From Lab to Fab – Supporting PV Industry in Europe
Contribution from GOPV project

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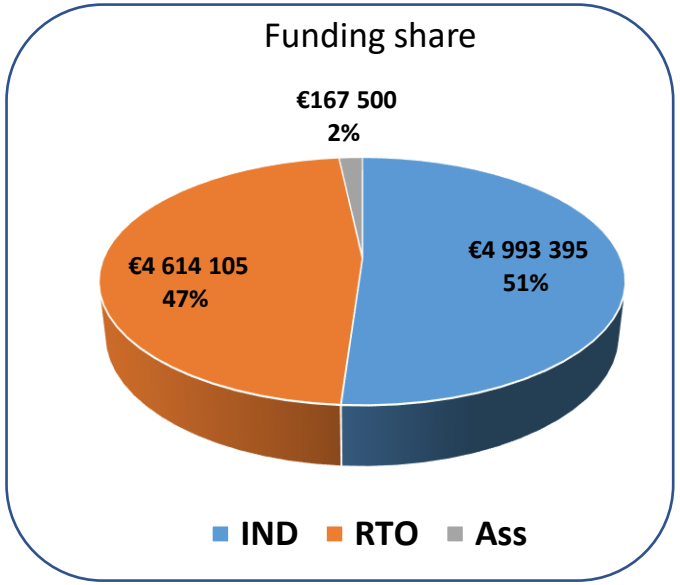
GLOBAL OPTIMIZATION OF
INTEGRATED PHOTOVOLTAICS SYSTEM
FOR LOW ELECTRICITY COST

ID Card

Grant agreement N° 792059
11 partners
Budget: 11,915 k€
Funding: 9,775 k€
Start date: 01/04/2018
Duration : 48 months

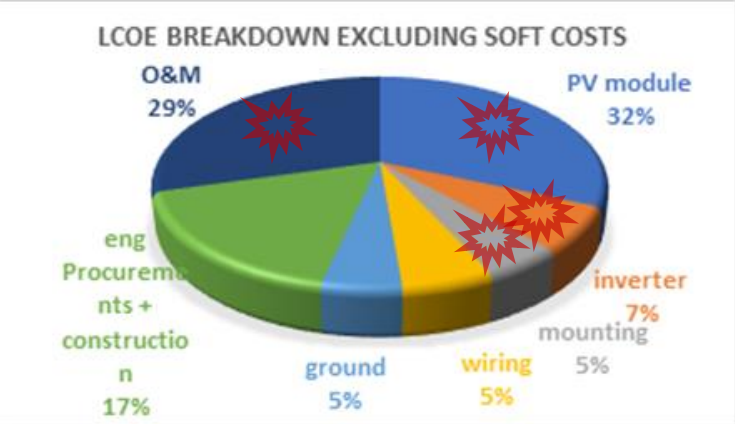
IND	RTO	Assoc.
Enel green Power (IT)	CEA (FR)	INES-PFE (FR)
GXC coatings (DE)	EPFL (CH)	
Mondragon Assembly (ES)	LEITAT (ES)	
REFU Elektronik (DE)	TECNALIA (ES)	
Convert Italia (IT)	RSE (IT)	



Main objectives

General/societal objectives

- Reduction of the cost of PV electricity for increasing its competitiveness and its share in the European electricity mix
- Creation of added value for European industrial players to be competitive on the global market



