporting information shall be provided: - The efficiency values shall be presented in a tabulated form. - An annual temperature derating factor for the climate zones defined in IEC 61853-4 and calculated relative to 25°C
2.3.2 Efficiency requirements for PV inverters with possibility to connect storage or with integrated storage	Require a minimum system efficiency of 90% at 25% of nominal power, at minimum MPP voltage with the battery at around 50% state of charge. Measurement to be made according 'Effizienzleitfaden 2.0'.
2.3.3 Smart readiness	Manufacturers shall ensure that the inverter supports class C data monitoring according to IEC 61724-1. The inverter shall have physical and/or wireless connectivity and be capable of communicating with other devices using the Modbus data transfer protocol in accordance with IEC 61158..

8.1.4 Preferred inverter option 2.4: Performance requirements on quality, durability and circularity

This preferred option is based on the introduction of a standardised basis for the minimum durability of inverters placed on the market, together with a focus on information about the repairability of the inverter. These requirements are an important first step in extending the potential service life of inverters, particularly for those intended to be placed in outdoor environments, where the failure rate during the first ten years can be high. Failures provoked by high temperature operating conditions are a focus of attention.

The design qualification of inverters according to test sequence set out in IEC 62093 is proposed as a Minimum Requirement. Requiring such a design type approval would, however, require further legal analysis because, although there are some enabling provisions with the Ecodesign Directive 2009/125/EC, they have to date not

[2] BVES, *Effizienzleitfaden für PV-Speichersysteme v. 2.0.1*, July 2019, https://www.bves.de/effizienzleitfaden_2/

been used. Moreover, from the point of view of minimising regulatory burden some of the testing within the overall sequence is already mandatory for CE marking, as mandated by the Low Voltage Directive 2014/35/EU.

In order to ensure factory (mass production) conformity with the design type approval it is also considered important to request factory quality controls and auditing according to IEC TS 63157. However, this is not as suitable to be considered as an Ecodesign requirement given that it would not relate to the testing of specific product characteristics as such.

The potential to maintain the functionality of the inverter on-site is also considered important in order to minimise the life cycle impacts associated with short replacement cycles. To this end repairability requirements are proposed that seek to inform professionals and consumers about the maintenance and repair potential of the product. The outcome is anticipated to be an improved focus on mid-life wear-out and preventative maintenance in the residential and commercial market segments.

Table 8-4. Preferred inverter policy option 2.4: Quality, durability and circularity requirements

Performance aspect	**Detailed proposed requirements**
2.4.1 Durability product test sequence	Each model shall be certified to have passed the product test sequence required for qualification under IEC 62093.clearly stating whether the product is for indoor or outdoor applications. *This requirement could be further extended to require factory quality controls and auditing according to IEC TS 63157 and the associated IECRE OD [pending a code].*
Additional information requirements	
2.4.2 Repairability requirements for inverters <30 kW	The manufacturer shall identify which of the circuit boards can be replaced on site.
2.4.3 Repairability requirements for inverters >30 kW	Manufacturers shall provide a preventative maintenance and replacement cycle. This shall include a list of parts that may be replaced and the timing of preventative measures to achieve a declared intended design technical lifetime (as required in IEC TS 63157). *Note: the possibility exists to include semi-quantitative criterion if a product specific standard is developed in accordance with the forthcoming horizontal standard for repairability prEN 45554.*
2.4.4 Material disclosure	The manufacturer shall declare the content in grams of the following materials in the product as a whole and in the replaceable circuit boards: - Lead - Cadmium - Silicon carbide - Silver - Indium - Gallium - Tantalum

8.1.5 Preferred Ecodesign option 2.5: Life cycle GER and GWP information requirement

This additional overarching Ecodesign option would establish a standardised basis for the collection, analysis and presentation of module and inverter life cycle data and Life Cycle Assessment (LCA) results in the EU. The initial focus would be on two impact categories – primary energy (GER) and Global Warming Potential (GWP). The latter is also sometimes referred to as a carbon footprint or embodied CO_2 emissions.

This requirement would represent a first step in establishing a consistent basis for comparing the life cycle impacts of the products, in turn providing data in support of life cycle criteria for the EU Ecolabel and/or Green Public Procurement, if taken forward. It is anticipated that, if introduced, a delayed introduction would be needed so that manufacturers would have time to prepare EPDs.

