# CALL TO ACTION: FOR A RENAISSANCE IN EUROPEAN PV MANUFACTURING CAPACITY

| CO-SIGNATORIES | | | | | |
|---|---|---|---|---|---|
| **COUNTRY** | RTO | **COUNTRY** | RTO | **COUNTRY** | RTO |
| **AUSTRIA** | AIT | **EU** | SOLARPOWER EUROPE | **ITALY** | MIBSOLAR |
| **BELGIUM** | IMEC | **FINLAND** | AALTO | **LITHUANIA** | PROTECH |
| **CZECH REPUBLIC** | FZU | **FRANCE** | CEA-INES | **NETHERLANDS** | TNO |
| **CZECH REPUBLIC** | JHIPC CAS | **FRANCE** | IPVF | **NETHERLANDS** | TU DELFT PVMD |
| **DENMARK** | DTU | **GERMANY** | FRAUNHOFER ISE | **POLAND** | SAULE |
| **ESTONIA** | TTÜ | **GERMANY** | ISC KONSTANZ | **POLAND** | WUT |
| **EU** | EERA | **HUNGARY** | OBUDA | **SPAIN** | IES |
| **EU** | EUREC | **ITALY** | CHOSE | | |
| **EU** | ETIP PV | **ITALY** | ENEA | | |
| **COUNTRY** | RTO | **COUNTRY** | RTO | **COUNTRY** | RTO |
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The European Green Deal has ambitious goals for energy transformation. It says decarbonising the energy system is critical to reach climate objectives in 2030 and 2050[1]: “A power sector must be developed that is based largely on renewable sources” and “At the same time, the EU's energy supply needs to be secure and affordable for consumers and businesses.”

This follows the Intergovernmental Panel on Climate Change (IPCC), stating the too slow decrease in global greenhouse gas (GHG) emissions will not allow to keep the average global temperature increase below 2°C. According to this analysis, a temperature increase of 1.5°C would be reached at the beginning of 2030, with a prospect of 2.0°C in 2050. Decarbonising our energy supply is a crucial element in achieving these collective goals, as 65% of current global $CO_2$ emissions are due to the use of fossil fuels.

**Photovoltaics (PV) is a key technology solution to fight climate change and to make Europe climate-neutral by 2050; it can be deployed in a modular way anywhere in the world**. Solar resources in Europe and around the world are abundant. All future energy scenarios foresee a key role for solar photovoltaic energy. Photovoltaics has enormous global and European potential, making it an important component of a secure and sustainable energy system of the future. In several European countries, photovoltaics already covers more than 5% of the annual electricity demand, which was initially foreseen only after 2020. Photovoltaics currently covers 3% of total EU electricity demand, with a trend towards 15% in 2030.

**The photovoltaic industry has changed radically in recent years.** In Europe, the rapid growth of the PV market has not led to similar growth in capacity for the production of solar ingots, wafers, cells and modules, as policies have focused on supporting the use of PV electricity. As a result, Europe has lost considerable market share over the last decade. While 30% of global PV module manufacturing was done in Europe in 2007, it has fallen to less than 3% ten years later. The overall annual global turnover of the European PV industry is currently estimated at €5 billion. More than 60% of this figure goes to equipment manufacturing, 20% to the manufacture of inverters, 9% to the production of polysilicon and about 7% to the manufacture of cells and modules. **The EU has to consider the PV sector as Strategic Value Chain and go towards IPCEI.**

In a context where almost all photovoltaic modules are produced outside Europe (97%) and in particular in China (68%), and where all analyses show that photovoltaics plays an increasingly important role in the future global energy system, and where there is still plenty of room for breakthrough concepts, developing an industry and research-innovation strategy that will ensure Europe's strong position in this sector is essential. **It is aligned with the Commission’s “New Industrial Strategy for Europe” vision[2]: a source of economic growth, job creation and, last but not least, strategically increased sovereignty.**

**Advances will have to be based on innovations and technological breakthroughs** that will provide unique opportunities in terms of intellectual property development while opening up spaces for new entrants into the research and industry ecosystem that surrounds this production. The cost of PV-generated electricity has been strongly reduced over the last decades. However, technological innovation remains essential to further enhance light-to-power conversion efficiency and to reduce module and system prices. Established concepts need to be optimized and R&D on novel concepts needs to be accelerated to bring these technologies into the market. For

[1] https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

[2] European Commission. A New Industrial Strategy For Europe COM(2020)12:

both optimization of manufacturing and process equipment, integrating smart automation and novel digitization strategies is essential. Moreover, further enhancement of lifetime, quality and sustainability and hence improving environmental performance is mandatory.

