OUTPUT 1. Guide package on legislation, market, technologies and best practices

Document elaborated by KU Leuven

Based on the WP1 deliverables and the contributions from consortium partners

Note: *This public document may be extended and improved during the project lifetime to include more recent information and/or relevant information obtained within the Solarise project. Any comments and suggestions for regarding the content of the document may be sent to* ***Emilia Motoasca: emilia.motoasca@kuleuven.be***

Executive summary

This document summarizes the results of the activities in WP1 and includes also information resulted from interaction among consortium partners and with the target groups during all the Solarise activities in progress. It is a guide package on legislation, market, technologies and best practices in the 3Seas region. Since the solar energy related legislation, market, costs models and hybrid/new technologies are in continuous changing, this document may reflect just the current situation and it may not be up to date in just a few months. Therefore it will be updated during the project lifetime to account for the continuous changes in legislation, market, technologies and new best practices developed meanwhile, including the Solarise-pilots.

The solar energy deployment in the 2Seas countries involved in the Solarise project, Belgium, France, Netherlands and UK, may be in the very near future negatively affected by Brexit, by the changes in economic policy with respect to the imports of PV-cells/panels from China (the main producer), by the smart metering measures and other EU, national or local measures. Despite the barriers and challenges solar energy harvesting is progressing well, but it can do much better the 2Seas countries as the factsheets in his report are showing.

The information related to the most important aspects for the successful deployment of solar energy harvesting is gathered in 7 factsheets, that summarize and update the findings and information from deliverables D1.1.1, D1.1.2., D1.2.1, D1.2.2., D1.3.1, D1.4.1 and D1.4.2. The textual version of each factsheet a is accompanied by visual representation of the most important findings, commonalities and country specific issues.

Best practices are important in order to gather 'models' of successful solar energy projects for developing own feasibility studies and pilots. However, it is not easy to give a simple definition of a 'good practice' for solar energy application, since it depends on the ranking based on one or more weighted evaluation criteria. Also, a 'good' PV-installation already operating for some 5-10 years has much lower performance (due to less performant PV- panels for example) than a newer and cheaper installation of the same size nowadays. So, care should be taken in evaluating and comparing the older 'best practices' and general information taken or added to solar installations databases.

Within Solarise a smaller database containing relevant and newer solar installations has been started with the contribution of the consortium partners. The collected information represent actually an extended set of best practices in solar energy harvesting in Belgium, France, Netherlands and UK. A few best practices are presented in this report in a condensed form, together with a short explanation of the main evaluation criteria.

We are just a few months away from the year 2020 and many EU countries still have a long-way ahead to reach the proposed 20-20-20 targets. Uptake of solar energy as proposed and exemplified by the Solarise project may be a step forward in reaching the 2020 and 2030 EU-targets.

Table of contents

1. Solarise Factsheets on solar energy

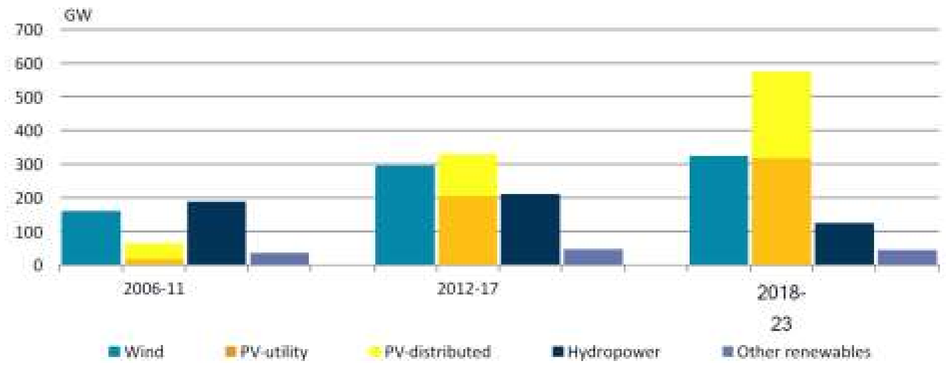
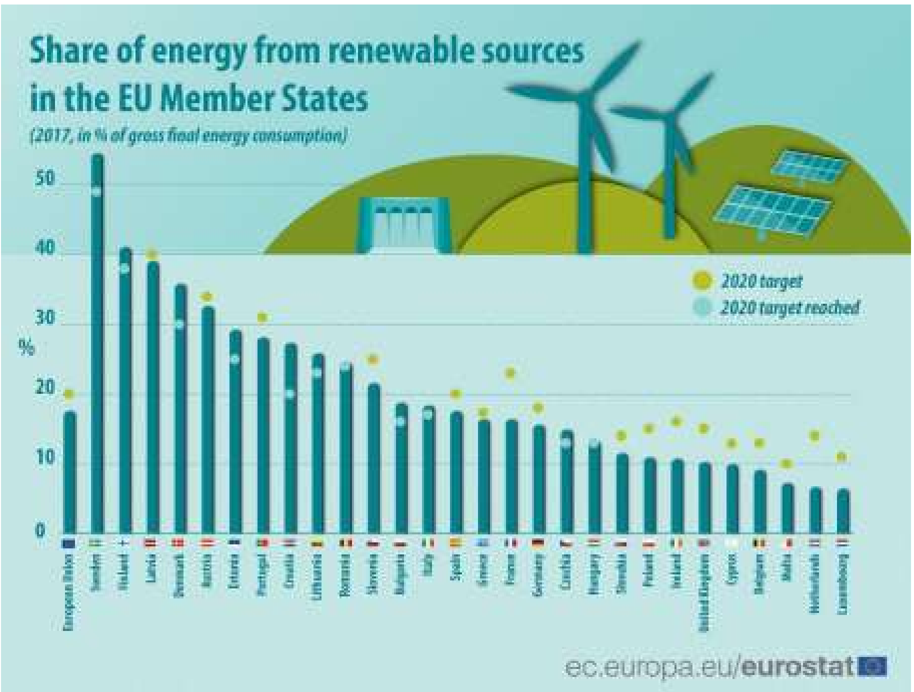


Figure 1 Renewable electricity capacity growth by technology

Worldwide there is a boost in application of solar energy harvesting technologies, both as large scale installations as well as distributed PV-systems, as can be seen on Figure 1. However, the growth is not yet sufficient to cover the future energy needs in the 2Seas region. Therefore, the main objective of the SOLARISE (Solar Adoption Rise in the 2 Seas) project is to facilitate the large-scale deployment of solar electricity and heat generation in the 2 Seas region and to support the EU to meet its target of 20% energy consumption from renewables by 2020.

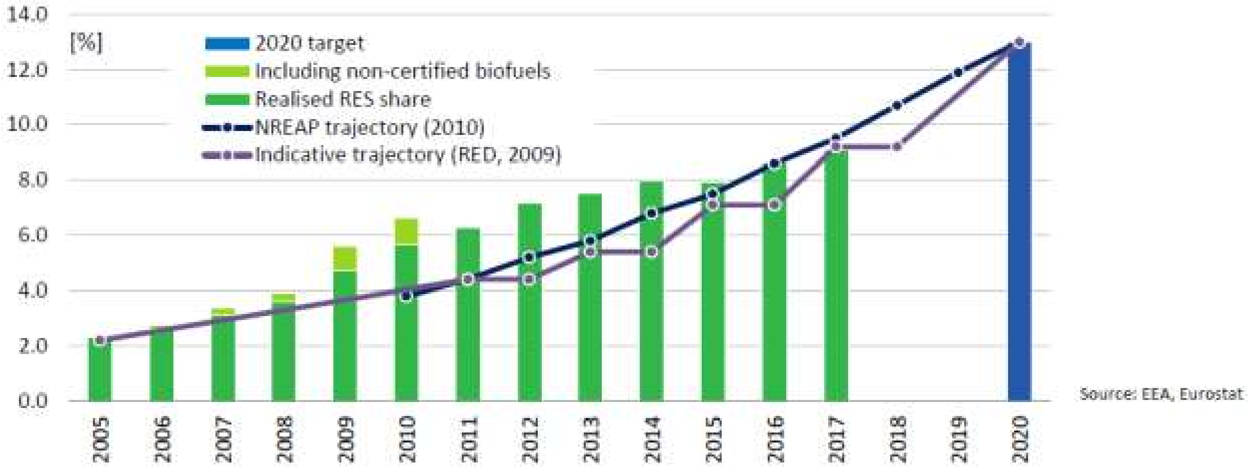
We are just a few months away from the year 2020, when the proposed 20-20-20 targets should be achieved. The share of renewables in gross final consumption of energy is one of the headline indicators of the Europe 2020 strategy. The EU's target is to obtain 20% of energy in gross final consumption of energy from renewable sources by 2020 and at least 32% by 2030. However, it seems that despite the good will and the sustained efforts many EU countries will not reach the proposed targets, see figure below. All the countries in the SOLARISE consortium are further away from their targets are: the Netherlands (7.4 % from its national 2020 objective), France (6.7 %), United Kingdom (4.8 %) and Belgium (3.9 %).

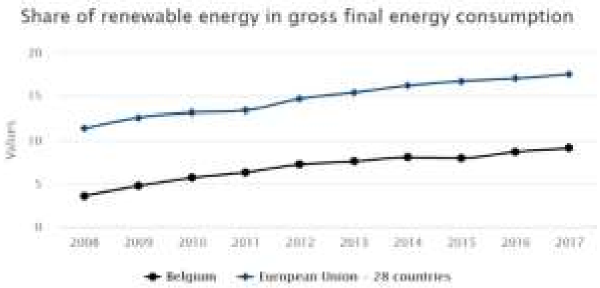


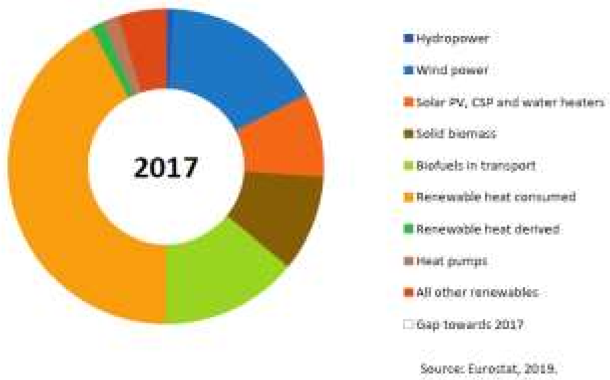
Within the SOLARISE project, an international consortium from Belgium, France, the Netherlands and United Kingdom has already started to develop demonstration projects using innovative solar harvesting technologies on public buildings (with or without historical value) and on residential social housing, located in both urban and rural areas. For each demonstrator, various technical solutions have been theoretically investigated and ranked in accordance to various criteria, in order to reduce the cost of solar energy generation and to assess the value of suitable combinations of solar energy harvesting installations with innovative storage technologies, such that self-consumption is enhanced. Not only the technical aspects, but also economic aspects related to the cost/business models and social, local governance aspects have been included in this analysis.

In order to provide suitable guidelines for anyone who intends to start, develop and exploit a solar energy harvesting project in one of the four participating countries, a summary and a comparison of the of the most important boundary conditions in each country had to be made. However, these boundary conditions are in permanent change, therefore the presented information reflects the situation until June 2019.

BELGIUM: Belgian electricity prices show price spikes caused by low nuclear availability in the second half of 2018 and more efforts are put into wind than solar energy. The established RE-targets for 2020 of 13% are not yet to be realized as expected in 2020, but the increase in solar PV, CSP and water heaters is significant, from 0,1 ktoe in 2005 to 282,7 ktoe in 2017. Also with a significant number of jobs (200 jobs) this sector had a turnover of aprox. 600 MEUR in 2017.