Establishing such an Ecodesign information requirement is anticipated to support and establish synergies with a number of other EU policy instruments:

- The EU Taxonomy on sustainable activities: A regulation on the establishment of a framework to facilitate sustainable investment. is currently undergoing Impact Assessment [3] and accompanying technical screening criteria for economic activities, including renewable electricity generation, are currently under development and are currently proposed as including a requirement to disclose to investors the life cycle CO_2 emissions of solar PV systems. It is anticipated that in the future this disclosure would be expected as a condition for investment and/or companies with solar PV assets would have to disclose this data to equity investors. This will particularly apply to large-scale systems.
- Construction Product Regulation: The reference to sustainability within the Basic Works Requirements has already mandated the development of the two standards EN 15804 (PCR for construction products) and EN 15978 (LCA for buildings). However, the availability of EPDs for construction products is still limited, particularly for building technical services. Given that solar PV is the favoured technology for NZEB buildings, there is the need to develop more EPDs for system components.
- European Green Deal: The new European Commission has approved proposals for a 'European Green Deal'. This includes proposals for a border requirement or tax relating to embodied CO_2 emissions. This would require a mandatory standardised basis for declarations of performance.

However, in order for this proposal to be made 'operational' within an Ecodesign implementing regulation, a dedicated check on the legal feasibility of such a requirement in the framework of the Ecodesign Directive would need to be carried out.

Table 8-5. Preferred Ecodesign policy option 2.5: Life cycle data information requirement

Performance aspect	**Detailed proposed requirements**
2.5.1 Life cycle GER and GWP product declaration	At the latest by [*delayed year of introduction*] and for a representative product from each module series placed on the market, an Environmental Product Declaration for, as a minimum, life cycle primary energy (GER) and Global Warming Potential (GWP) shall be developed and provided. *For further discussion: options are for the EPD to be in conformity with EN 15804 or the PEFCR and to have been registered with a Type III Product Category Rule operator.*

8.2 Recommendation 2: Energy Label for residential systems

In this second recommendation it is proposed to establish an Energy Label for solar PV systems that is targeted at systems installed on residential buildings – referring to any building, public or private, that is intended for use as a permanent dwelling.. This shall include Building Integrated Photovoltaic (BIPV) systems made up of one discrete array consisting of a homogenous PV product. For simplicity, it is proposed that the labelling requirements would

[3] Commission legislative proposals on sustainable finance, 24th May 2018, https://ec.europa.eu/info/publications/180524-proposal-sustainable-finance_en#investment

be placed on the *as-built* rather than the *monitored* performance of a system. It is also proposed that systems that incorporate Building Integrated (BIPV) photovoltaic arrays could be labelled.

The aim of the label would be to optimise and increase the energy yield of residential installations by enabling consumers to make an informed choice based on the performance of system designs offered by retailers and installers. Installers and designers would in turn be free to develop designs and packages of system components and maintenance services that can improve the energy yield, and therefore the label rating of systems.

From a technical perspective, evidence from selected Member States suggests that the distribution curve of normalised energy yields and performance ratios for the system stock has the potential to be shifted positively upwards through a combination of:

- better design to take into account of site-specific conditions,
- learning applied to installation practices,
- reduced losses due to equipment, cabling and maintenance practices.

In this respect, both the repowering of old systems and the optimisation of new system has the potential to contribute.

This recommendation would be complemented and supported by Recommendation 1 in so far as module energy yield (MOD 2.1) and inverter Euro efficiency (INV 2.3) are required as input data for yield calculation transitional method. Normalisation of the calculated yield to the rated power and area of the module array are essential in order to maximise the potential benefits of this policy recommendation. This is because retail customers should be encouraged to upgrade performance on a like for like area (m^2) basis.

In establishing such a label it will be important to carefully adapt format of the labelling scale, so as not to portray systems with site constraints in a negative light e.g. a residential roof with an east-west orientation. In the context of EU renewable energy targets and the need for mass deployment of the technology, all new solar PV capacity should be considered advantageous and it will be important to inform rather than dissuade consumers.