Estimated Breakdown of LCOE for PV plants > 100 kW in EU and US

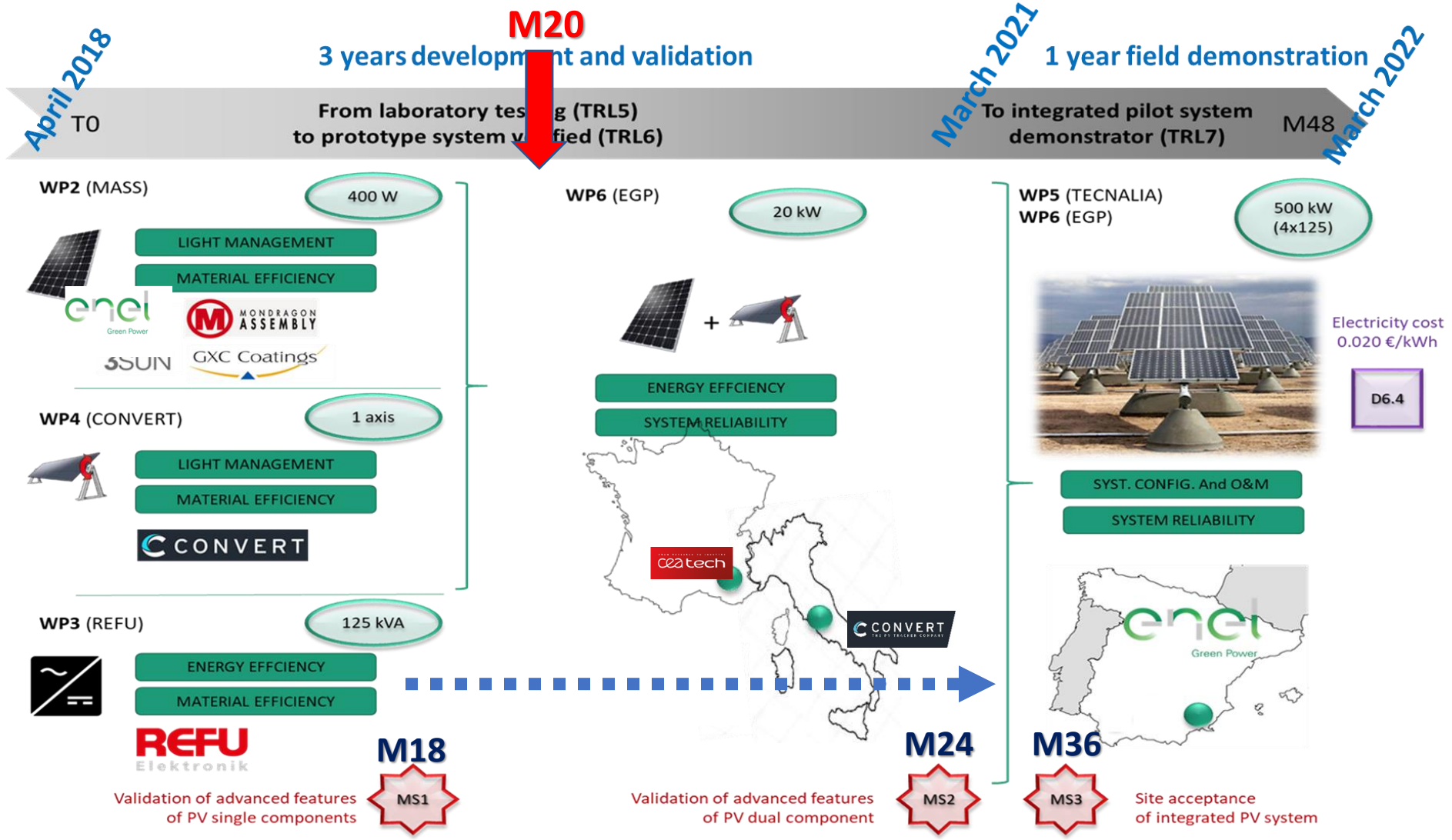
Targeted LCOE = 0.02 €/kWh (GHI = 1900 kWh/m²/year)

Techno-economic objectives

PV plant cost element	GOPV developed component	Main characteristics	Targeted cost	Targeted lifetime
Module	Bifacial HJT modules	400W + bifaciality ≥ 90%	0,22€/W	35 years
Tracker	1 axis tracker	Low cost structural material	0,11€/W	35 years
Inverter	Current source string inverter	125 kVA + Energy efficiency ≥ 99%	0,05€/W	20 years
O&M	Advanced fault detection & diagnostics tool	Energy availability ≥ 99.5%	10k€/MW/Year	-