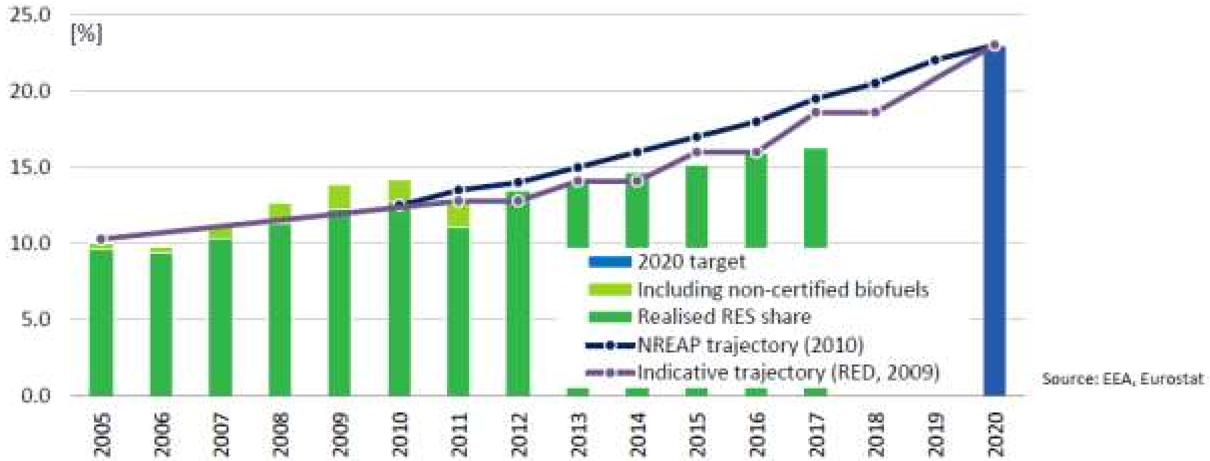
Data for 2017

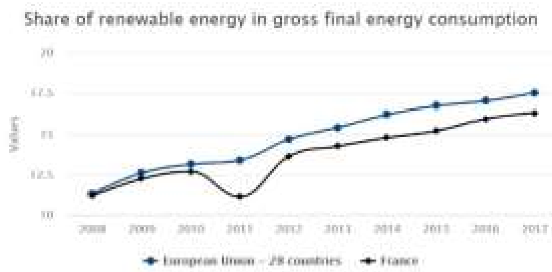
Overall RES share:	9.1%	Avoided fossil fuels:	5.1 [Mtoe]
Overall RES 2020 target:	13.0%	Avoided fuel expenses:	1.5 [billion euro]
Share RES-E in electricity:	17.2%	RES Turnover:	3820 [MEUR]
Share RES-T in transport:	6.6%	RES Employment:	17800 [jobs]
Share RES-H/C in heating:	8.0%		

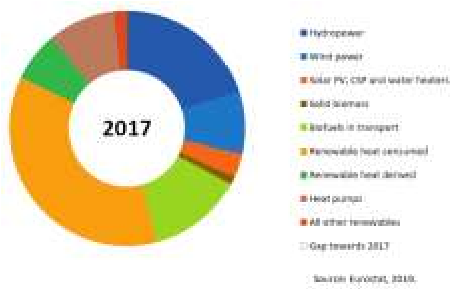
	2005	2017		
	Energy	Energy	Employment	Turnover
Hydropower	29.1 ktoe	27.6 ktoe	400 Jobs	80 MEUR
Wind power	20.1 ktoe	554.3 ktoe	5500 Jobs	1100 MEUR
Solar PV, CSP and water heaters	0.1 ktoe	282.7 ktoe	3100 Jobs	600 MEUR
Solid biomass	82.5 ktoe	328.2 ktoe	2000 Jobs	590 MEUR
Biofuels in transport	0.0 ktoe	465.1 ktoe	1500 Jobs	420 MEUR
Renewable heat consumed	643.7 ktoe	1395.6 ktoe		
Renewable heat derived	35.5 ktoe	43.7 ktoe		
Heat pumps	5.9 ktoe	52.9 ktoe	1400 Jobs	270 MEUR
All other renewables	54.2 ktoe	161.0 ktoe		
Gap towards 2017	2439.8 ktoe			

Source: Eurostat, EurObserv'ER, 2019.

FRANCE: The price of electricity is highly dependent on availability of nuclear energy and also strongly correlated with the Belgian nuclear energy availability. Auctions in renewable energy are scheduled a few times a year. In 2019 the largest auction on solar power from the 3-rd of June has dealt with 720MWp of solar power. Three smaller solar auctions in the second half of 2019 for a total of 750MW have been planned. In general, renewable generation is set to increase in 2019, as data from RTE showed renewable output gained a larger share of power output in 2018. Also France is far away for the proposed RES targets of 23 % in 2020, however the increase in solar PV, CSP and water heaters is significant, from 0,9 ktoe in 2005 to 823,1 ktoe in 2017. Also with a very large number of jobs (10300 jobs) this sector had a turnover of aprox. 1440 MEUR in 2017.







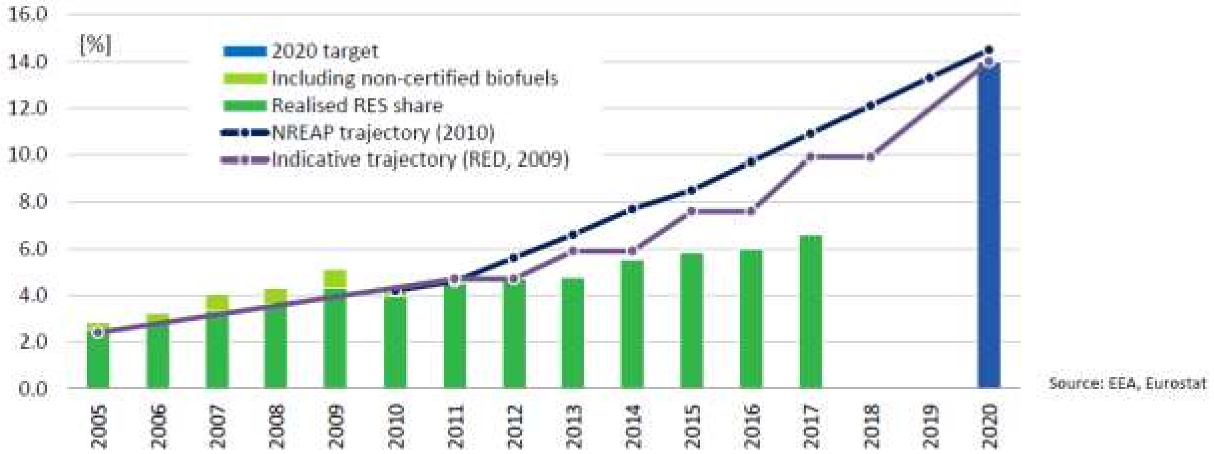
Data for 2017

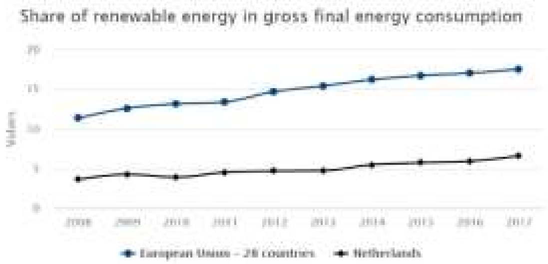
Overall RES share:	16.3%	Avoided fossil fuels:	32.9 [Mtoe]
Overall RES 2020 target:	23.0%	Avoided fuel expenses:	11.2 [billion euro]
Share RES-E in electricity:	19.9%	RES Turnover:	18430 [MEUR]
Share RES-T in transport:	9.1%	RES Employment:	140700 [jobs]
Share RES-H/C in heating:	21.3%		

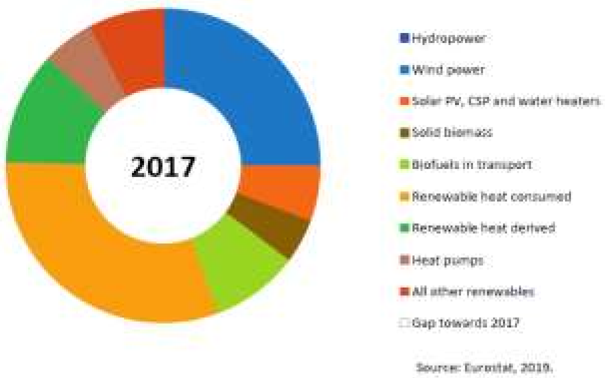
	2005	2017		
	Energy	Energy	Employment	Turnover
Hydropower	5608.7 ktoe	5117.7 ktoe	9900 Jobs	1480 MEUR
Wind power	92.2 ktoe	2186.1 ktoe	18500 Jobs	2860 MEUR
Solar PV, CSP and water heaters	0.9 ktoe	823.1 ktoe	10300 Jobs	1440 MEUR
Solid biomass	107.8 ktoe	287.3 ktoe	33900 Jobs	3990 MEUR
Biofuels in transport	591.2 ktoe	3335.0 ktoe	24400 Jobs	2350 MEUR
Renewable heat consumed	8602.3 ktoe	9267.6 ktoe		
Renewable heat derived	351.0 ktoe	1751.6 ktoe		
Heat pumps	200.9 ktoe	2375.3 ktoe	36200 Jobs	5310 MEUR
All other renewables	225.1 ktoe	433.5 ktoe		
Gap towards 2017	9797.1 ktoe			

Source: Eurostat, EurObserv'ER, 2019.

NETHERLANDS: in 2019 the Dutch power market is going to finalize the country's long-term climate agreement, which is being assessed by the Netherlands' Environmental Agency (PBL). Auctions for renewable capacity under the SDE+ scheme have been planned for spring and autumn of 2019. In December 2018, the government unveiled a draft strategy for reducing CO2 emissions, wherein a lower level for the carbon price floor than previously expected is proposed to be achieved by 2020. Currently, the target for renewable sources is 14% of final energy consumption in 2020. Data from the national statistics office shows the share was only 6.6% in 2017, which indicates that the proposed targets of 14% will not be meet in 2020. The increase in solar PV, CSP and water heaters is significant, from 3 ktoe in 2005 to 189,5 ktoe in 2017. Also with a significant number of jobs (6100 jobs) this sector had a turnover of approx. 740 MEUR in 2017.







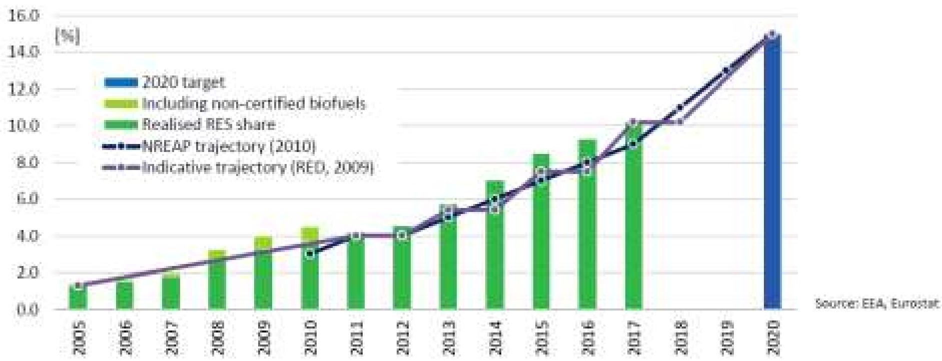
Data for 2017

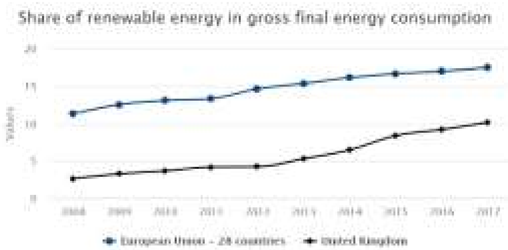
Overall RES share:	6.6%	Avoided fossil fuels:	5.2 [Mtoe]
Overall RES 2020 target:	14.0%	Avoided fuel expenses:	1.2 [billion euro]
Share RES-E in electricity:	13.8%	RES Turnover:	3790 [MEUR]
Share RES-T in transport:	5.9%	RES Employment:	28700 [jobs]
Share RES-H/C in heating:	5.9%		

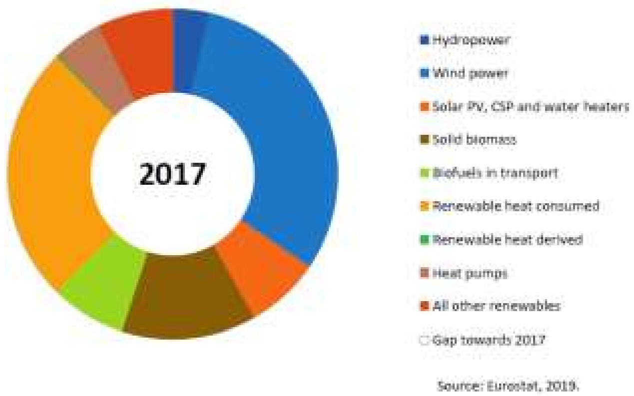
	2005	2017		
	Energy	Energy	Employment	Turnover
Hydropower	8.6 ktoe	8.1 ktoe	<100 Jobs	<10 MEUR
Wind power	174.9 ktoe	829.0 ktoe	5800 Jobs	830 MEUR
Solar PV, CSP and water heaters	3.0 ktoe	189.5 ktoe	6100 Jobs	740 MEUR
Solid biomass	193.2 ktoe	152.4 ktoe	4800 Jobs	550 MEUR
Biofuels in transport	0.0 ktoe	303.0 ktoe	2800 Jobs	440 MEUR
Renewable heat consumed	601.9 ktoe	1034.1 ktoe		
Renewable heat derived	114.2 ktoe	388.7 ktoe		
Heat pumps	16.8 ktoe	178.5 ktoe	6800 Jobs	870 MEUR
All other renewables	260.3 ktoe	254.3 ktoe		
Gap towards 2017	1964.8 ktoe			

Source: Eurostat, EurObserv'ER, 2019.