Table 8-6. Preferred energy label policy option 3.2: System yield-based EEI

Performance aspect	**Detailed proposed requirements**
3.2 System yield-based Energy Efficiency Index (EEI)	The system provider shall follow instructions for the calculation of the overall yield derived from the module yield and Performance Ratio for the system design. In addition the yield shall be calculated on the following basis according to the transitional method: – For a notional 30 year service life. – For the closest representative EU climate zone. – By applying the listed derate factors, together with prescribed (default) values, which will be provided in the Implementing Regulation. The EEI shall be expressed in units of MWh/kWp.m^2.
NOTE: the present analysis deals with techo-economic aspects. In parallel, a check is ongoing on the legal feasibility of an Energy labelling scheme for PV products/system, in the form of a delegated act in the framework of Regulation 2017/1369	

8.3 Recommendation 3: EU Ecolabel for residential systems

In this third recommendation it is proposed that a new EU Ecolabel product group is established targeted at systems intended to be installed on residential buildings and with low voltage connections that facilitate self-consumption of the electricity generated by the occupants. Residential buildings refers to any building, public or private, that is intended for use as a permanent dwelling.

A qualitative evaluation, which was made with reference to DG Environment's criteria for establishing new product groups, found it to be feasible but indicated some areas of uncertainty. One of the most important areas related to metrics and benchmarks. Whilst initial criteria areas with metrics are proposed as an outcome of this study, the setting of the thresholds will require further dialogue and evidence gathering in conjunction with industry stakeholders.

Taking into account the need for the verification and award of products or services by EU Ecolabel Competent Bodies prior to them being placed on the market, the multi-criteria set is recommended to comprise the following two aspects:

1. Package approach: There would be criteria for modules and inverters. The criteria could make use of input data from Policy Recommendations 1 (Ecodesign) and 2 (Energy Label) in order to set criteria that have an extended and stricter focus with pass/fail criteria on:
   - life cycle performance,
   - hazardous substances
   - circular design.
2. Service approach: There would be a criteria covering aspects of the service provided by system installers, to include the system design, site protocols and aftercare (monitoring and maintenance).

The scope shall allow for inclusion of collective or community owned solar PV systems where shares can be purchased by individual consumers. This may include systems installed on buildings or free standing ground mounted systems.

An important consideration in seeking to establish a new product group is the potential for products to comply with Articles 6(6) and 6(7) of the Ecolabel Regulation (EC) 66/2010. The product group is considered feasible subject to the acceptance of a series of derogations for hazardous substances that are required to be present in order to ensure the performance or durability of certain product variants. An overview of the principal derogations that have been identified as being required is presented below. If the policy recommendation is taken forward, it is to be further discussed with industry stakeholders the extent to which the three Candidate List substances identified are necessary and the potential impact on potential uptake if their derogation was not to be granted.

Anticipated derogations under Articles 6(6) and 6(7) of the Ecolabel Regulation (EC) 66/2010

Given the need to comply with Articles 6(6) and (7) of the Ecolabel Regulation, it is already anticipated that the following substances are likely to require formal 'derogation' in order to allow module or inverter products to be awarded the EU Ecolabel:

- REACH Candidate List substances (0.10% w/w screening threshold)
  - Cadmium sulphide (semi-conductor)
  - lead (solder/metallisation)
  - diarsenic trioxide (module glass)
- CLP hazard classification (0.10% w/w screening threshold)
  - Substitute plasticisers with a more favourable hazard profile used in cables,

- Substitute flame retardants with a more favourable hazard profile used in inverter PCBs,
- Diantimony trioxide (crystalline module glass)
- Titanium dioxide, zinc dioxide (antisoiling)

A further important consideration of the label, if taken forward, will be alignment with other international labels and standards. A priority will be compatibility with the NSF/ANSI 457 Sustainable Leadership standard for modules and inverters, now to be adopted as an EPEAT standard. Although the criteria in the standard are largely process-based, as opposed to the EU Ecolabel which must have pass/fail criteria, the potential for the management processes, standards and practices specified within the criteria to form a basis for the verification for performance under specific EU Ecolabel criteria should be ensured. Examples include:

- Required criterion 7.1.1 - Conducting life cycle assessment [including primary energy and GWP]
- Required criterion 9.1.1 - Product take-back service and processing requirements (corporate)
- Optional criterion 5.2.2 - Presence of substances on the European Union REACH Regulation Candidate List of Substances of Very High Concern
- Optional criterion 5.1.5 – [Substance] Alternatives assessment
- Optional criterion 9.2.1 — Identification of materials for EOL management