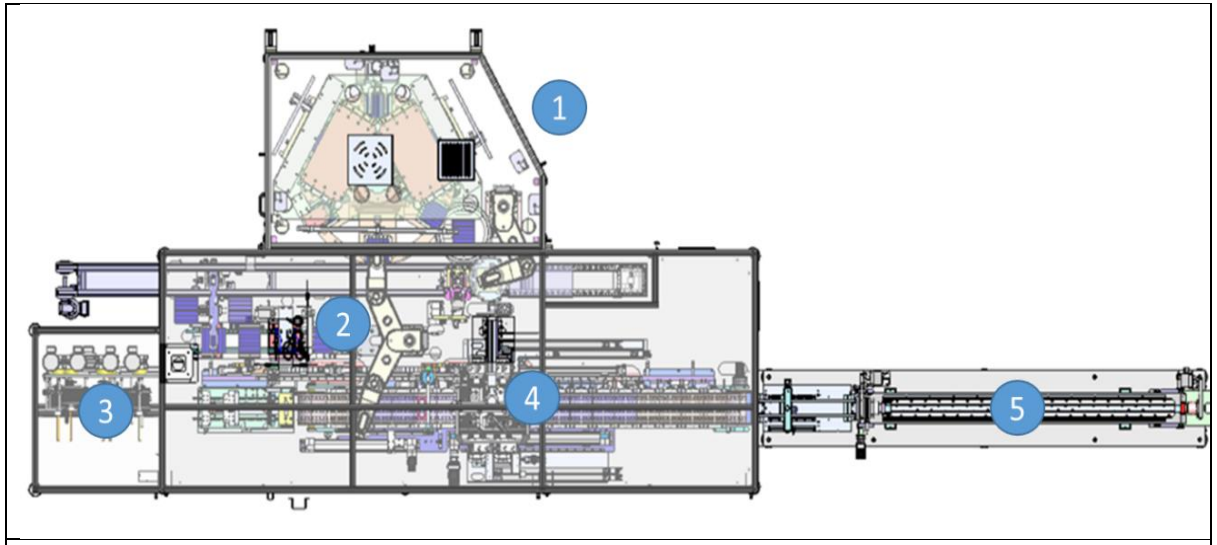
Higher efficiency, longer lifetime, lower cost components

STEPWISE DEVELOPMENT UP TO LARGE SCALE DEMONSTRATOR



Development of an innovative stringer

- **To connect PV cells by gluing with ECA**
- **Enable to manage 6 to 8 ribbons, ½ cells**



1.- Rotative plate for adhesive printing
2.- Cell transferring robot
3.- Ribbon feeding station
4.- Adhesive thermal curing
5.- String output belt

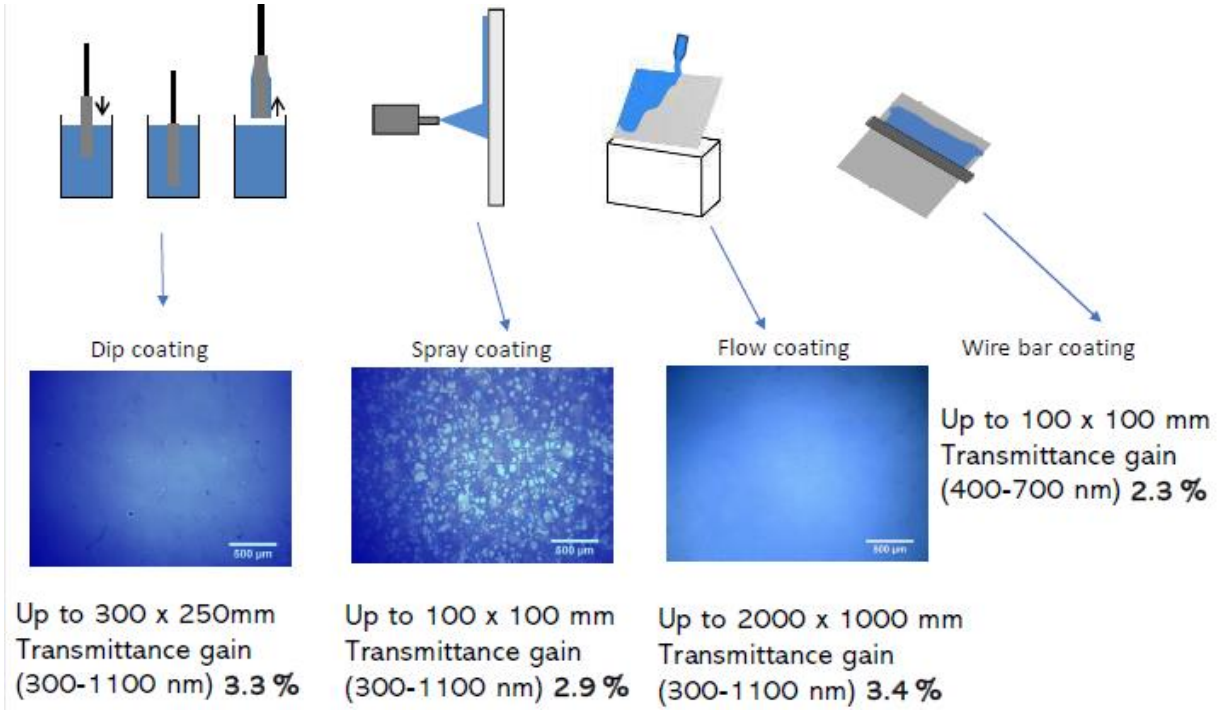
First demonstration: Fabrication of strings of 12 SHJ cells with 6 glued interconnection ribbons