UNITED KINGDOM: The electricity market faces several uncertainties with the UK's withdrawal from the European Union, suspension of the capacity market policy and retail price cap all posing significant challenges to the industry. Uncertainty remains over the structure of post-Brexit carbon pricing in the UK, with the eventual decision likely to have a substantial impact on the country's mid- to long-term power price outlook. The 2020 targets related to RES of 15% are also not met yet. In the last 12 years the increase in solar PV, CSP and water heaters is very large, from 0,7 ktoe in 2005 to 991 ktoe in 2017. Also with a significant number of jobs (13100 jobs) this sector had a turnover of aprox. 1320 MEUR in 2017.







Data for 2017

Overall RES share:	10.2%	Avoided fossil fuels:	21.7 [Mtoe]
Overall RES 2020 target:	15.0%	Avoided fuel expenses:	5.4 [billion euro]
Share RES-E in electricity:	28.1%	RES Turnover:	13100 [MEUR]
Share RES-T in transport:	5.1%	RES Employment:	131400 [jobs]
Share RES-H/C in heating:	7.5%		

	2005	2017		
	Energy	Energy	Employment	Turnover
Hydropower	403.5 ktoe	491.1 ktoe	2300 Jobs	250 MEUR
Wind power	242.8 ktoe	4199.3 ktoe	69900 Jobs	7360 MEUR
Solar PV, CSP and water heaters	0.7 ktoe	991.0 ktoe	13100 Jobs	1320 MEUR
Solid biomass	290.1 ktoe	1785.3 ktoe	15000 Jobs	1230 MEUR
Biofuels in transport	68.8 ktoe	1016.0 ktoe	10100 Jobs	820 MEUR
Renewable heat consumed	506.2 ktoe	3418.2 ktoe		
Renewable heat derived	0.0 ktoe	31.4 ktoe		
Heat pumps	0.0 ktoe	641.8 ktoe	1700 Jobs	170 MEUR
All other renewables	492.6 ktoe	998.0 ktoe		
Gap towards 2017	11567.3 ktoe			

Source: Eurostat, EurObserv'ER, 2019.

Summarizing these findings we can conclude that all four countries are still struggling to meet their 2020 targets related to RES. Despite the large increase in the total energy equivalent energy obtained from solar PV, CSP and water heaters in the last 12-15 years, these is still a lot to be done to encourage the adoption of the solar energy harvesting on a larger scale.

	Belgium	**France**	**Netherlands**	**UK**
Target RES	13,0%	23,0%	14,0%	15,0%
Actual RES 2017	9,1%	16,3 %	6,6%	10,2%
Energy Solar PV (ktoe)	282,7	823,0	189,5	991,0
Jobs 2017	3100	10300	6100	13100
Turnover (MEUR) 2017	600	1440	740	1320

1.1. FS01 Solar energy market

1.1.1. Solar energy market in BE, FR,NL,UK

Unlike Japan, Europe has left its several-year long downward trend in 2017, adding 9.2 GW, a 30% increase compared to the 7 GW installed the year before. The European growth is primarily a result of Turkey's gigantic growth, adding 2.6 GW, from less than 1 GW in 2016. When looking at the 28 members of the European Union, there was hardly any growth at all: the EU-28 added only 5.91 GW in 2017, compared to 5.89 GW in 2016. This result still stems from the UK's 'solar exit' in 2016, which again halved new installations in 2017. Even though 21 of the 28 EU markets showed growth, this wasn't enough to compensate for the British losses.

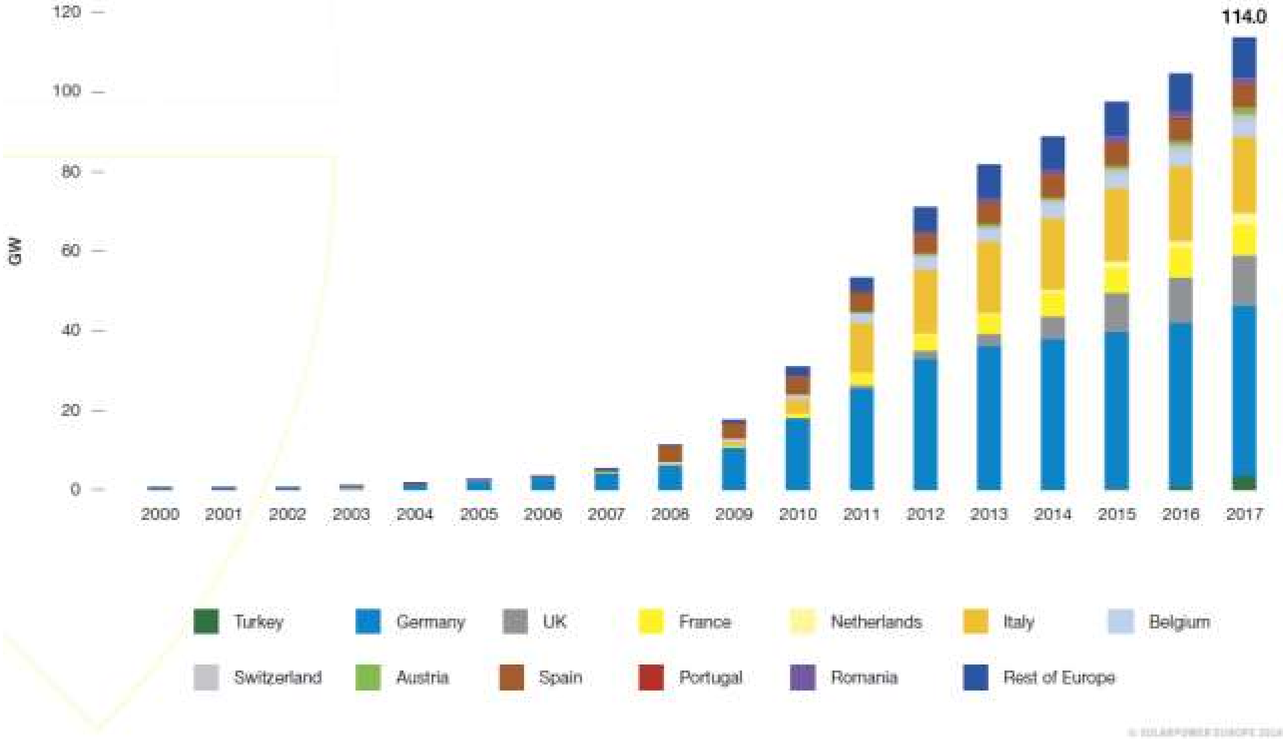


Figure 1 Total installed PV capacity in EU 2000 – 2017 [7]

The **UK** continues its steep downhill trip, after its government slashed its solar support in 2016. While the final big batch of the form subsidy pipeline was installed by March, for the rest of the year monthly PV additions remained mostly below 20 MW. in total, only 954 MW was installed, down over 50% from 2.1 GW in 2016, after it had already dropped 52% from 4.2 GW in 2015. The only positive solar headline from the UK in 2017 was about a subsidy free 10 MW solar plus 6 MW storage system. However, even this special project is yet waiting for a wave of followers as a level regulatory playing field still needs to be established.

While the **French** market increased by 56% to 873 MW in 2017, from only 559 MW in 2016, it has not reached the 2015 level of 895 MW. But after regulatory changes regarding self-consumption systems, which had been hindered by levies and complicated regulatory frameworks and a number of solar tenders issued and awarded, the stage finally seems to be set to enter the gigawatt level in 2018.

The **Netherlands** was the only other European market that added more than 500 MW in 2017; in fact, the market increased by 54% to 770 MW. While growth continued to be mostly driven by rooftop systems, the ground-mount segment fuelled by the country's SDE+ program for large-scale solar and RE projects is starting to take off – in 2017, its share was 8%. But the pipeline is quickly getting larger: in the SDE+ 2017 Spring round, solar won 2.4 GW, in the 2017 Autumn round 1.9 GW.

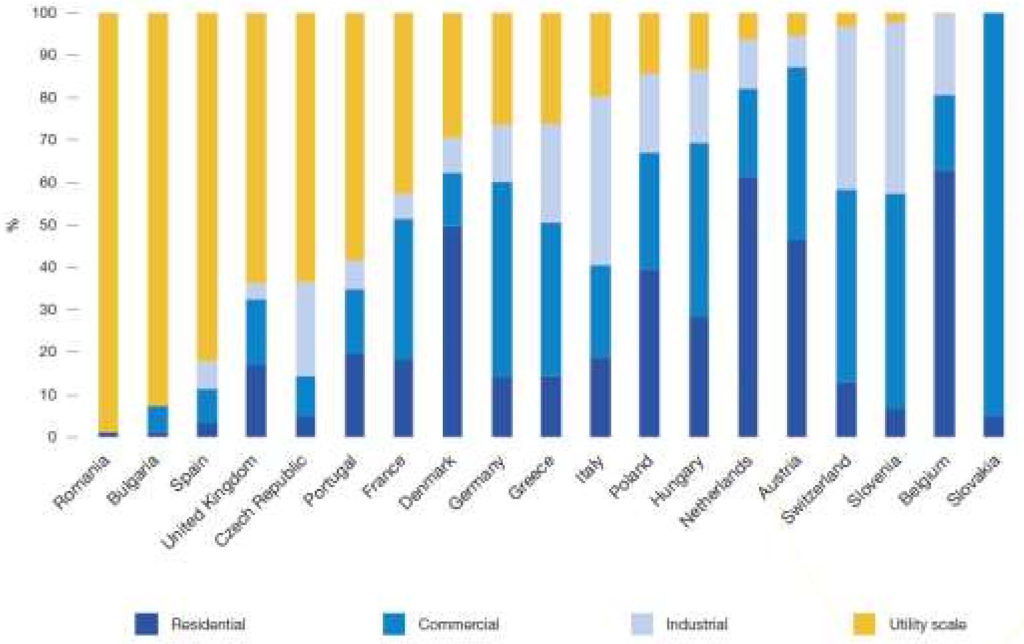


Figure 2 total installed PV capacity in EU countries *[7]*

For the coming years it is expected that the PV market will grow as well as the Solar thermal and CSP market. However, various scenarios have been made to account for the reaction possible changes in the future PV-scenario after in early June 2018, China's National Energy Administration (NEA) announced strong subsidy cuts to slow down domestic solar demand that had been much larger than originally planned in 2016 and 2017. Several solar experts revised their forecasts from strong growth in 2018 to no growth at all, we still see a high probability for further global solar market expansion in 2018.

Comparison of the PV and solar collectors systems in 2Seas countries.

	Belgium	France	Netherlands	UK	EU-avg
PV-Installed in 2017 (MW)	284	908	854	871	
PV-Installed in 2018 (MW)	367	862	1357	271	
Cumul PV in 2017 (MW)	3610	8610	2903	12783	
Cumul PV in 2018 (MW)	4255	9466	4300	13054	
PV-W/inhabitant	373,2	141,4	250,3	197,0	223,0
Solar coll. installed in 2017 (MWth)	24,8	85,8	21	7	
Solar coll. installed in 2018 (MWth)	20,9	109,3	25,3	4,9	
Cumul solar coll. In 2017 (MWth)	525	2166	455	1000	
Cumul. solar coll in 2018 (MWth)	539	2258	457	1005	
Wth/inhabitant	0,047	0,034	0,027	0,015	0,073

BELGIUM: There is now an EU-wide renewable energy target of 32% by 2030. In the current draft of its NECP, Belgium promises a 2030 total renewables target of 18.3%. This stands in contrast to Belgium's 2020 renewable energy target of 13%. At the moment, renewables account for just 9.1% of Belgium's energy demand. There is still a long way to go.

According to the draft plan, the renewables share in different sectors will be as follows:

- 40.4% in electricity
- 20.6% in transport
- 12.7% in heating and cooling

In 2011, Belgian installations peaked with over 1 GW of new systems, before starting to decline in 2012. At the end of 2017, cumulative installed capacity was over 3.8 GW with about 290 MW installed in that year. Over 9.3 % of Belgian households are already generating their own PV electricity, and PV power supplied 2.89 TWh or 3.6 % of the country's net electricity production in 2017.