Table 8-7. Preferred EU Ecolabel criteria set for modules, inverters and services

Performance aspect	**Detailed requirements**
4.1 Energy and CO_2 criteria	
4.1.1 Energy return on investment	The EU Ecolabel applicant shall calculate the energy return on investment for the module and inverter package. The EROI should be below [*threshold tbd*]. *The production and use stage primary energy use shall be derived from the method set out in the corresponding Ecodesign information requirement, which is proposed as being based on EN 15804 and the PEFCR.*
4.1.2 Life cycle GWP	The EU Ecolabel applicant shall calculate the life cycle GWP for the module and inverter package. The kg/CO_2.kWh shall not exceed [*threshold tbd]* *The life cycle impacts shall estimated according to method set out in Ecodesign, which is based on EN 15804 and the PEFCR.*
4.2 Hazardous substances criterion This criterion will require the formal 'derogation' under Articles 6(6)/6(7) of the EU Ecolabel Regulation (EC) No. 99/2010 of a number of substances that may be present in modules and inverters.	
4.2.1 Candidate list substances	The IEC 62474 substance declaration shall be used to declare that Candidate list substances are not present at >0.1%
4.2.2 Lead and cadmium	The content of lead and cadmium in modules and inverters shall be less than 0.1% and 0.01% respectively. By weight or by Wp The cadmium level may be >0.01% if recovery of the semi-conductor can be demonstrated as part of a take back service provided.

4.2.3 Fluorinated backsheets	Module products shall not be manufactured with fluorinated backsheet materials.
4.2.4 Glass additives	Antimony and arsenic in glass shall not be present at >50 ppm
4.2.5 Flame retardants and pthalates	The hazard restrictions of the personal computer product group on cables and main circuit boards shall apply.
4.3. Circular economy criterion	
4.4.1 Module durability and quality	Design type approval proposed as an Ecodesign requirement shall be implemented by an audited factory quality control system in accordance with IEC TS 62941 and IECRE OD 405.
4.3.2 Module degradation rate	Declaration of the rate shall be validated by the Transitional Method for Ecodesign and demonstrate an average performance degradation rate over a 30 year time period of 0.6%
4.4.3 Module design for recycling	The manufacturer shall document and report the sequence of steps and tools required to dismantle the module and recover the solar cells or semi-conductor material.
4.4.4 Inverter on-site repair service	The installer shall ensure that a responsive repair service is provided for inverters, with on-site replacement of the main circuit boards forming part of the service.
4.4.5 Repairability requirements for inverters	<30 kW: The manufacturer shall ensure that the power, filter and communications circuit boards as well as firmware updates shall be made available for a minimum period of 7 years. >30 kW: Manufacturers shall ensure that replacement parts and firmware updates are made available in line with the recommended replacement cycle.
4.5 System service criteria	
4.5.1 Optimised design	The system design shall be optimised taking into account the specific local conditions of the installation. The service provider shall demonstrate that the system design software used takes into account, as a minimum: – Orientation and possible shading, – Local climatic conditions, including temperature dependency – Exposure/access to the inverter
4.5.2 Handling and installation protocols	The contractors used to install the system shall follow a protocol designed to minimise any breakages to modules during transport to and handling on site.
4.5.3 Monitoring and maintenance	The service shall include, for a minimum of 10 years, the monitoring of the system for faults and a responsive repair and maintenance service designed to optimise performance. This shall include, as a minimum: – Fault diagnosis, – Repair and replacement cycles for major components, and

	– Cleaning of the modules.

8.4 Recommendation 4: EU Green Public Procurement criteria for PV systems

In this fourth recommendation it is proposed that a new GPP product group is established targeted at the procurement of PV systems for grid connected power generation by public authorities, but with an additional, broader focus on the public authority acting as a catalyst to increase local residential PV system installations and to create demand for green (solar) electricity.

A qualitative evaluation, which was made with reference to DG Environment's criteria for establishing new product groups, found it to be feasible. The main focus of the criteria set for direct use by public authorities would be the project management of a PV system installation to minimise life cycle cost and environmental impacts. This could extend from contractor selection through to decommissioning and would seek to manage solar PV system procurement processes in order to:

- optimise the site specific potential to generate solar power,
- seek a balance between optimising energy yield and life cycle energy/GWP of the installations
- minimise risks to loss of income from quality issues that may arise related to equipment and the installation itself,
- minimise the Levelised Cost of Electricity (LCOE) along the life cycle of a project.

