[30/30/30] GOAL FOR MODULES

“To support global research efforts to produce photovoltaic modules with a >30% energy conversion efficiency for a <30 c$/Wp price by 2030: [30/30/30]”. This is the roadmap put forth by representatives of the leading solar photovoltaics research institutes [the signatories]. Together with innovations in other PV system components, and with storage and digital technology developments that will allow PV integration into the electrical system, this ambitious goal will lead to great strides toward meeting global challenges in the fight against climate change.

PV STATE OF AFFAIRS AND GLOBAL CHALLENGES

Solar photovoltaic technology has reached a **significant level of industrial maturity**, with over 40 GW in new installations in 2014, for a total installed capacity of almost **180 GW at the end of 2014** (for 200 TWh products, that is slightly less than 1% of global electricity production). In recent years, very significant technological and economic advances have been made in regards to the three main types of modules. The current performance levels of the best industrial productions of modules are as follows: **[16%/<60** c$/Wp **] for silicon multicrystalline modules, [23%/>65** c$/Wp **]** for silicon **monocrystalline** modules, and **[15.6%/58** c$/Wp] for thin-film modules (CdTe, CIGS, etc.). Since 1980, prices have fallen by 20-23% with each doubling of the total installed base. In the past five years alone, prices decreased five-fold. These gains come as much from technological innovations as from industrial progress and the effects of massification. We aim to pursue ventures that will allow this trend to continue.

As an initial approach, measuring PV economic competitiveness is based on the calculation of LCOE (Levelized Cost of Energy - expressed in $/MWh). This fluctuates significantly depending on sunlight exposure, capital cost, application type (ground-level farms, commercial and industrial rooftop or residential rooftop), and the local parameters of each geographical area (industrial applications, technical rules, etc.). For example: for solar farms, the LCOEs currently range between $60/MWh and $120/MWh before subsidies, whereas the LCOEs of rooftop installation distributed systems vary between < $100 and < $200/MWh, depending on the industrial, commercial, or residential segment. It is also important to factor in the electrical system’s externality costs. These costs notably depend on the system’s degree of flexibility and on the grid penetration rates of intermittent RESs in the production mix. PV electricity’s value also depends on the balance between PV production and consumption.

Geographically speaking, OECD and non-OECD countries face very different challenges. While the demand for energy is stable and even declining in OECD countries, it is rapidly increasing in non-OECD countries due to demographic and economic growth. **In non-OECD countries,** photovoltaics represent an energy-efficient solution, particularly in the form of hybrid solutions (PVs in combination with diesel generators, for example) and mini-networks to compensate for the shortfalls of electrical grids. For these countries, an LCOE goal of $65/MWh, which has already been reached in some especially sunny areas, supports competitive PV projects, particularly in locations where peak consumption coincides with maximum sunlight. **In OECD countries** with a RES penetration rate above 20% approximately and where abundant and cheap storage solutions are not available, the cost of integrating intermittent RESs into the electrical system becomes a concern. In addition to the direct costs (investment and operating costs) of PVs, it is also important to consider the indirect costs of this variable energy’s impact on electrical system management. One must also take into account existing electricity production capacities against the backdrop of the overhaul of electricity markets. Nevertheless, an LCOE goal of $40-$50/MWh renders the PV competitive so long as the quantities installed are controlled and provided such development does not entail a drop in electricity rates at maximum sunlight times.

The reduced costs must involve the entire value chain. This requires innovation, and especially higher energy conversion efficiencies, which also indirectly reduce costs in other components of complete systems. However, improved PV competitiveness is not restricted to modules. There is much room for improvement among all other components of the photovoltaic system (BOS: Balance of System that covers all inverters, trackers, engineering, and installation). The cost of these elements varies greatly depending on application type, and on the financing costs that make up the other two sections of the LCOE. The development of PV penetration within the electricity mix will also greatly benefit from **electricity storage innovations and the emergence of new business models made possible by digital technologies**.