Table 4: Other informations

	2017 Numbers
Number of PV systems in operation in your country (a split per market segment is interesting)	**≤ 10 kVA:** 459.854 systems **> 10 kVA et ≤ 250 kVA :** 7.009 systems **> 250 kVA :** 1.004 systems **TOTAL** : 467.867

Table 5: The cumulative installed PV power in 4 sub-markets (MWp).

Year	Off-grid (including large hybrids)	Grid-connected distributed (BAPV, BIPV) < 250 MW	Grid-connected centralized (Ground, floating, agricultural...) >250 MW	Other uses (VIPV, wearables...)	Total
2007	nd	24	nd	nd	24
2008		110			110
2009		667			667
2010		1096			1096
2011		2164			2164
2012		2890			2890
2013		3154			3154
2014		3266			3266
2015		3386			3386
2016		3587			3587
2017		3877			3877

FRANCE In 2017, 887 MW of new PV systems were connected to the grid in France. Total cumulative installed capacity increased to over 8.06 GW, including about 400 MW in the French Overseas Departments. Electricity production (continental France and Corsica) from PV systems was 9.2 TWh or 1.7 % of the national electricity generation.

	2017		
	Peak Power range	**Installations (number)**	**Power (MW)**
Number of PV systems in operation in your country	0 – 3 kW	289 494	779
	3 kW – 9 kW	73 224	467
	9 kW – 36 kW	17 522	438
	36 kW – 100 kW	13 213	1 070
	100 kW – 250 kW	6 071	1 072
	> 250 kW	1 415	4 219
	Total	**400 939**	**8 044**
	Total Off-grid		**30**

Table 5a: The cumulative installed PV power in 3 sub-markets.

	Off-grid	Grid-connected centralized ground-mounted	Grid-connected distributed	Grid-connected total
2007	22,5	0	53	53
2008	22,9	7	150	157
2009	29,2	42	300	342
2010	29,3	242	938	1180
2011	29,4	702	2242	2944
2012	29,6	1012	3052	4064
2013	29,7	1264	3454	4718
2014	29,75	1709	3963	5672
2015	30,15	2318	4257	6575
2016	30,15	2598 (revised)	4573	7171 (revised)
2017	30,15	3059	4985	8 044

SOURCE: SDES and previous IEA NSR-FR reports (revised), PV Atlas Observ'ER and ADEME

NETHERLANDS: Since the 1990s, the application of solar electrical energy (or Photovoltaic Energy, PV) in the Netherlands has shown a steady increase in the installed capacity and a decrease in the price. On average, prices for solar panels fell 10% per year and the installed capacity grew 30% per year, see figure below. At the moment there is more than 4 GWp of electric solar power installed in the Netherlands. The current installations of more than 4 GWp cover a combined area of more than 40 km2. So where are all these solar panels located? A traditionally very important segment are buildings. At present, approximately 95% of all solar panels in the Netherlands are attached to a building. However, three other segments are gradually gaining ground and will eventually gain a market share comparable to that of buildings [source: Roadmap for PV Systems and Applications in the Netherlands, SEAC2].

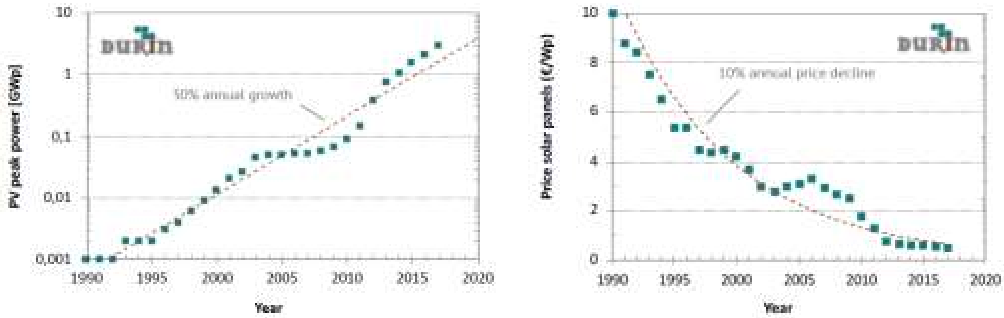


Figure 2 - *Historical data of the Dutch solar power market for the time frame between 1990 and 2018, with on the left the installed capacity of solar panels in the Netherlands [source: CBS] and on the right the average selling price of solar panels in Europe [source: Navigant consulting, pvXchange].*

UK: Solar energy market in the UK is represented primarily by Photovoltaic (PV) electricity generation. The total installed PV capacity at the end of 2018 Q2 was 13.012 GW. As can be seen from Figure 3 and Table 1, the growth in the installed capacity slowed down sharply in 2016 and went down even further in 2017. The latest data show that the growth has halved in 2018 compared to 2017.

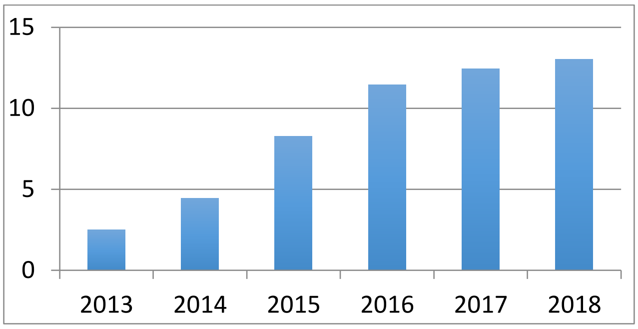


*Figure 3: Installed PV generation capacity, GW (Q2 of each year taken as the reference) [**Fout! Verwijzingsbron niet gevonden.**, **Fout! Verwijzingsbron niet gevonden.**]*

2014	2015	2016	2017	2018
77.9%	86.4%	38.5%	8.5%	4.6%

Table 1: Annual growth in PV capacity (Q2 of each year taken as the reference) *[**Fout! Verwijzingsbron niet gevonden.**, **Fout! Verwijzingsbron niet gevonden.**].*

In terms of the overall renewable electricity generation, the share of PV is on par with onshore wind electricity generation at 30.9% of all renewable electricity capacity. As can be seen from Figure 4, the parity with onshore wind generation has persisted for the last three years, while the fastest growing share has been in offshore wind generation.

The total UK renewable electricity capacity was 42.2 GW at the end of 2018 Q2, representing an increase of 10% (3.9 GW) on the installed capacity at the end of 2017 Q2. The increase in the offshore wind capacity, which rose by 2.2GW, accounted for 38% annual growth. Therefore, the 4.6% annual growth in the PV capacity (see Table 1) is at the moment lagging significantly behind the fastest growing renewable options for electricity generation, as well as the renewable electricity sector overall.

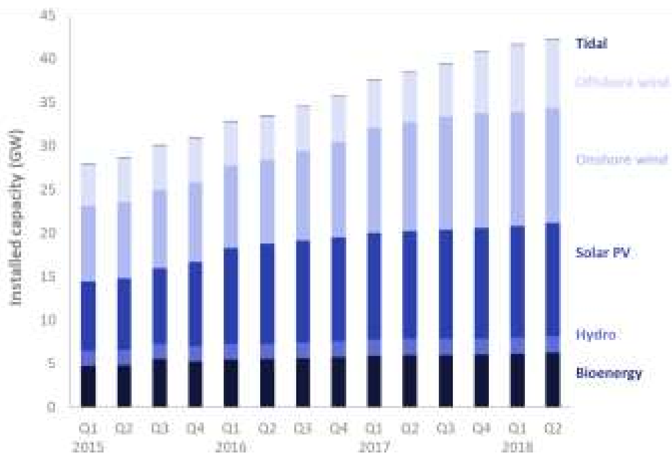


*Figure 4: Renewable electricity capacity (Reproduced from [**Fout! Verwijzingsbron niet gevonden.**])*

There were 963,764 solar PV installations reported in the UK in September 2018. The overwhelming majority of the installed capacity falls into three categories according to the installation size: 5-25 MW (33.4%), 50 kW-5 MW (27%), and under 4 kW (19.9%).

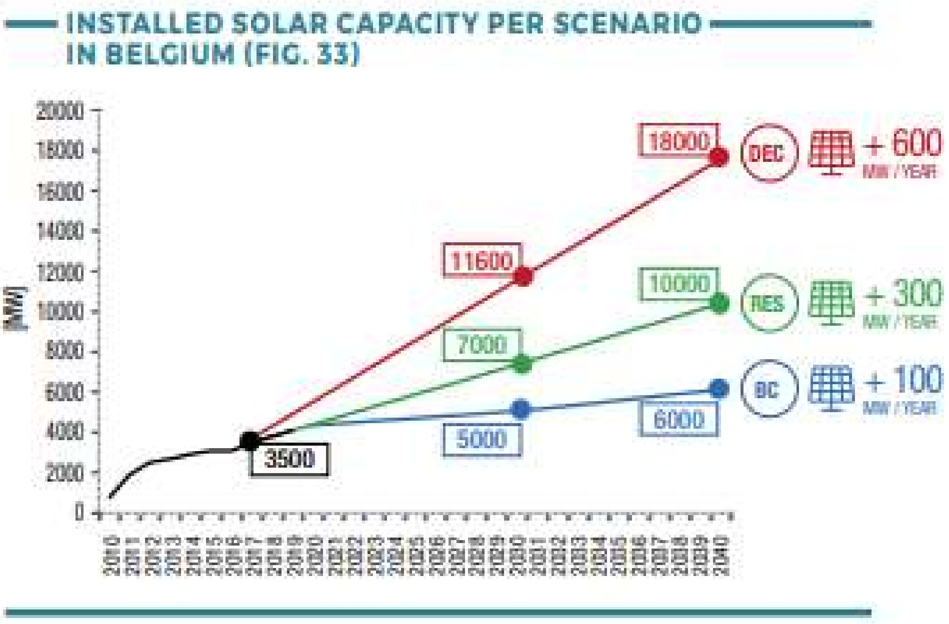
1.1.2. What is the predicted future potential in 2 Seas region?

BELGIUM: If all rooftops (excluding shadow zones) are covered with PV panels (around 250 km² for Belgium), this would correspond to about 40 GW of generation capacity. This value is retained as maximum potential but reaching such amounts would certainly require massive curtailment or large amounts of local storage capacities and/or local grid upgrades to evacuate or store the produced energy surplus. As mentioned in some studies, the potential could be much greater considering other surface types such as fields, roads, along highways and train tracks, windows, walls, ...

The proposal of the Belgium Parliament for a new Energy Pact 2050 was published in January 2018. The main issues concerning photovoltaics are:

- Gradual phase-out of Belgium's 6 GW of nuclear capacity between 2022 and 2025 and increase of renewables in the power supply to 40% by 2030 (8 GW of PV, 4.2 GW onshore wind and 4 GW offshore wind).
- Increase of renewables in the power supply to 100% by 2050.
- 2 GW of large-scale storage and 3 GW of distributed small-scale storage.

The Belgian grid operator Elia published three scenarios for the Belgian electricity supply indicating that total PV power could be in the range of 5 to 11.6 GW by 2030 and in the highest scenario could go up to 18 GW by 2040.



FRANCE On 22 July 2015, France's National Assembly adopted the Energy Transition for Green Growth Act. The legislation aims to reduce France's reliance on nuclear to 50 % of power generation by 2025 and increase the share of renewable energies in the final gross energy consumption to 23 % in 2020 and 32 % in 2030. The targets for PV to achieve the 2023 goal are 10.2 GW installed PV power by 2018 and between 18.2 and 20.2 GW by 2023.

NETHERLANDS:

UK:

1.1.3. Local (EU) manufacturers of components (panels, inverters) and installers

As can be seen in table below from Photovoltaic Barometer 2019, in 2018 there was still no relevant manufacturer of PV panels in Europe. This can be a serious threat to the uptake of solar PV, since most of the installations depend on the import of the solar panels.

Tabl. n° 5

Main photovoltaic module manufacturers in 2018

Company	Country	Shipment (MW)
Jinko Solar	China	11 380
JA Solar	China	8 800*
Trina Solar	China	8 100*
LONGi Solar	China	7 200*
Canadian Solar	China	6600
Hanwha Q-CELLS	Korea	5 600*
Risen Energy	China	4 800*
GCL-SI	China	4 100*
Talesun	China	2 900*
First Solar	USA	2706

*Estimates from GlobalData. **Sources: Annual reports, GlobalData.**

Over the past two years, most of the Chinese photovoltaic players have delisted from the American stock exchange. As they are no longer subject to the same communication obligations, information about them has become much scarcer. This primarily applies to their annual delivery figures, total manufacturing capacity and turnover.