Because the development of local markets for solar PV appears to be in part driven by visibility and peer pressure, GPP criteria have a potentially important leadership role. The public sector has a substantial stock of buildings and land on which solar PV could potentially be installed – either by direct procurement or via access rights. They also have a substantial demand for electricity which could be used via bilateral arrangements such as Power Purchase Agreements to drive investment in new solar generating capacity.

Once a decision has been made to procure solar PV systems a public authority can in most cases exert a direct influence on the competencies of contractors, the design of systems and the specification of components. In the case of reverse auctions or the procurement of electricity this influence can be extended to third party, installations.

Table 8-8. GPP criteria set for PV system procurement

Performance aspect	**Detailed proposed requirements**
Module and inverter factory quality and performance testing	
5.1.1 Design quality of modules and inverters	*Technical requirement for design qualification and factory quality*: – Core: Design type approval of each model deployed according to IEC 61215 and IEC 62941 – Comprehensive: Factory quality controls and auditing according to IEC TS 63157 and the associated IECRE OD [pending a code].
5.1.2 Module degradation rate	*Award criteria based on declared module degradation rate.* Points shall be awarded based on the validated performance degradation rate period expressed as the average annual % loss over a 30 year time. The transitional method shall be used as the basis for verification.
Design and yield estimation	

5.1.3 Energy return on investment	*Award criteria based on declared system EROI.* The EU Ecolabel applicant shall calculate and declare the energy return on investment for the system. *The production and use stage primary energy use for the modules and inverters specified shall be derived from the corresponding Ecodesign information requirement, which is proposed as being based on EN 15804 and the PEFCR.*
5.1.4 Life cycle GWP	The EU Ecolabel applicant shall calculate the life cycle GWP for the system. The $kg/CO_2.kWh$ shall not exceed [threshold tbd]. *The life cycle impacts shall estimated according to method set out in Ecodesign, which is based on EN 15804 and the PEFCR.* *Note:* there is an option to provide default values in tabular form as has been done by the French Government for the national PV capacity auction process.
5.1.4 System energy yield	*Award criteria based on an estimate of the system yield (with reference to the Energy Label EEI)* The system provider shall make a design estimate of the system yield based on the methodology for calculating the Energy Label EEI. The EEI shall be expressed in units of $MWh/kWp.m^2$. The contractor shall also declare a target plant Performance Ratio. Under a contract performance clause the yield and target plant performance ratio the installed system shall then be monitored according to IEC 61724.
Installation/ construction	
5.1.5 Handling and installation protocols	*Selection Criteria evidencing the use of such protocols and/or Technical Specification requiring specific actions within a protocol.* The contractors used to install the system shall follow a protocol designed to minimise any breakages to modules during transport to and handling on site.
5.1.6 Commissioning test	*Contract performance clause based on the target plant Performance Ratio* A commissioning test shall be carried out according to IEC 61724 in order to evaluate the Performance Ratio of the system. The commissioning PR shall be compared with the target plant Performance Ratio declared at bid stage.
Operation & Maintenance	
5.1.7 Inverter preventative repair cycle	*Technical Specification based on planning to respond to inverter manufacturers recommended repair cycle* In order to use a longer inverter lifetime than the default for the life cycle GWP calculation manufacturers shall provide a recommended preventative maintenance cycle. This shall include a list of parts recommended to be replaced and preventative measures to achieve an intended design technical lifetime.
5.1.8 Monitoring	*Technical Specification/Award Criteria for the granularity of monitoring system* Manufacturers shall ensure that the system design supports class C data monitoring according to IEC 61724-1. The system shall have physical and/or wireless connectivity capable of communicating with remote monitoring systems using a recognised data transfer protocol.

5.1.9 Maintenance	*Technical Specification/Award Criteria for the provision of aftercare services* The service shall include, for a mínimum of [award] years, a repair and maintenance service designed to optimise performance. This service shall include, as a minimum: – Fault diagnosis, – Responsive repair and planned replacement cycles for major components, and – Cleaning of the modules.