For the dominant silicon-based technology (95% of the market) developments are ongoing to realise concepts that reach its limits around 21-22% modules efficiency for mainstream technologies. Reaching the silicon efficiency limit 25 to 26% (theory limit set to 29%); and to transfer these into high throughput manufacturing is a first challenge. Looking further ahead tandem technologies, which consist of the association of two cells made of different and complementary materials, could in theory exceed efficiencies of 42%. Several materials have already shown strong advantages in constituting these tandem cells (silicon, perovskites, III-V, CIGS, organic). This race for conversion efficiency not only opens the way to new, more efficient methods of producing electricity, based on new processes and equipment, but also hydrogen, by photoelectrochemical means. Advances are thus based on skills and ecosystems that cut across different areas of the energy transition.

**Many technological obstacles still need to be overcome with regard to production costs, the selection of constituent materials and large-scale manufacturing processes.** International research in the field is highly competitive and many institutes have also launched ambitious programmes in this area. In Europe, major institutes have positioned themselves strongly in this race and are collaborating on these new technologies with high added value, such as the Perovskite tandems and III-V tandems: IPVF and CEA-INES in France, Fraunhofer ISE, ISFH and ISC Konstanz in Germany, IMEC in Belgium, EPFL and CSEM in Switzerland, and TNO in the Netherlands, to name but a few. All these institutes are joining forces and organise the first international tandem PV workshop: www.tandemPV-workshop.com. The major part of these developments is jointly carried-out with key European equipment manufacturers.

**A large scale highly automated eco-friendly PV production in Europe adopting European cell developments and up to date digitalization in production could be a key for combination of green energy and jobs in Europe.** A 5-10 GW PV production in Europe, using PV technologies developed in Europe and modern production technologies would generate jobs, lower $CO_2$ impact by transportation of heavy PV modules from Asia, and support European machine builders[3]. Furthermore – together with the world leading PV research centres in Europe – Europe can become market leader of high-end PV cell and modules. European institutions should support this by any measures there are.

Another important topic to be tackled are conflicts and acceptance problems originating from a massive further expansion of free-standing PV plants. A smart solution is the **integration of PV** into building envelopes, car exteriors, roadways and railways, and combining them with agricultural and surface-water areas. Enormous areas, which are already used for other purposes can also be exploited for generation of solar electricity and lead to positive synergistic effects in many cases. Integrated photovoltaics requires tailored solutions for different surroundings and need to fulfill other demands in addition to cost aspects. Further research and industrial scale-up is needed to meet those demands.

Achieving this ambition relies on three strategic axes:
1. The success of an ambitious European R&D program focused on markets,
2. The development of collaborative technology platforms, and
3. The development of revenues ensuring the construction of financial stability and the sustainability of the resulting ecosystem.

Here are the major milestones associated with the required calls we would like to put forth:
- To have **demonstrated the technological feasibility** (TRL4+) of one (or more) concept(s) and to have **developed the associated corpus of intellectual property**. The challenges for tandem cells are at the level of electrical engineering (interconnection modes for cells with three or four terminals) and at the level of transparent and conductive interfaces and materials at the tunnel junction in the case of cells with two terminals (monolithic).
- To have demonstrated the **economic interest of industrializing** premium and cost-effective innovative concept(s) (market and industrial sector studies; ...) in Europe.
- Have **identified and involved industrial end-user partners** (end-users, equipment manufacturers, etc.).
- Have **completed the associated prototyping work and proof of concept paving the way for commercialization.**

[3] Fraunhofer ISE, VDMA Photovoltaic Equipment: « Competitiveness of a European PV Manufacturing Chain »

## OPPORTUNITIES FOR A RENAISSANCE IN EUROPEAN PV MANUFACTURING CAPACITY

The European Commission plans to raise the GHG emissions reduction target from 40% towards 55% by 2030 and make Europe the first climate-neutral continent by 2050. Achieving this will require accelerated energy efficiency measures, deeper electrification of sectors currently consuming conventional fuels and the deployment of more renewables, faster. In the Commission long-term strategy (LTS) for energy and climate, electricity generation in 2050 is much higher than in 2015 (between +30% and +150% depending on the scenario), in particular due to the electrification of transport (battery electric vehicles) and to the production of hydrogen and e-fuels (which starts with water electrolysis). The March 2020 study[4] issued by the **European Commission's Joint Research Centre (JRC)** looks specifically at the role of PV, based on scenarios from the Commission LTS. **The prospect of an invigorated EU PV market builds the case for a development strategy for the full PV value chain, supported by research and innovation. This should include new wafer, cell and module manufacturing in the EU.**