However for the solar collectors more EU manufacturers can be found in the table below extracted from Solar/CSP Barometer 2019:

Tabl. n° 6

Representative European solar thermal collector manufacturers

Company	Country	Activity
GREENoneTEC	Austria / China	Flat plate and vacuum tube collectors
Dimas	Greece	Flat plate collectors manufacturer
Bosch Thermotechnik	Germany	Heating equipment supplier / Flat plate collector manufacturer
Solimpeks	Turkey	Flat plate collectors manufacturer
Thermosolar	Slovakia	Flat plate and vacuum tube collectors manufacturer
Eraslanlar	Turkey	Flat plate collectors manufacturer
Hewalex	Poland	Flat plate collectors manufacturer
Viessmann	Germany	Heating equipment supplier / solar thermal
Delpaso Solar	Spain	Flat plate collectors manufacturer
Ariston	Italy	Flat plate collectors manufacturer
Vaillant Group	Germany	Heating equipment supplier / solar thermal
Arcon-Sunmark	Denmark	Flat plate collectors manufacturer
Nobel	Bulgaria	Flat plate collectors manufacturer
Cosmosolar	Greece	Flat plate collectors manufacturer and heating equipment supplier
BDR Thermea	Spain	Heating equipment supplier / solar thermal

Source: EurObserv'ER 2019.

	EU 28	Belgium	France
2008	301.779	2,068	1,974
2016	81,319	2,338	5,778
2021	174,682	2,687	19,878

Figure 6: Total jobs per year (FTE)

	EU 28	Belgium	France
2008	15,729	146	126
2016	4,639	148	391
2021	9,529	170	1,342

Figure 5: Gross Value Added (MEURO)

There is an important split in jobs between the segments of rooftop and ground-mounted systems in the EU, with the ground-mounted segment historically supporting more jobs than the rooftop.

BELGIUM: Belgium has almost no solar manufacturing industry and imports almost all solar systems. Some smaller companies are existing focusing on the development of specific types of modules or on BIPV. In the past some attempt have been done by construction companies to diversify their business, however mostly unsuccessful. There are a lot of smaller installers of rooftop solar systems that are trying to professionalize as fast as possible. After the first booming period, a shake-out happened and some consolidation took place. Yet there are important economies of scale to realize.
FRANCE: Compared to the situation in 2008, the socio-economic contribution of the PV industry in 2016 has fallen in most European countries. Only the UK and France and some other countries with a small PV installed capacity (captured under 'rest of Europe' in the charts) have experienced a significant increase in supported jobs and GVA over the same period of time. In France, it is estimated that the increase will continue. The workforce mainly consists of operational and maintenance jobs of existing installations, while numbers linked to the manufacturing are slightly decreasing.

Among the most important solar photovoltaic developers in EU, there are only 3 located in the 2Seas region, namely EDF Renouvelables and ENGIE Green from France and Lightsource BP from UK. Other local developers located in the 2Seas region are too small to make a difference.

Tabl. n° 6

Main European solar photovoltaic developers in 2018

Company	Country	Installed photovoltaic capacity (MW)
Enerparc	Germany	[illegible]
Lightsource BP	United-Kingdom	[illegible]
EDF Renouvelables	France	[illegible]
Juwi AG	Germany	2 500
Belectric	Germany	[illegible]
Voltalia	Portugal	1 800
Enel Green Power	Italy	[illegible]
Scatec Solar	Norway	> 1800
ENGIE Green	France	[illegible] (France)

Source: EurObserv'ER

1.1.4. Legislation with respect to resid./comm. solar rooftop installations and solar farms

BELGIUM

1.Rooftop installations

Rooftop panels are subject to approval by the services for environmental planning of the municipalities and outcome differs from municipality to municipality. In some cases, the color of solar panels still leads to a negative decision. An attempt has been done to resolve this from regional government. This initiative was however not successful.

Financial incentives for installations up to 10kW consist out of not having to pay distribution and VAT taxes on auto/self-consumption, accounted on yearly basis. With the introduction in Flanders of digital metering, yet unsuccessful efforts have been made to change this system. It can be expected that after elections later this year, legal procedures are started, leading to investment uncertainty. In the Walloon region, this introduction is foreseen for 2021.

The most important incentive is due to the situation that it is nearly impossible to reach the Energy Prestations for new buildings without solar panels. As a result, nearly 98% of new buildings have roof solar panels.

2.Solar farms

Solar farms are also subject to building permits. Citizen protest against large installations is less important than for windmills. Regional planners however do object regularly due to the impact on the rural look and feel. There is also an important risk due to the emphasis on conservation of animal natural habitats, leading to important delays in the realization of projects.

Incentives consist out of green certificates. The amount is depending on the banding factor, covering different parameters in one formula, aiming for a RoI of 5% over a period of 10 years. Also for solar farms, it is difficult to have a business case without auto-consumption. Between 10kW and 750kW, almost no initiatives are realized.

[redacted]

met burgerparticipatie	≤10 kW	>10 en ≤40 kW	>40 en ≤ 250 kW	>250 en ≤750 kW
vanaf 1 januari 2019	n.v.t.	0,460 (2173 kWh)	0,731 (1367 kWh)	0,698 (1432 kWh)

zonder burgerparticipatie	≤10 kW	>10 en ≤40 kW	>40 en ≤ 250 kW	>250 en ≤750 kW
vanaf 1 januari 2019	n.v.t.	0,457 (2188 kWh)	0,728 (1373 kWh)	0,693 (1443 kWh)

FRANCE

1.Rooftop installations

In 2016, the mandatory introduction of smart meters started and should be completed by 2021. This measure provides an indirect support measure for small self-consumption systems, because it removes the grid connection costs. These costs were in general more than 12% of the price of a 3 kW system.

2. Solar Farms

Under the new support mechanism, feed-in tariffs are only available for systems below 100 kW capacity and tenders for systems above. However, there is still a difference for the larger systems: Systems between 100 and 500 kW bid for fixed tariffs, larger systems for a market premium. In the first half of 2018 PV systems with a capacity of 479 MW were connected to the grid. The capacity of projects in the planning stage increased to 6 GW, of which 2.5 GW already had a signed connection agreement.

1.1.5. The most important 3 main barriers for the solar energy uptake

Accounting for all the findings presented above, we can conclude that the most important legislative barriers for the solar energy uptake in the 2Seas region are:

- **Uncertainty of incentive schemes**; Investment companies as well as citizen are at this moment very reluctant to invest due to the lack of consistency in communication between politicians and the regulator. People are not sure whether this is the appropriate moment to invest. Provinces are trying to mitigate this introducing joint purchasing

- **Environmental planning**; Rooftop PV systems are often made impossible due to local imposed regulations. Large scale systems face large delays due to environmental issues. Landscape planning often are a big hurdle for large scale systems in dense countries such as Belgium and the Netherlands.

- **Lack of integrated climate policy**; In Belgium, the responsibilities are split amongst different federal, regional and local authorities making it difficult and cumbersome to introduce a consistent climate policy. Also this is the situation at the EU-level. However it is expected that in the future the legislation of the EU-countries will progress towards a harmonization of the policies and measures also related to solar energy harvesting and use.

The results are also presented in a visual form, see FS01 poster in Annex2.

1.2. FS02 Solar energy harvesting cost and investment models

At a general level, the electricity supply industries still heavily depend on fossil fuels. This specific technology is based on finite resources that can threaten the security of supply, but it also generates great environmental impacts. For this reason, the transition to alternatives could become urgent, so interest in support schemes for renewable energy has never been greater.

Renewable energy-generating technologies (thus also the solar-based ones) have high upfront costs compared with some conventional forms of electricity generation. Although schemes imposing emission limits (and trading) and fossil fuel taxes should make renewable energies more attractive investments, these are usually insufficient to make renewable technologies commercially viable. To ensure that renewable energies are produced in the desired quantities, governments therefore put in place support mechanisms that transfer some of the additional costs of RES schemes to society at large or to those who buy electricity.

In the following fact-sheet, we offer a synthesis of the state of the incentives for investment in photovoltaic solar energy in the 2 Seas countries, focusing on (1) the support schemes and the incentives (2) the cost / benefit models of the investments (3) risks, barriers and surpassing measures; and (4) the CO2 offsetting for a PV installation life-cycle.

1.2.1. Support schemes and incentives for a solar installation investment in the 2 Seas countries

Since 2009, support for electricity for renewable in EU member states is governed by Directive 2009/28/EC, commonly referred to as the "RES Directive", deriving from the climate-energy package, that has set the target of 20% renewable by 2020. However, Member States have full freedom regarding the contribution of different sectors (i.e. electricity, heat and transport) and the support instruments used to reach the targets.

In addition to certain direct subsidies for the development of certain renewable projects, or also the policy designed to discourage the use of fossil fuels (taxes -France, United Kingdom, Netherlands or the European Union Emission Trading Scheme), a common form of support mechanism is the production incentive, but also the quota system. In the case of the electric sector in the 2 Seas countries, we find the following support schemes for the promoting of renewable energy:

BELGIUM: Electricity from renewable sources is promoted at regional and federal levels mainly through a certificates-endorsed renewable quota scheme, complemented by regional support measures. In the three regions small PV installations benefit from net metering. The federal government supports renewable heating and cooling by way of a tax deduction on investment costs. The main support scheme for renewable energy sources used in transport is a biofuels quota scheme under the competence of the federal government.

Table 1: Overview of support schemes to promote renewable energy in Belgium

	REGULATORY POLICIES						FISCAL AND OTHER STATE FUNDED INCENTIVES		
	Feed-in tariffs	Feed-in premiums 1)	Tenders	Quota obligation with Tradable Green certificates	Quota obligation without Tradable Green certificates	Net-metering/ net-billing	Investment subsidies	Tax credits mechanisms	Soft loans
RES-E									
- Offshore wind		x	x	X					
- Onshore wind				X			x		
- Solar PV		x		X		x	x		
- Hydro				X			x		
- Geothermal				X			x		
- Solid biomass				X			x		
- Biogas				X			x		
RES-H/C									
- Solar thermal							x		x
- Geothermal							x		x
- Biomass							x		x
- Biogas							X		x
- Small scale installations, e.g. solar thermal collects, heat pumps, biomass boilers and pellet stoves							X		x
- Others, i.e. aerothermal, hydrothermal							X		x
RES-T									
- Bio gasoline					x			X	
- Biodiesel					x			X	

1) Formally no feed-in tariffs and premiums whatsoever are in place in Belgium. But the public service obligations imposed on TSO Elia and DSOs to grant technology-specific minimum payments to operators of renewable electricity generation installations if the latter desire so, boil down to feed-in premiums in the case on offshore wind and certain medium and large scale PV installations.

Sources: RES-Legal Europe (2019), EurObserv'ER,

Table 2: Overview of instruments used at present in Belgium

Instrument	Description
Feed-in premiums	Guaranteed premium during the support contract period on top of revenues from electricity sales: the guaranteed minimum certificate price granted by Elia works out as a feed-in premium for offshore wind and medium and large PV projects.
Tendering	Applied in offshore wind sub-sector
Renewable quota scheme, certificates-based	Obligation upon electricity suppliers to surrender on the settlement day of the current year a number of certificates corresponding to a pre-set minimum share of their annual sales volume last year.
Net metering	Possibility for an operator of a small roof-top PV installations to settle electricity fed into the grid in the course of a calendar year at the retail electricity tariff (including taxes and surcharges) up to a maximum level, i.e. the aggregated volume of electricity absorbed by the operator concerned from the grid during the same calendar year.
Tax credits scheme	Renewable heating & cooling installations in buildings are eligible for an exemption from property tax for building owners.
Biofuels quota scheme	Importers/suppliers of transport fuels are subject to a renewable quota scheme for biofuels. Compliance based on sample testing rather than certificates-based. No (direct) incentives for other alternative transport fuels.

In Belgium the *electricity from renewable sources (RES-E)* is promoted mainly through a renewable quota scheme based on the trade of certificates. As for these schemes, national TSO Elia has the obligation - when renewable electricity generators wish so - to purchase green certificates at a minimum price set by law for certain renewable electricity generation technologies (offshore wind and hydropower). The regional renewable quota schemes are based on a framework set by the federal government including guaranteed price floors for certain technologies, but may have region-specific features including the level of quotas set. Region-specific complementary support measures in Flanders include a renewable quota scheme stipulating different technology-specific quantities of renewable electricity per certificate (technology banding); an ecological (investment) premium for certain technologies included in the “limited technology list (LTL” in lieu of the Flemish renewable quota scheme, a “strategic” (investment) premium on a successful application basis for technologies not on the LTL , net metering for small technologies ≤ 10 kW)).