8.5 Combined policy option recommendations

One of the aims of considering both mandatory and voluntary policy instruments within the frame of the Preparatory Study has been to analyse the potential for synergies between them. Two combined policy options were therefore identified and modelled in Task 7 in order to determine the improvement potential. The two combined options reflect the mandatory and voluntary nature of the instruments and the differing ways in which they may act on the market:

- **COM 6.1 (ED+EL+GPP)** would be led by implementation of the two mandatory instruments, namely Ecodesign and Energy Labelling, to be complemented by voluntary Green Public Procurement criteria.
- **COM 6.2 (ED+GPP+EU Ecolabel)** would be led by implementation of the two voluntary instruments, namely the EU Ecolabel and Green Public Procurement, backed by the mandatory instrument Ecodesign.

The two options are further compared and contrasted in the following sections 8.5.1 and 8.5.2 before an overall recommendation is made in section 8.5.3.

8.5.1 Combined policy option 6.1: Mandatory instruments complemented by Green Public Procurement (GPP)

The basis for this option would be implementation of the two mandatory instruments, namely **Ecodesign and Energy Labelling**, to be complemented by voluntary **Green Public Procurement** criteria. Table 8-9 provides an overview of the metrics and requirements that would be brought together under this policy option and which were modelled in Task 7 as COM 6.1. The proposals in Table 8-9 reflect the state of the art (in particular in terms of metrics) at the moment of drafting the present Task (December 2019). The availability of future metrics could entail changes in the nature of the proposed requirements (e.g. from Ecodesign information requirements to mandatory threshold requirements).

Introduction of the two mandatory instruments would ensure a consistent focus in the market on long term performance and circularity, acting at both component and system level. An important aim of introducing the GPP criteria would then be to use public sector influence, in particular at regional and local level, to exploit a range of synergies with the mandatory instruments by providing guidance and criteria in three key areas:

1. The *direct procurement of new solar PV systems*, with reference to component life cycle requirements established under Ecodesign.
2. The establishment of *procurement frameworks for residential 'reverse auctions'* that would facilitate an increase in residential installations, with reference to component requirements established under Ecodesign and the system EEI under the Energy Label.
3. The auction of *usage rights for public assets* (land and roofs) as the basis for green (solar) electricity generation, with bilateral Power Purchase Agreements as a related option.

The GPP criteria would also seek to influence the practices of system installation contractors and the supply chain.

Table 8-9 Metrics and requirements for combined policy option COM 6.1: Mandatory instruments + Green Public Procurement (GPP)

Metric/requirement	Ecodesign	Energy Label	GPP
Life cycle performance and yield			
Euro efficiency (Inverter)	MR	As input data	As input data
Energy yield (module)	IR	As input data	*CSER as input data*
Energy yield (system)		EEI	*EEI used for AC*
Design optimisation (system)		User defined data	*EEI used for AC*
Operation and maintenance (system)		User defined data	TS
Long-term degradation (module)	IR	As input data	AC
Life cycle GER and GWP	IR		AC
Energy Return on Investment			*EEI and life cycle data used for AC*
Smart readiness	MR		TS
Material efficiency and circularity			
– **Durability (IEC tests)**	MR		TS
– **Factory quality (IECRE)**			TS
– **Warranty**			TS/AC
– **Repairability**	IR (MR?)		TS/AC
– **Recyclability**	IR (MR?)		AC
– **Hazardous substances**	IR		
– **Material content**	IR		

Key to acronyms used:
MR Minimum Requirement
IR Information Requirement
EEI Energy Efficiency Index
TS Technical Specification
AC Award Criterion

8.5.2 Combined policy option 6.2: Voluntary instruments supported by Ecodesign

The basis for this option would be the implementation of the two voluntary instruments, namely the **EU Ecolabel** and **Green Public Procurement**, backed by the mandatory instrument **Ecodesign**. Table 8-10 provides an overview of the metrics and requirements that would be brought together under this policy option and which were modelled in Task 7 as COM 6.2. The proposals of Table 8-10 reflect the state of the art (in particular in terms of metrics) at the moment of drafting the present Task (December 2019). The availability of future metrics could entail changes in the nature of the proposed requirements (e.g. from Ecodesign information requirements to mandatory threshold requirements).

The two voluntary instruments would provide a means of stimulating green innovation in a coherent framework of criteria that address life cycle hot spots:

- The EU Ecolabel would focus attention on *module and inverter designs* that have a high Energy Return on Investment, a low life cycle GWP, contain less hazardous substances and which facilitate future repair and recycling. These criteria would in turn provide the basis for Comprehensive GPP criteria.
- Both the instruments would have a focus on the *system service 'offer'* of installers, addressing design, monitoring and maintenance aspects, and aiming to maximise the *Energy Return on Investment and life cycle performance of systems*.