Next steps:

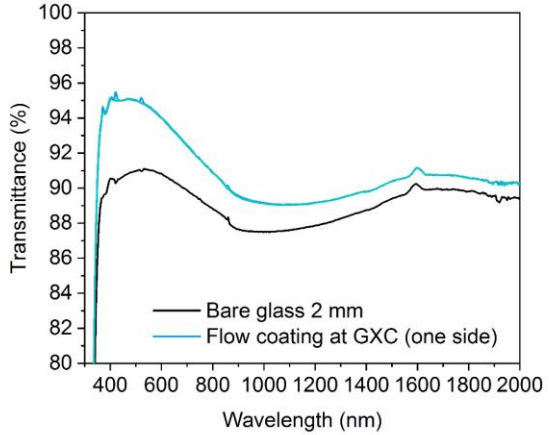
- **Fine tuning of equipment and interconnection process**
- **Interconnection of ½ cells**
- **Optimisation of width/number of ribbons**

Development of an innovative AR-AS coating

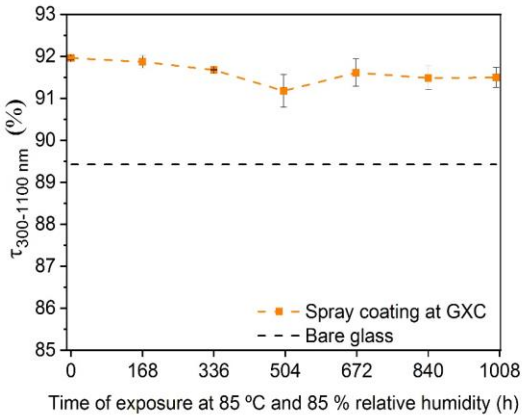
- **To improve light harvesting with a long lasting AR-AS glass coating**
- **Industrialization of process (patented by Tecnalia)**



First demonstration: Fabrication of 2000x 1000 mm² AR treated glasses by flow coating



+2.5 % optical transmitance



-0.5% optical transmitance @ 1000 h DH

Next steps:

- **Fine tuning of coating process (thickness homogeneity)**
- **Implementation of hydrophobic treatment**
- **Integration in glass production process**

GXC Coatings
Transparent Performance

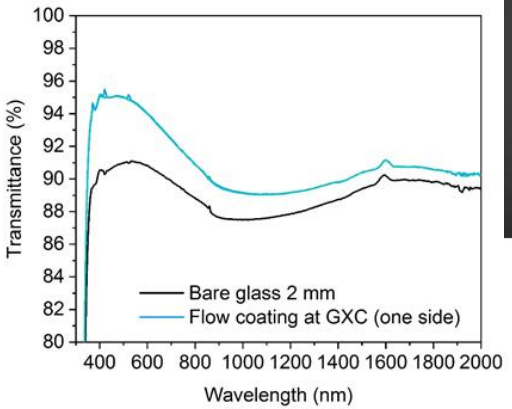
tecnalia
Corporación Tecnológica

Development of an innovative bifacial SHJ module

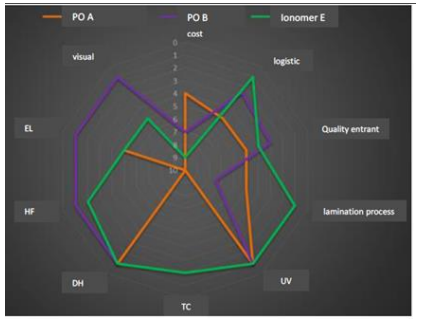
- **To increase conversion efficiency and increase lifetime**
- **To lower material consumption (silicon, silver, encapsulant)**

First demonstration: Fabrication of 16 modules with avg power of 370 W (max : 375W)