As for *renewable heating and cooling (RES-H/C)*, the federal government provides support to companies investing in technologies producing renewable heat and/or cooling by way of a tax deduction measure and indirect measures such as applicable RD&D programmes. Region-specific complementary support measures in Flanders include a renewable heating quota scheme; obligation to conduct energy auditing and use renewable heat in schools and public office buildings; R&D by the Environment and Energy Innovation Platform MIP), Energy Regulation transposing the buildings obligations for heat from renewable energy into Flemish law, Strategy on Heating and Cooling introducing area-based RESH policies, training programmes for installers of heat pumps and PV installations

FRANCE: RES-E is promoted through a feed-in tariff, a premium tariff as well as through tenders for the definition of the premium tariff level. The French government invites tenders for the construction of renewable energy plants in order to reach the target capacity set by a multi-annual investment plan. For RESH& C the Heat Fund support is the main tool for collective buildings. For individual housing, a tax credit is the main support scheme for renovation. For new building RES technologies are put forward through the legal text RT2012. The promotion of biofuels in France is mainly provided through fiscal regulation mechanisms.

In France, electricity from renewable sources is promoted through a feed-in tariff, a premium tariff as well as through tenders for the definition of the premium tariff level. Renewable energy producers may benefit from a premium tariff on top of the sale price they get on the electricity market. For almost all RES technologies, The French government invites tenders for the construction of renewable energy plants in order to reach the target capacity set by the multi-annual investment plan (Programmation Pluriannuelle de l'Énergie - PPE) of which last version was released in October 2018. For the smallest plants (less than 500 kW) feed-in tariff are still operating. Furthermore, persons that install photovoltaic installations on buildings are eligible for a reduced VAT rate.

For heating and cooling purposes the Heat Fund, implemented to finance RES-H/C projects and which has been implemented in 2009 and is still the main supporting measure for RES application in collective buildings. Its budget has been increased in 2019. Another important measure is Thermal Regulation reglementation (RT 2012) that began to operate at the beginning of 2013. It created restricting measures to promote energy efficiency and renewable energies in all new buildings. A new thermal reglementation should be implemented in 2020 (RE 2020).

For individual housing the main tool remains the tax credit measure implemented more than a decade (it started in 2005). In 2019 a 30% rate of the total cost of the RES appliance for heat purposes are refunded by the tax administration. This measure covers almost all RES individual equipment (individual wood stoves or wood boilers, solar thermal collectors and ambient heat). Moreover, lower VAT rates were implemented for RES-H&C materials and also zero rates eco-loan to improve overall energy performance of housing.

Table 1: Overview of support schemes to promote renewable energy in the France

	REGULATORY POLICIES						FISCAL INCENTIVE AND PUBLIC FINANCES		
	Premium tariff	Feed-in tariff (for < 500 kW plants)	Tendering	Quota obligation with Tradable Green certificates	Quota obligation without Tradable Green certificates	Net-metering/ net-billing	Capital subsidy, grants (Heat Fund and)	Tax regulation mechanism (Tax credit)	Loans
RES-E									
- Offshore wind	○		○						
- Onshore wind	○		○						
- Solar	○	○	○						
- Hydro	○	○	○						
- Geothermal	○		○						
- Solid biomass	○	○	○						
- Biogas	○	○	○						
RES-H/C									
- Solar thermal							○	○	
- Geothermal							○		
- Biomass							○	○	
- Biogas							○		
- Small scale installations, e.g. solar thermal collects, heat pumps, biomass boilers and pellet stoves								○	
- Others, i.e. aerothermal, hydrothermal								○	
RES-T									
- Bio gasoline					○				
- Biodiesel					○				

Sources: EurObserv'ER, French National Climate and Energy Plan, RES-Legal Europe (2019)

Table 2: Brief description of key policy instruments aimed at promoting RES in the France

Instrument	***Description***
Premium tariff *Complément de rémunération*	Premium tariffs are allocated through a quasi-tendering process, where energy producers compete against each other for feed-in premium support. For all RES technologies, FiP are reachable through calls for tenders auction published by Authority. The aim is to pilot the technologies growth as close as possible to the RES investment program define by the government in October 2018. Website: http://www.ecologique-solidaire.gouv.fr/index.php/dispositifs-soutien-aux-energies-renouvelables
RES-H building obligations *Réglementation thermique*	The thermal regulation 2012 obliges new buildings to comply with minimum energetic performance requirements as defined by the label BBC-Effinergie. Since 2012, the use of renewable energies in order to reach energetic performance requirements (including the use of sanitary hot water and heating devices) is mandatory for single-family houses (Art. 16 arrêté du 26 octobre 2010). The thermal regulation 2012 applies for new buildings as follows: • For service sector buildings and residential buildings situated within a national renovation programme area: from 28 October 2011 • For residential buildings situated within 500 meters of a national renovation programme area: from 1 March 2013 • For other residential buildings: from 1 January 2013 As far as existing buildings are concerned, buildings of the service sector and public service sector are obliged from January 2012 to improve their energetic performance by 2020 (Art L 111-10-3 Code de la construction et de l´habitation), including renewable energy plants for heating purposes. Except single-family houses, there are no RES-H building obligations directly supporting the use of heating systems from renewable energy sources. However, RES-H can be required indirectly through the energetic performance obligations.
Heat Fund scheme *Fonds chaleur*	The Heat Fund, managed by ADEME since 2009, is dedicated to renewable heat production in collective housing, communities and businesses. The fund can participate to a project financing up to 30% of its total amount. During the period 2009-2018, the heat Fund allocated 2.17 billion euros to support nearly 4,820 projects and a total production of 2.38 million toe. Website: http://www.ademe.fr/expertises/energies-renouvelables-enr-production-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur-bref
Tax credit scheme *Crédit d'impôt pour la transition énergétique*	A tax credit programme which gives a direct financial advantage to individual consumers that invest in energy-saving equipment and sustainable energy. Consumers may deduct 30% of the equipment costs (installation costs are excluded) over the calendar year in which the equipment was purchased. The list contains almost all the main RES-H technologies for individual houses. The measure, implemented in 2005, is the most popular scheme in France to support RES applications. In 2018, the cost of the measure only for RES technologies was evaluated around M€ 200. Website: https://www.service-public.fr/particuliers/vosdroits/F1224
Investments for the Future programme *Programme investissement d'avenir*	The Investments for the Future programme is intended to support projects fostering innovation and the creation of non-relocatable jobs in sectors with strong potential for the French economy. It is a matter of strengthening France's strategic competitive advantages. The implementation of the Investments for the Future program is steered by the General Investment Commission (CGI). It is supported by several operators, including ADEME, which is responsible for innovation for energy and ecological transition. RES technologies and smart electricity grids are eligible to this programme. Website: http://www.ademe.fr/en/investments-for-the-future
Training programmes for Installers *Référencement RGE*	The association Qualit´EnR was established in 2006 as an initiative of five national professional organisations in order to promote quality installations in the field of solar thermal energy, photovoltaic, biomass as well as heat pumps and geothermal probes. The association was established for private households willing to install a renewable energy plant, with the aim to ensure them a quality installation.
Biofuel quota (Réduction de la taxe générale sur les activités polluantes TGAP)	The act on energy transition of 2015 sets a target of 10% renewable energies in the total energy consumption of the transport sector by 2020 and of at least 15% by 2030. In order to reach these targets, the quota of biofuels to be blended within conventional fuels is defined for each fuel type. In case companies releasing fuel for consumption do not respect the biofuels quota, they are submitted to a higher rate of the tax on polluting activities (TGAP).

NETHERLANDS Since 2011 the main support instrument for new renewable electricity, gas and heat projects is the SDE+ scheme, a tender-based feed-in premium scheme. Other support instruments include a range of fiscal facilities, a reduced-interest “green loan” instrument and net metering for household and community renewable electricity generation installations. Main support instrument for renewable liquid and gaseous transport fuels is a biofuels quota scheme.

The Netherlands is mandated by renewable energy directive 2009/28/EC to achieve a share of renewables in gross final energy consumption of 14% by 2020. Boasting the highest population density in Europe (415 persons/km2 in 2018) and negligible hydropower potential, the country is endowed with a relatively modest renewables resource base, rendering achievement of this target an ambitious task. Whereas, so far, biogenic energy boasts the largest share in Dutch renewable energy production, the renewable sources with largest potential are wind onshore and notably offshore as well as, to a lesser extent, solar PV. Although allocating over the past 10 years significant public funding for renewable energy stimulation, the country risks to significantly under-comply its 2020 renewable energy target. In the national Energy Agreement (SER, 2013) was concluded between the Dutch government and key Dutch societal organizations in year 2013, which states a renewables target of 16% and an offshore wind sub-target of 4.5 GW by 2023. Since then decarbonizing the Dutch energy sector got more robust political support. Political commitment to push renewable energy deployment was further reinforced by the government decision in March 2018 to phase out natural gas production from the giant Groningen natural gas field within 12 years and adopting of the Climate Law in May 2019. With a GDP of €billion 913 and government expenditures of €billion 277 in year 2018, annual spending on Dutch support schemes MEP, SDE, and most importantly, SDE+ stood at € 1072 million in 2018 against € 690 million in 2010: see Table 1 below. The SDE+ support budget limit for a sequel of 3 tender rounds in March 2019 was €5 billion; in autumn 2019 another 3-rounds tender sequel will be held with a budget limit of €5 billion as well. These amounts concern budgets for SDE+ support applications over the whole SDE+ support contract period (15 years for most technologies). The support budget for 2019 totalling € 10 billion is substantially higher than annual support budgets before 2017. The annual budget (also in two tranches) for 2017 and 2018 was even € 12 billion.

With the SDE+ support intensification the Dutch government aims at speeding up renewables deployment to reduce the gap towards compliance of the 14% renewables target by 2020. Focal points of Dutch renewables policy include offshore wind development to an installed base of 4.5 GW by 2023, onshore wind development to an installed base of 6 GW by 2020 (which seems optimistic at present, September 2019) as well as the take-off of renewables-based hydrogen development. Green hydrogen is envisaged to play a significant role as from 2030 onward.

Table 2: Overview of support schemes to promote renewable energy in the Netherlands

	NON-FISCAL SUPPORT SCHEMES					FISCAL AND OTHER STATE FUNDED INCENTIVES			
	Feed-in premium (SDE+)	Tendering	Quota obligation with Tradable Green certificates	Quota obligation without Tradable Green certificates	Net-metering/ virtual net metering	Capital subsidy, grants (e.g. ISDE)[4]	Tax regulation mechanism I (EIA)	Tax regulation mechanism II (MIA/VAMIL)	Soft loans
RES-E									
- Offshore wind	x	x					x	x	
- Onshore wind	x	x			x		x	x	x
- Solar	x	x			x		x	x	x
- Hydro	x	x			x		x	x	x
- Geothermal	x	x					x	x	x
- Solid biomass	x	x					x	x	
- Biogas	x	x					x	x	
RES-H/C									
- Solar thermal	x						x		x
- Geothermal	x						x		x
- Biomass	x						x		
- Biogas	x						x		
- Small scale installations, e.g. solar thermal collects, heat pumps, biomass boilers and pellet stoves						x	x		
- Others, i.e. aerothermal, hydrothermal							x		
RES-T									
- Bio gasoline			x					x	
- Biodiesel			x					x	

Sources: RES Legal, EurObserv'ER

Table 3: Brief description of key policy instruments aimed at promoting RES in the Netherlands

Instrument	***Description***
SDE+: Support Scheme for Sustainable Energy Production *Stimulering Duurzame Energieproductie*	Floating feed-in premium scheme which is used to promote RES-based electricity, gas and heating. SDE+ subsidies are allocated through a quasi-tendering process, where energy producers compete against each other for feed-in premium support. It encompasses a system of two annual three-phased admission rounds with escalating reference cost of energy rates which favours low cost renewables technologies. In 2020 the prevailing SDE+ scheme will evolve into a broader support scheme, entitled stimulation of sustainable energy transition (*Stimuleringsregeling Duurzame Energietransitie*) , SDE++. SDE++ will apply the same support allocation methodology as SDE+, but unlike SDE+ the future support scheme will also include non-renewable CO_2 reduction technologies, such as notably carbon capture and storage (CCS).
ISDE: Sustainable energy investment subsidy scheme *Investeringssubsidie Duurzame Energie*	Provides both private persons and small-scale business with a subsidy for the purchase of solar thermal collects, heat pumps, biomass boilers, and pellet stoves.
EIA: Energy Investment Allowance *Energie investerings-aftrek*	A tax relief programme which gives a direct financial advantage to companies that invest in energy-saving equipment and sustainable energy. In year 2019 entrepreneurs may deduct 45% of the investment costs for such equipment (purchase and/or production costs) from their company's pre-tax profits, over the calendar year in which the equipment was purchased. The business assets that qualify for the EIA for the year 2019 are set out in the Energy List 2019.
MIA/VAMIL: Environmental Investment Rebate *Milieu-investerings aftrek* **Arbitrary depreciation of environmental investments** *Willekeurige afschrijving milieu-investeringen*	The MIA scheme, offering a tax refund on environmental investment, and the Vamil scheme providing for voluntary depreciation on environmental investment, are two different schemes run by the Ministry of Economic Affairs and Climate and the Ministry of Finance. The aim of both of them is to encourage Dutch entrepreneurs to invest in their business operations in an environmentally friendly way. The MIA scheme allows investment tax credits up to 36% of the investment cost of an environmentally sound investment from pre-tax corporate profit while the Vamil scheme facilitates accelerated depreciation for 75% of eligible investment costs.
Green fund	The Dutch government grants a tax benefit to consumers who invest in a green fund, which enables banks to offer loans at lower interest rates to officially accredited 'green' projects. For a project to qualify for such a loan it should apply for a declaration on the basis of the Regulation Green Projects issued in 2016. The declaration is valid for 10 or 15 years depending on the application.
Green Deal Programme	Introduced by the Dutch government in 2011 with the aim of identifying sustainable projects (not only energy related) that would benefit from streamlined permitting and planning procedures, specific advice and/or the introduction of public-private funding structures. Eligible projects vary from large-scale geothermal research projects, industrial heat utilisation projects and smart grid projects, to smaller-scale biomass projects in the horticultural industry. Support provided is focus on facilitation (non-financial) rather than direct subsidisation.