This document is based on work done by the IPVF community.

THE ROADMAP

In the HiRen scenario (limiting the average global temperature increase to 2°C while integrating a larger proportion of renewable energies) presented in its last PV roadmap[1], the IEA considered that this technology may represent **16% of the global electricity demand by 2050, with 4,600 GW** of installed capacity. Such PV deployment could **avoid a yearly CO_2 release of 4 billion tons**. With a carbon content of 15 gCO_2/kWh (highly variable depending on the module production country, even exceeding 150 gCO_2/kWh in some cases (when the industrial chain is inefficient in a country where coal dominates in the electricity mix), photovoltaics are an efficient way to help decarbonize many electrical systems. Such growth presents a challenge to the entire solar industry. Given the high volumes at stake, it is important to ensure that this development is not stunted by vulnerable supplies of certain materials – which is not the case for silicon, one of the most abundant materials on Earth.

By 2020, incremental improvement through **industrial research into already mature technologies should result in** modules with a **yield over 20% for a cost below 50c$/Wp**. This will partially meet the challenges by extending PV competitiveness to more countries beyond the Sunbelt. Multicrystalline, monocrystalline, and thin-film module production processes will benefit from progress made in advanced semiconductor and flat screen industry technologies, scale effects (plants>1 GW), robotization, Industry 4.0 concept, and vertical integration in the industrial chain. The improvements to high-efficiency mono-Si technologies (PERT, heterojunction, and IBC) should significantly decrease the LCOE by reducing costs and improving efficiency through progress in metallization, thinner wafers, hybrid thin-film technologies, crystalline silicon etc. The **PV industry and research laboratories must work together to sustain these efforts**.

To take it one step further and anticipate competitive development in countries with moderate amounts of sunlight, **module prices of 30c$/Wp must be obtained, along with more energy-efficient technologies, beyond 30% yield by 2030 [30/30/30].** This requires technological breakthroughs. Multijunction thin-film/crystalline silicon technologies represent one high-yield solution, but their manufacturing costs must be significantly lowered. Another focal point involves the development of new high-performance materials (such as perovskites, for example). The new experimental concepts, based on more sophisticated physics (hot carriers, intermediate bands, etc.) aim to generate yields between 40% and 50%. With good economic performance, these could also spread new competitive technology breakthroughs to more areas beyond the Sunbelt. Transverse works (nanophotonics, light resonator development, etc.), like those that seek to optimize the solar spectrum (up- or downconversion), and new solar PV paradigm research (beyond the principle of light absorption via diodes) are also worth considering.

	Current	Target
LCOE [OCDE]	60-120 $/MWh 100-200 $/MWh (distributed)	40-50 $/MWh
LCOE [non OCDE]		65 $/MWh
Modules prices	~ 60 c$/Wp	50 c$/Wp [2020] 30 c$/Wp [2030]
Modules yield	15-23%	30% [2030]

Table 1: Current LCOE, modules prices and yield, and related targets

PROPOSALS FOR SPEEDING UP THE MOVE

Targeted and timely investment aid by multilateral development agencies would help overcoming certain barriers to the deployment of photovoltaic systems in non-OECD countries. Indeed, if photovoltaic installation development remains simple and at very low marginal costs (free primary energy, few maintenance fees, etc.), the initial investment remains substantial and potentially stifling.

Long term goal achievement will also require **support for collaborative R&D efforts**, working toward innovations that are incremental as well as groundbreaking Therefore, though it **seems attainable today, the [30/30/30] goal requires significant research,** supported and coordinated by an international scientific coordination Forum focusing on next-generation solar PV (["New Gen PV forum"] / ["30^3 PV Summit"] / ["Triple 30s PV Forum"] / / ["Gen 30^3 PV Forum"] ["Target 30/30/30 PV Forum"]).

Today we call upon one such international Forum during the Paris COP21 Conference.

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[1] IEA – "Technology Roadmap – Solar Photovoltaic Energy – 2014 Edition"

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