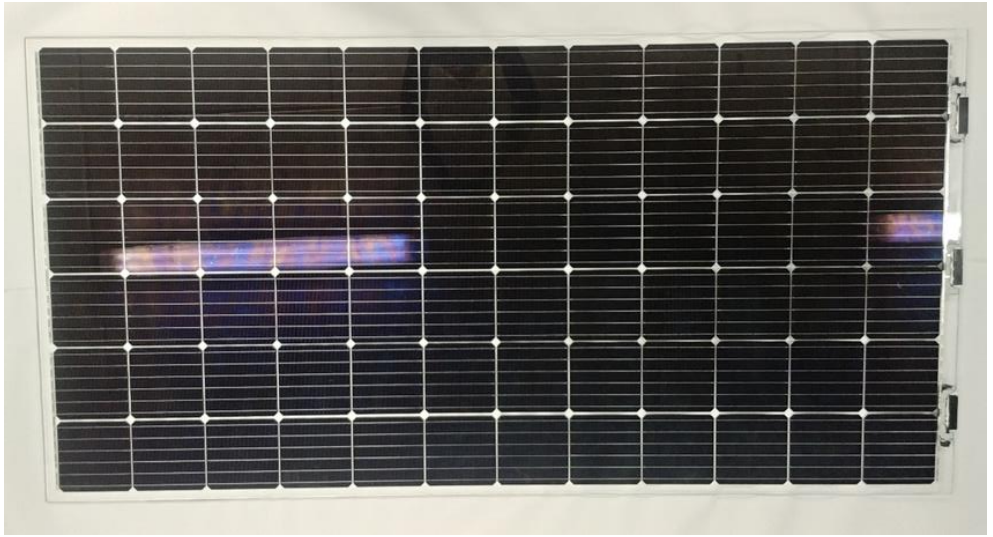
6 ECA-bonded ribbons interconnected cells
Strings fabricated @ MASS



ARGICOAT anti-reflectice coating
AR glasses fabricated @ GXC



Selected encpasulant



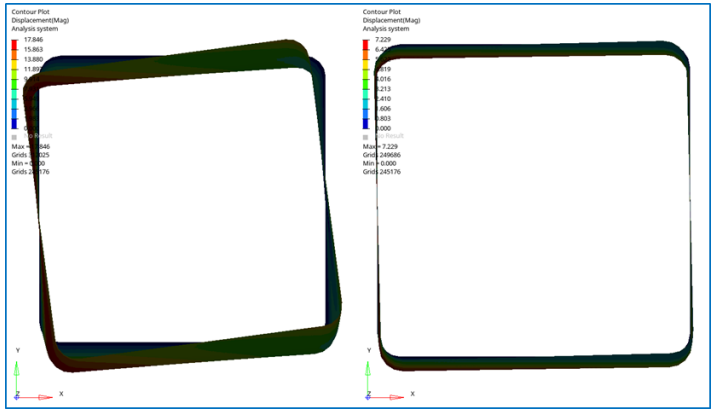
Next steps:

- **Improve module efficiency (AR coating, cell efficiency + ½ cells)**
- **Validate projected lifetime**
- **Reduce cell thickness and silver content**

Development of an innovative 1 axis tracker

- **To reduce cost of 1 axis tracker**
- **To optimize tracker structure for bifacial modules**

2 materials tested
- Weathering steel : low cost
- Glass fiber reinforced polymer: corrosion resistance



Mechanical simulation: Comparison of the deflection of the main beam: (left) for the GFRP and (right) steel main beam

New driving system and control unit

First demonstration: Fabrication of 5 trackers

Next steps:
- **Validation of structural elements (field + wind tunel tests)**
- **Optimisation of the design (tracking +bifacial gain vs cost)**

Development of an innovative O&M strategy

- **To reduce O&M cost**

Construction of a toolbox

Qualitative and quantitative impacts of failures in large PV plants

Economic model of large PV plant operation

Early failure detection and diagnosis models

Predictive maintenance software tool

Next steps:
Development and validation of tools

Development of an innovative string inverter

- **To increase conversion efficiency and lifetime**
- **To reduce cost of string inverter**