UNITED KINGDOM: RES-E are supported through a feed-in tariff, Contracts for Difference scheme and tax regulation mechanism. RES-E is connected to the grid under the principle of non-discrimination, RES-E plant operators are granted the right to access the grid and grid operators are obliged to expand the grid if this is necessary to accept all generated RES-E from a plant. As for RES-H&C price-based mechanisms are available for supporting RES-H installations. Furthermore, a quota system for biofuels for transport is in place. A training programme for RES-E plant installers is in place, as well as a certification programme for RES-E installations.

In the United Kingdom, the generation of electricity from renewable sources is supported through a combination of a feed-in tariff system, Contracts for Difference system, in terms of a quota obligation, a certificate system and a tax mechanism. Under the feed-in tariff, accredited producers, whose plants have a capacity of less than 5 MW, can sell their electricity at fixed tariff rates established by the Gas and Electricity Market Authority (Ofgem). The scheme is applicable to England, Wales and Scotland only. Under the Contracts for Difference (CfD) scheme, a RES-E generator and a CfD Counterparty (Low Carbon Contracts Company) enter into a contract, which is based on a difference between the market price and an agreed “strike price”. Currently, the scheme is applicable in England, Wales and Scotland. From April 2017 the CfD scheme is the only support scheme for all new RES-E plants exceeding 5 MW. The first Allocation Round took place in October 2014, while the second Allocation Round took place in April 2017.

Furthermore, in Great Britain commercial and industrial users of traditional energy sources are subject to a tax on fossil fuels used for electricity generation. Electricity from renewable sources is exempt from this tax. Furthermore, in Great Britain commercial and industrial users of traditional energy sources are subject to Carbon Price Floor (CPF), a tax on fossil fuels used for electricity generation. Electricity from renewable sources is exempt from this tax.

The Renewable Heat Incentive (RHI) is the main instrument for funding RES-H sources in the United Kingdom by supporting RES-H installations with a fixed amount per kWth produced. The scheme consists of two parts:

- The Non-Domestic RHI (UK) that provides payments to industry, businesses and public sector organisations
- the Domestic RHI (UK and Northern Ireland until 2016) that is open to homeowners, private landlords, social landlords and self-builders.

In addition, the Department for Business, Energy & Industrial Strategy (BEIS) plans to introduce changes to the Non-Domestic/Domestic Renewable Heat Incentive (RHI) scheme Regulations that came into effect in September 2017. Further amendments are introduced in 2018.

Table 1: Overview of support schemes to promote renewable energy in the United Kingdom

	REGULATORY POLICIES					FISCAL INCENTIVE AND PUBLIC FINANCES		
	Feed-in tariff < 5MW	Premium tariff	Quota obligation with certificates system > 5 MW	Tendering	Net-metering/ net-billing	Capital subsidy, grants	Tax regulation mechanism	Loans
RES-E								
- Offshore wind	o	o						
- Onshore wind	o	o						
- Solar	o	o						
- Hydro	o	o						
- Geothermal	o	o						
- Solid biomass	o	o						
- Biogas	o	o						
RES-H/C								
- Solar thermal	o							
- Geothermal	o							
- Biomass	o							
- Biogas	o							
- Large ambient heat application	o							
- Small scale installations, e.g. solar thermal collects, heat pumps, biomass boilers and pellet stoves	o							
- Others, i.e. aerothermal, hydrothermal	o							
RES-T								
- Bio gasoline			o					
- Biodiesel			o					

Sources: EurObserv'ER, British National Climate and Energy Plan, RES-Legal Europe (2019)

Table 2: Brief description of key policy instruments aimed at promoting RES in the United Kingdom

Instrument	*Description*
Feed-in tariff	Eligible renewable energy plants with a capacity of up to 5 MW must generally undergo an accreditation process, which may differ according to plant size and energy source. Once this process is completed and the plant has been accredited, the electricity exported to the grid by the plant is bought by a FiT licensee, i.e. an electricity supplier, at rates fixed by the FTO 2012 and corrected yearly by the Gas and Electricity Markets Authority (Ofgem). This system only applies in Great Britain, i.e. Scotland, England and Wales. The Order is not applicable in Northern Ireland. With some exceptions, until 31 March 2017 plants between 50 kW and 5 MW are entitled to choose between the above-mentioned system and the Renewables Obligation.
Contracts for Difference (CfD)	A Contract for Difference (CfD) is a private law contract between a RES-E generator and the CfD Counterparty – Low Carbon Contracts Company (LCCC), wholly owned by the UK Government. The scheme is based on a difference between the market price and an agreed "strike price". Where a "strike price" is higher than a market price, the CfD Counterparty must pay the RES-E generator the difference between the "strike price" and the market price. Where market price is higher than the "strike price", RES-E generator must pay back the CfD Counterparty the difference between the market price and the "strike price". An operator of eligible RES-E technology, willing to secure a Contract for Difference, has to take part in an allocation round. The CfD scheme is currently in place in Great Britain Northern and Ireland. With some exceptions, until 31 March 2017, RES-E generators are able to choose between Renewables Obligation (RO) and CfD schemes. Since April 2017 the CfD scheme will be the only support scheme for all new RES-E plants over 5MW.
Tax regulation mechanism	From April 2013, Carbon Price Floor was introduced in Great Britain. The tax applies to fossil fuels used for electricity generation. Renewable electricity is exempt from paying this tax.
Non-domestic Renewable Heat Incentive (RHI)	The RHI is the world's first Feed-in-Tariff for renewable heat, introduced in 2011 (non-domestic) and 2014 (domestic). The government announced in late 2015 that the RHI scheme would be extended to 2020/21. The budget is to increase from £430 million in 2015/16 to £1.15 billion in 2020/21. The heat demand that can be claimed for (which is deemed) is being reduced, thus cutting the amount of RHI that can be claimed by larger properties. All technologies used for heat generation from renewable energy sources are eligible
Training programmes for Installers *Green Deal Skills Alliance (GDSA)*	Launched in January 2012, the aim of this scheme is to ensure that the UK has the right skills to implement the Green Deal - the flagship policy to improve the energy efficiency of buildings. GDSA is tasked with creating new training and accreditation opportunities for the energy assessment, advice and installation workforce.
Biofuel quota *Renewable Transport Fuel Obligations*	A quota system for biofuels is in place in the United Kingdom since 2007. Fuel suppliers for transport are obliged to satisfy a specified quota amount of biofuels in the total supplied fuel. There is a certificate system for providing proof of compliance.

Feed-in schemes, in France, United Kingdom and Netherlands

Feed-in schemes either use feed-in tariffs or feed-in premiums whose level is either administratively set or determined in a competitive auction. Traditionally, feed-in tariffs were designed as administratively set feed-in tariff, as currently applied in France for photovoltaic solar installations below 500 kWp and in the United Kingdom for plants that have a capacity of less than 5 MWp. Such a system implies a very low risk for plant operators as they receive a fixed amount of money for each unit of electricity generated regardless of the demand situation. While this system led to comparatively low support costs per unit of electricity due to low capital costs, it also implies some problems like a little adaptation of the support level to respond to sinking technology costs, especially in the case of PV; the public cost of the funds invested, or the absence of incentives to react to the demand situation. As a consequence of these challenges, many EU Member States have changed and are changing their support schemes from administratively set feed-in tariffs to auction-based feed-in premium schemes. This move is also supported by the EU Commission's "Guidelines on State aid for environmental protection and energy 2014-2020" published in late 2014.

As in the Netherlands with the SDE + (in Dutch: Stimulering Duurzame Energieproductie), or France in the case of photovoltaic solar for installations of more than 500 kWp, in feed-in premium schemes, renewable plant operators sell the electricity generated on the regular electricity market. On top of the regular electricity price, they receive a premium which can be either fixed or floating. If the premium is fixed the revenue of the plant operator per unit of electricity fluctuates to the same level as the electricity price. In schemes with a floating premium, plant operators also receive a premium on top of the regular electricity market price. However, this premium adapts to the level of the market price such that the overall revenue of a plant operator for each unit of electricity generated remains stable, i.e. if the market price sinks the premium increases and vice versa. As usually it is not the SPOT market price but the average monthly market price which is used for the premium calculation, generating electricity in hours with high prices is still slightly more profitable than in hours with low electricity prices.

Auctions

In Auctions (Netherlands, France > 100 kWp solar PV) for determining the support level (feed-in tariff), a certain amount of installed capacity is tendered which means that at a maximum this auctioned capacity can receive support in a given period.

Contracts for Difference in United Kingdom

A Contract for Difference (CfD) is a private law contract between a RES-E generator and the CfD Counterparty – Low Carbon Contracts Company (LCCC), wholly owned by the UK Government. The CfD is based on a difference between the market price and an agreed "strike price". Where a "strike price" is higher than a market price, the CfD Counterparty must pay the RES-E generator the difference between the "strike price" and the market price. Where market price is higher than the "strike price", RES-E generator must pay back the CfD Counterparty the difference between the market price and the "strike price". An operator of eligible RES-E technology, has to take part in an allocation round.

Quota scheme in Belgium

In Belgium, electricity from renewable sources is promoted mainly through a quota system based on certificates trade. In this scheme, the electricity supply chain is obliged by Government to source a certain quota of electricity from renewable sources. Renewable plant operators receive one or several certificates for every unit of electricity they produce. They sell the generated electricity on the regular electricity market where they receive the regular electricity price. In addition, they sell the certificate on the certificates markets where demand is created based on the obligatory quota.

Net-metering, Netherlands and regions of Belgium (Brussels, Flanders, Wallonia)

Net-metering applies to clients who are at the same time producers of electricity, and are connected to the electricity grid. Clients need to apply for an offer from the responsible grid operator for injecting electricity to the grid and are required to pay a grid use charge. For small scale clients, energy taxes only apply to the net electricity consumption.

Tax regulation mechanisms in France, Netherlands and United Kingdom

In the Netherlands, generators of electricity from renewable energy sources that use the electricity they consume (own consumption clause) may be exempt from the tax levied on electricity consumption (Energy tax). Moreover, enterprises are eligible for a tax credit (EIA - Energy Investment Allowance) for investments in renewable energy plants. In France reduced VAT rate applies to services, equipment and delivery of renewable energies (individuals < 3 kWc). Finally in the United Kingdom, The Carbon Price Floor (CPF) is a tax levied on fossil fuels.

Urban planning and construction

Certain provisions in the urban planning laws likewise enable the installation of photovoltaic panels as an option under the objective of reducing GES emissions, within the framework of the Directive on the Energy Performance of Buildings 2010/31 / EU of 19 May 2010.This is the case of the 4 countries analyzed. In France the law called RT 2012 is applied mainly in the construction of new buildings, which must reach a "low consumption buildings" label. This jump will take the path of positive energy buildings in 2020.