The establishment of mandatory Ecodesign requirements would lay down the units of measurement and methods that would be required for a number of the voluntary criteria – specifically: energy yield, derating factors, performance degradation, life cycle GER and GWP.

Table 8-10. Metrics and requirements for combined policy option COM 6.1: Voluntary instruments + Ecodesign

Metric/requirement	Ecodesign	EU Ecolabel	EU GPP
Life cycle performance and yield			
Euro efficiency (Inverter)	MR		*As input data*
Energy yield (module)	IR	*As input data*	*CSER as input data*
Energy yield (system)			TS/AC
Design optimisation (system)		*Modelling requirements*	*EEI used for AC*
Operation and maintenance (system)		EC	TS
Long-term degradation (module)	IR	EC	AC
Life cycle GER and GWP	IR	EC	AC
Energy Return on Investment		EC	AC
Smart readiness	MR	EC	TS

Material efficiency and circularity			
– **Durability (IEC tests)**	MR	EC	TS
– **Factory quality (IECRE)**		EC	TS
– **Warranty**			TS/AC
– **Repairability**	IR (MR?)	EC	TS/AC
– **Recyclability**	IR (MR?)	EC	AC
– **Hazardous substances**	IR	EC	
– **Material content**	IR		

Key to acronyms used:
MR Minimum Requirement
IR Information Requirement
EEI Energy Efficiency Index
EC Ecological criterion
TS Technical Specification
AC Award Criterion

8.5.3 Recommendation on the combined policy options

The results of the scenario modelling in Task 7 showed that COM 6.1 was estimated to provide the greatest improvement in yield until 2050, initially providing an uplift of 3.4% in 2025 rising to as much as 7.7% by 2035, versus an uplift of 2.4% in 2025 and 5.4% in 2035 for COM 6.2 The difference is accounted for assumptions made in COM 6.1 about efficiency gains and improved system yields driven primarily by substitution effects in the market from the mandatory Energy Label option 3.2.

More modest assumptions about similar effects that could be driven by the EU Ecolabel criteria set still drive up yield in COM 6.2 but not to the extent of the Energy Label 3.2 option and in fact the assumptions about market confidence made for the EU Ecolabel can be considered to have a higher level of uncertainty due to it being a voluntary instrument. This could therefore increase the gap between the performance of the two options. Note also that the potential for GPP to have a broader market influence – primarily through facilitating an increase in residential deployment, as modelled in option 5.2, was not included in the modelling for either COM 6.1 or 6.2.

In terms of the annual GER, the results of the scenario modelling in Task 7 showed that the most beneficial combined scenario for GER was COM 6.2. This scenario was modelled as providing a benefit of up to 21% on the BAU in the period 2025 – 2035 with the improvement largely driven by the mandatory Ecodesign instrument, supported by the EU Ecolabel. The more modest improvement of 4-5% achieved by COM 6.1 is the result of a trade-off between the higher yield it achieves and, in order to achieve this yield, the deployment of module technologies that have a higher GER.

Given the policy significance of renewable energy deployment and consequently renewable energy yield to the EU's climate change mitigation objectives, it is considered that COM 6.1 is the preferred option. This option is driven by mandatory instruments that can exert a strong influence on life cycle energy yield and in the case of

Ecodesign this can be used to lay down market entry requirements that can exert an influence on the stock life cycle GER. The GPP voluntary instrument could, moreover, be used to exert a range of broader market influences via local and regional government, with a particular focus on increasing residential solar PV system deployment. In the case of the EU Ecolabel the potential influence on the residential market segment is considered to have a higher level of uncertainty.

Although there is a trade-off in a lower improvement in GER from option COM 6.1, this study has also identified that solar PV technology achieves a relatively high Energy Return on Investment across all the policy options, This is because the energy invested in the production stage to extract raw materials and manufacture modules and inverters is, even in the worst case scenarios modelled, a factor of approximately 4-7 times less than the use stage benefit from energy generation. Moreover, further improvements in GER could be achieved in option COM 6.1 by making further progressive updates in the Ecodesign requirements described under option 2.2 and 2.4.