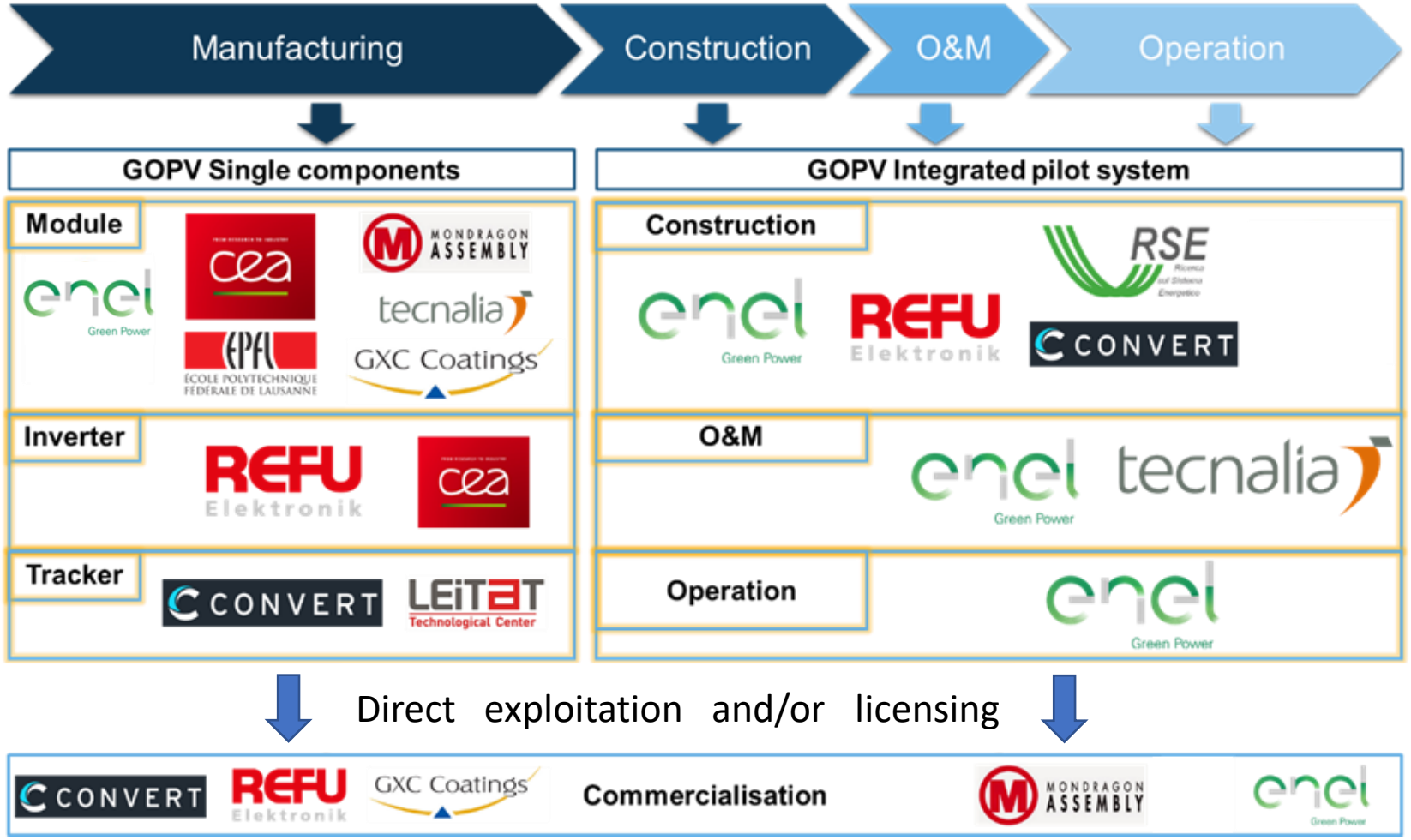
change of inverter topology (@ M15) → SiC flying capacitors

(due to availability and cost of 1700 V SiC power electronics)

Max PV Power	215kW
DC Voltage	1500V
MPPT number	6
DC Current / MPPT	22A
AC Power	166kVA
AC Current	120 A
AC Voltage	800V (3/PE)
Max Efficiency	98.8%
EU Efficiency	98.3%

Next steps:
Validation of performances at the mockup level
Fabrication of industrial prototypes

Partners in the value chain



Added value & exploitation potential for industrial partners
To stay in the race

	Product	access to market	turnover (k€)	
			2022	2027
MONDRAGON ASSEMBLY	New advanced stringing equipment with advanced features in line with foreseen market evolution	2022	580	4 800
enel Green Power	HET bifacial modules with lower cost (€/W) and longer lifetime (vs Ampere)	2022	15 000	18 000
	PV plants integrating GOPV developments	2023	24 000	420 000
	Improvement of O&M strategy to reduce operation cost	2023		
	Knowledge about future products emerging on the market for biding: continuous	continuous		
GXC Coatings Transparent Performance	Diversification of technology portfolio with access to the fast growing PV market: Creation of a new BU 'PV coating'	2022	11	5 250
REFU Elektronik	Hight efficiency string Inverter with SiC technology (Flying capacitor toplogy)	2022	1 200	54 320
CONVERT THE PV TRACKER COMPANY	1 axis tracker optimised for bifacial modules with materials less costly than HDG steel	2022	30 800	165 000

From GOPV prototypes to products: very short time to market

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Thank you for your attention!