According to the JRC study, reaching a 55% GHG emissions reduction, requires the cumulative PV capacity in the EU and the UK to surge to 455-605 GW, depending on the strategic policy scenario. This implies a compound annual growth rate between 12 and 15% in the timeframe 2020-2030 to increase the annual PV European market from approximately 16.5 GW in 2019 to 50-80 GW by 2030. The current production capacities for wafers, solar cells and modules in the EU are less than 2 GW, less than 1 GW and around 6 GW respectively. **From a security of supply viewpoint, the projected massive increase of installations should be matched by an EU regional manufacturing to bring balance to the worldwide production capacity, ensure supply and avoid disruptions.**

**Recent rapid cost reductions in PV manufacturing coupled with a large increase in module demand should bring PV factories back to Europe.** CAPEX costs for polysilicon, wafer, solar cell and module manufacturing plants have decreased by 75 to 90% between 2010 and 2018[5]. Economies of scale are critical, and a recent study has shown that a European manufacturing chain would be competitive with global PV factories, should an annual production volume between 5 and 10 GW[6] be reached. Chinese and American industrial experiences illustrate the benefits cutting-edge automation solutions (digital transformation) would bring, compensating the often-cited obstacle of EU high labour costs. Furthermore, solar PV is aligned with the new Commission's Circular Economy Action Plan.

**As far as raw materials are concerned, the EU hosts one of the leading polysilicon manufacturers** (Wacker Polysilicon AG) with total annual productivity of 80'000 MT (60'000 in Germany and 20'000 in USA). With an average material consumption of 4 g/W this production alone is sufficient for manufacturing 20 GW of solar cells. A significant part of the polysilicon manufactured in Europe is currently exported to China. However, the increase of Chinese cell manufacturing capacity exceeding the overall market growth led to a significant decrease in sales and profits for Wacker in 2018.

**Such a dynamic market provides the basis for reviving the European solar manufacturing industry as well as creating more than 100'000 jobs along the value chain.** The European Green Deal offers an opportunity to expand sustainable and job-intensive activities in the areas of low-emission technologies, thus compensating for the reductions in employment in the fossil fuel sector and in carbon-intensive processes. Here again, the PV sector can play an important role. A revival of the EU PV industry that follows the Manufacturing 4.0 paradigm would create about 14'000 permanent jobs for a 20 GW annual production, from wafer to module. On top of that is the increased need for construction, installation, operation & maintenance (O&M) of the various systems (utility-scale, rooftop installations, commercial and industrial systems).

**83% of the carbon-neutral electricity needs to be supplied by Renewable Energy Sources (RES)[7] in order to reach the EU climate targets.** Wind and photovoltaics are the main pillars providing the required amounts of clean electricity. However, the envisaged wind installations are already significant (350 GW in 2030[6]) and any further increase would be challenging. Given the limited options for hydropower and biomass expansion, moderate PV deployment would perforce increase power imports. Besides, emerging RES (e.g. ocean) and carbon capture & storage (CCS) may not be ready to scale up by 2030. Moreover, a higher increase in the final electricity demand due to sector coupling effects could even drive up the annual PV module demand to 200 GWp in 2030.

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[4] Jager-Waldau A, Kougias I, Taylor N, Thiel C. How photovoltaics can contribute to GHG emission reductions of 55% in the EU by 2030. 2020. Renewable and Sustainable Energy Reviews.

[5] Woodhouse M, Smith B, Ramdas A, Margolis R. Crystalline silicon photovoltaic module manufacturing costs and sustainable pricing: 1H 2018 benchmark and cost reduction roadmap. 2019. Golden, CO.

[6] VDMA Photovoltaic Equipment. European photovoltaic production can be profitable. Press Release; 2019

[7] European Commission. Supplementary information In-Depth Analysis in Support of the Commission Communication COM(2018)773: a Clean Planet for all. A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy. Com. 2018. 773 2018:114