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GOPV has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 792059

Analysis of GOPV objectives

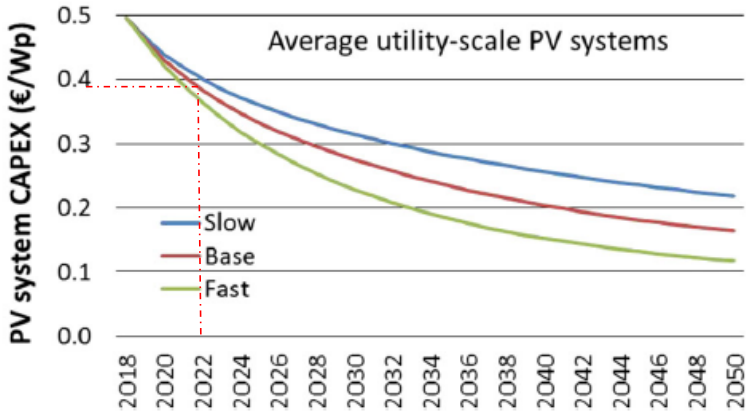


FIGURE 3 Utility-scale photovoltaics (PV) capital expenditure

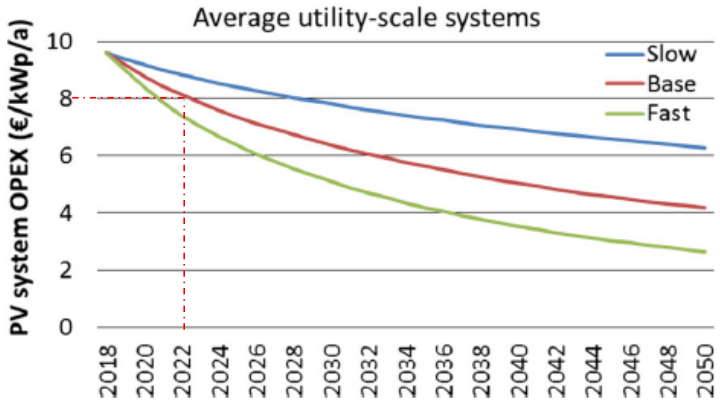


FIGURE 4 Operational expenditure (OPEX) development for the years 2018 to 2050 in three different scenarios [Colour figure can be viewed at wileyonlinelibrary.com]

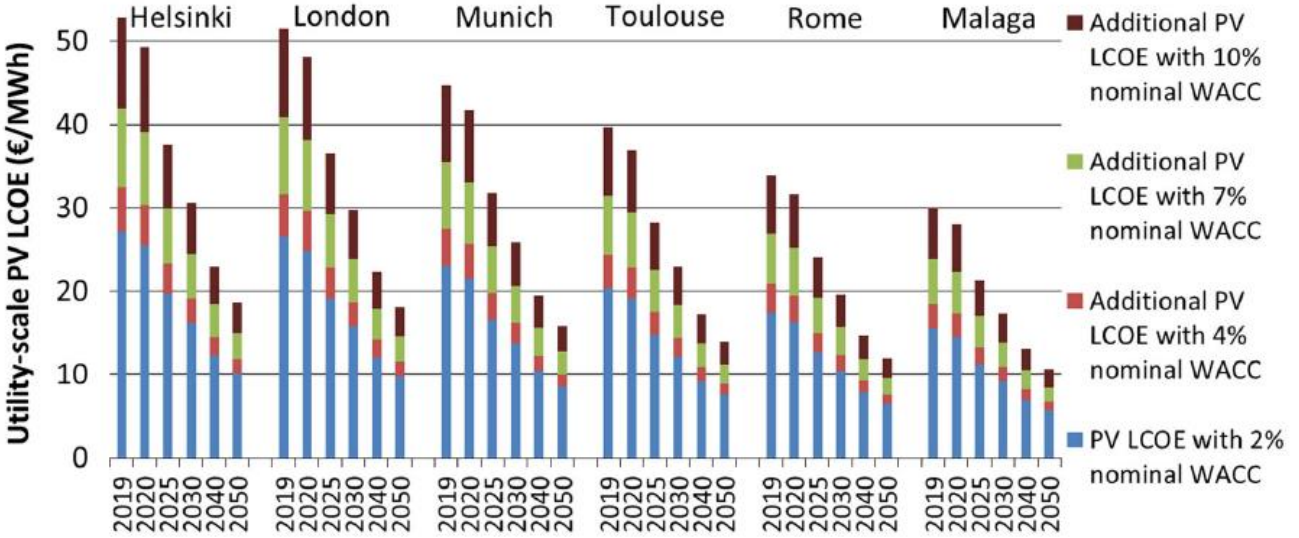
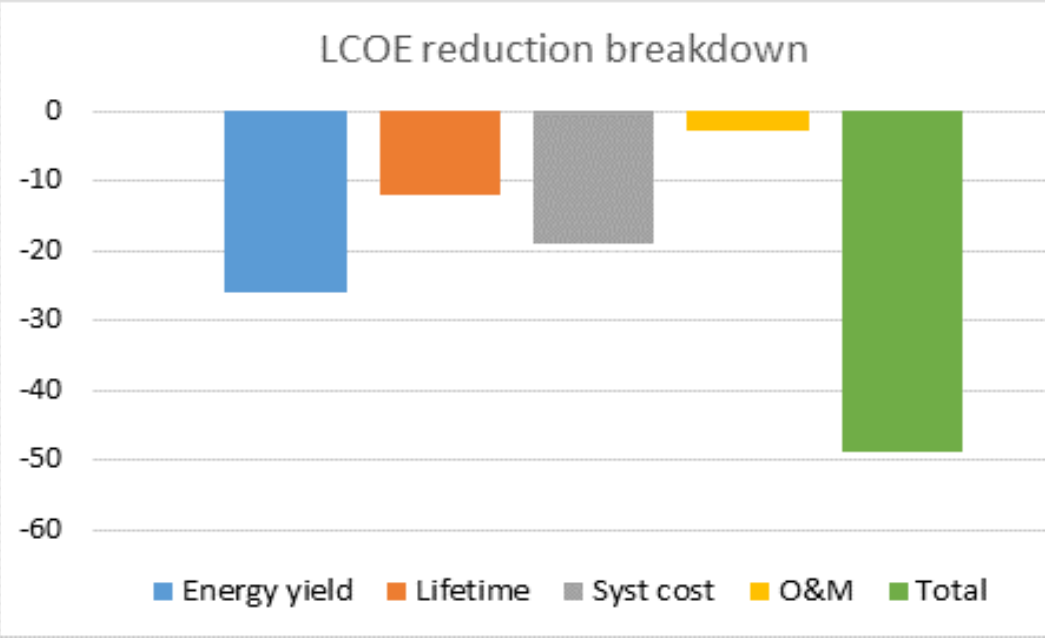


FIGURE 9 Photovoltaics (PV) levelised cost of electricity (LCOE) in six European locations for the years 2019 to 2050; in 2019 euros, taxes not included [Colour figure can be viewed at wileyonlinelibrary.com]

Source: Vartiainen_et_al-2019-Progress_in_Photovoltaics__Research_and_Applications (002).pdf - Adobe Acrobat Reader 2017

Underlying objectives	Target	Baseline (§2.1.1)	GOPV Gain
Obj 1 : Annual energy production rate	2360 kWh (AC)/kW	1700 kWh(AC)/kWp	+39 %
Obj 2 : Service lifetime	35 years (1 inverter change)	25 years (2 inverter changes)	+10 years
Obj 3 : CAPEX (excl. EPC)	0.38 €/W	0.47 €/W	- 0.09 €/W
Obj 3 : OPEX	10 €/MW/year	12 €/MW/year	- 2 €/ MW/year
Overall objectives	Target	Baseline	GOPV Gain
LCOE	0.02 €/kWh	0.04 €/kWh	- 0,02 €/kWh
EPBT (module)	1 year	1.4 years	-40 %

CONTRIBUTIONS TO LCOE REDUCTION



Main assumptions used for LCOE calculations:
PV plant: 10 MW, insolation= 1900kWh/m²/year (southern Europe) **Financial conditions**: WACC=7%, Equity ratio 20 %, Debt interest rate 5% on 15 years duration. **Reference scenario for 2017:** PERC+ monofacial module (60 cells,300Wp) at 0,33€/W, Fix mounting at 0.08 €/W, inverter at 0.06€/W + replacement cost, O&M at 0,012€/W/year. **GOPV scenario for 2022**: 'GOPV' module (72 cells, 400Wp) at 0.22€/W, GOPV 1 axis tracker at 0.11€/W, inverter at 0.05 €/W + replacement cost, O&M at 0.010€/W/year.