Belgium	**France**	**Netherlands**	**United Kingdom**
- Quota scheme with certificate system - Net-metering	- Feed-in tariff - Feed-in premium - Tenders - Tax reduction for installations < 3 kWp managed by individuals - Certificate of energy economy	- Feed-in premium - Net-metering -Tax exemption or imposition to fossil energies	- Feed-in tariff - Tenders (Contracts for Difference) -Tax regulation mechanism (Carbon Price Floor)

EU harmonized Support Schemes

The European Union has been advancing in the harmonization of the European energy sector, however within this process several aspects are still in the hands of national or subnational states and have not yet been subject to certain co-ordinations, such as the promotion of renewable energies. There is no development harmonization policy for solar energy on national territories between south and north and no policy to avoid competition with other land uses such agriculture or biodiversity preservation.

1.2.2. Cost/benefit model for a solar installation investment

The construction of a sustainable economic model for the realization of an investment in a solar photovoltaic project requires considering financial, environmental and legal aspects. To evaluate economic alternatives, one of the most widespread methods is the life-cycle costing (LCC), that accounts for all costs and benefits associated with a system over its lifetime. For larger systems, in order to be able to compare the costs of electricity from different sources, the levelized cost of electricity (LCOE) method has been introduced.

A solar installation may well save money over its lifetime while having a relatively high initial capital cost. In the whole PV life cycle, cost efficiency is determined by the total expenditure and the total income. The life span of solar modules and their wiring is anywhere from 25 to 35 years, and the life span of inverters, charge controllers, and other electronic components can be set at around 7 to 15 years.

Expenditure includes the initial investment in the project, the operation, the maintenance (O&M) cost and the replacement cost in the project cycle. The income is mainly derived from the saved electricity and electricity sales from PVs. In most countries, the government also offers different tax subsidies for PVs. The final profit of the project is obtained by deducting tax and all the costs from the total income. Moreover, in order to be valid, such cost estimates need to specify the interest rate, depreciation period, and other suppositions on which they are estimated. By addition, the level of solar irradiation and the efficiency of the solar cells will have a significant impact on the final balance. Other factors to be brought into play might be: carbon emission and other pollution savings over the lifetime of the project; ethical considerations; co-benefits such as improved air quality and health and energy security or the uncertainty of future fuel costs. At low or middle level of penetration, PVs have a minor impact on the distribution networks. The main consideration in this stage is the benefit from the PV investment. If the benefit is too low to cover costs, customers will directly purchase power from the utilities.

Types of investment costs in a photovoltaic power plant project

PV is a mature, proven technology that has reached the grid parity and that is approaching the electricity wholesale market. PV has made remarkable progress in reducing costs, fundamentally on the side of the solar PV modules. Out of the whole cost system, the capital cost, the cost of finance and efficiency are the most critical and improvements in these parameters provide the largest opportunity for cost reductions (IRENA, 2012). In a simple way, the investment costs of PVs can be divided into four parts: capital cost, O&M cost, replacement and remaining cost, and other cost.

a) Capital cost: refers to the cost needed at the initial stage of project construction, which mainly includes the system components cost and installation cost. Approximate costs of purchasing solar equipment:

- PV-modules account for, on average, 50 % of total system costs.
- DC/AC inverter (typically ~10% of total system price).
- BOS (balance of system) cost is all other hardware to complete the system (cables, substructure).
- Planning and installation of the system.
- All others (financing (ROIC), insurance, O&M, dismantling, etc.).

A typical price for a MW PV system in 2018 is around 1€/W and contains the three items from above. In addition to capital costs, there are also costs related to reforms, purchase of properties. Land purchase costs depend on the economic model of a PV plant and the region and its real estate market, as well as its urban planning. For small (<10 kVa) and for bigger installations - which are integrated in a building – there is a possible cost for renovation. In this case, the type, shape, and condition of the roof is the main parameter that can affect this cost. Installation-build costs depend on the scale and complexity of a project:

- For a small PV installation on a roof, it is between 2000€/kwc and 2600€/kwc
- For a larger PV installation on a roof, it is between 900€/kwc and 1200€/kwc
- For a ground PV plant, it is between 800€/kwc and 900€/kwc
- For a big ground PV on 30ha, it is about 600€/kwc

b) Grid access

In the 4 studied regions and their respective countries, the costs of grid connection are borne by the plant operator which submitted the application for connection. Generally, the cost of this connection depends on several factors: if it is low or high voltage; the installed power of the PV plant; if the producer is also a consumer; if the installation requires a connection reinforcement; among others. In addition, a network fee is also charged in all countries (which adds to the O&M costs). However, there are certain particularities that can influence connection costs. In France the regions establish a Regional Connection Plan for the Renewable Energy Network (S3REnr) for High voltage network, with the idea of guaranteeing and lowering costs for the RES access to grid. In this way, each electric post has a quota reserve capacity for RES. For example in Hauts de France, the defined shared cost is 82240€/MW. In Flanders (Belgium) the difference between the actual costs and the costs calculated on the basis of a virtual connection (the costs of the shortest distance that is available between the installation and the grid) is covered by the grid operator to whose net access is granted as part of its public service obligation. In the Netherlands or Great Britain the costs of the possible adaptations of the network are in charge of the client, although the regulatory framework is in full evolution. The connection to the network is usually a requirement to obtain incentive schemes like the government's Feed-In Tariff.

c) Operation and maintenance (O&M) costs

O&M cost refers to the expenditure needed in the whole life cycle; under normal circumstances, the annual maintenance only takes several hours to clean the dust and dirt from PV modules and check the operating performance of the inverter, cable faults and emergency maintenance and replacement of components. Self-cleaning coatings for panels are available. As such, the O&M cost is mainly the local labor fee. We can distinguish the following cost components: Current, normal operation costs ; Maintenance costs ; Unexpected failures costs.

d) Replacement and remaining cost

The remaining cost is the salvage value of each component which means the remaining value of components at the end of the project This refers to the cost of replacing components after a certain number of years. Inverters are the major component in PV installations that need to be replaced

e) Other costs

Cost reserved for emergencies and it is mainly used to deal with uncertain situations such as tax rate fluctuations, fluctuations of labor costs, and possible distribution network equipment replacement and line reconstruction in the construction process, and so on. End of life costs should also be considered, for recycling and/or dismantling the PV-installation and their physical components.

Business models for grid connected rooftop solar systems

(a) Solar installations owned by consumer: Solar Rooftop facility owned, operated and maintained by the consumer, or operated and maintained by the 3rd party.

(b) Solar installations owned, operated and maintained by 3rd parties. The combinations could be:

- the 3rd party implements the facility on the roof or within the premise of the consumers; the consumer may or may not invest as equity in the facility as mutually agreed between them. The power is then sold to the roof owner.
- the 3rd party implementing the solar facility shall enter into a lease agreement with the consumer for medium to long term basis on rent. The facility is entirely owned by the 3rd party and consumer is not required to make any investment in facility. The power generated is fed into the grid and the roof top owner gets a rent.

(c) Solar Installations owned by the utility: The utility may own, operate and maintain the solar facility and also may opt to sub contract the operation and maintenance activity. The utility may recover the cost in the form of suitable tariff. The electricity generation may also be used by utility for fulfilling the solar renewable purchase obligation.

1.2.3. Risks, barriers and overcoming measures

Risk assessment and allocation is at the center of project financing. Accordingly, project structuring and expected return are directly related to the risk profile of the project. The four main risk factors to consider when investing in renewable energy assets are:

- **Regulatory risks** refer to adverse changes in laws and regulations, unfavorable tariff setting and changes and breaches of contracts.
- **Construction risks** relate to the delayed or costly delivery of an asset, the default of a contracting party, or an engineering/design failure.
- **Financing risks** refer to the inadequate use of debt in the financial structure of an asset. Examples include the abusive use of leverage, exposure to interest rate volatility, and the need to refinance at less favorable terms.
- **Operational risks** include equipment failure, counterparty default, and reduced availability of the primary energy source (such as wind, heat, and insolation).

The level of risk in any case will depend on each project and its region or country. As a region and its operators gain experience in the development of this type of systems and their respective economic models, we can see that the risks tend to be reduced.
However, the scale of the project and its type of financing generate different risk scenarios. In general, large projects managed by large investment funds are often split off from the territories that host them, generating other types of risks for the electricity system if those projects do not respond to sub-regional needs. For this reason, some economic-financial models supported by small enterprises or groups of citizens tend to favour greater resilience of the electricity grid, by promoting the decentralization of production (lower operational risk), and by mobilizing financial structures anchored in trust networks (less financial risk). The emergence of cooperative and associative models in the management of electricity seemed to generate more stable long-term scenarios. Care must be taken in the regional regulatory framework.

In general, several barriers that have prevented penetration of RES, include cost-effectiveness, technical and market barriers such as inconsistent pricing structures, institutional, political and regulatory barriers, and social and environmental barriers. In the countries of 2 seas many of them have been overcome in recent years. Others have changed form. For example in Hauts-de-France, regarding the auction to acquire feed-in tariff made by the CRE (Energy Regulatory Commission) at the national level, the regional particularities are not taken into account. While the French south has the advantage of having greater insolation to accommodate more profitable projects, the north is damaged, and this to the detriment of an advantageous distribution of renewable energies in all regions of Europe. Therefore, Hauts-de-France sees the global national policy of the CRE as a barrier, as a regional policy should permit solar adoption raise.

The so-called environmental or social barriers must be taken with care. In terms of location of a project, a good decision method must incorporate other values besides the economic one, in order to be sure that the net environmental benefit of the project is positive. An example of this is the debate on whether the expansion of renewable energies (including solar) should be made on arable land or even on areas of high environmental value, such as wetlands or water mirrors. In some way, the policy of renewable energies must maintain a deep dialogue with the territorial policy of land use in each region. The final evaluation of a photovoltaic project installed on arable land or in natural areas, should consider in its evaluation the social or environmental loss resulting from the change in land use. At first sight, it is more environmentally advantageous to install photovoltaic power plants on roofs of existing building structures, in order not to alter (generating costs) the current territorial balances.

Different **methods of collecting funds for renewable energy projects** exist :

- Venture capital and private equity (vC/Pe)
- Publicly quoted companies
- Asset finance, which includes funds from equity, loans, and corporate balance sheets (but excludes refinancing)
- Mergers and acquisitions, where new corporate buyers take over the existing equity and debt of companies developing and/or operating renewable energy projects.
- Citizen investment funds and Cooperatives

1.2.4. CO2 offsetting for a PV-installation lifecycle

Carbon offsetting is the counteracting of carbon dioxide or other greenhouse gas emissions from one activity with an equivalent reduction of emissions to the atmosphere elsewhere. It is a controversial but sometimes useful practice. Carbon offsetting projects may include the prevention of emissions by energy efficiency activities, the installation of renewable energy generators, the planting of trees or the use of any means to absorb and safely and permanently sequester carbon dioxide from the atmosphere.

The energy generated by a solar project over a period of time can be estimated and claimed to offset the equivalent amount of energy from a fossil fuel source that it might displace or prevent the use of. It will then have saved the emissions equivalent to those arising from burning that amount of fuel – depending upon the fuel chosen. Different fuels emit differing amounts of greenhouse gases when burnt, per unit of energy generated. The greenhouse gas conversion factor is quoted as kgCO2e per unit of fuel consumed. If the fuel is electricity the conversion factor varies according to the generation technology mix (the amount of coal, gas, nuclear, renewables and oil) in the local grid. The benefit has been estimated at €12/MWh in Europe, compared with €23/MWh at the global scale, based on a global average GHG emission factor from electricity production of 0.6 kgCO2/kWh. This includes 12–25gCO2/kWh emitted from the PV lifecycle and assumes a CO2 abatement cost of €20/tCO2.

This estimate is conservative because the cost of CO_2 abatement in fossil fuel power plants is likely to be well above €20/tCO_2 in the long term. Other cost benefits that are external to a solar project include: the reduction of grid losses due to distributed generation (on the order of €5/MWh); the positive impact on energy security (€15–30/MWh, depending on fossil fuel prices) and on electricity demand peaks (i.e. peak shaving), thus reducing the need for additional peak capacity (€10/MWh).

Likewise it should be included in the analysis that many toxic chemicals are used during the manufacture of PV cells, and this also includes emissions, in addition to transport to the place of installation.
At final decommissioning, modules should be sent to specialist waste treatment;

The results are also presented in a visual form, see FS02 in Annex2.

1.3. FS03 Solar thermal and Hybrid PV/T systems

Solar Photovoltaic (PV) panels convert sunlight directly into direct current by using semiconductors. When sunlight hits the semiconductor material within the PV cell, it frees electrons causing a potential difference and a flow of current. The solar PV cells, depending on the material's range, absorb only part of the spectrum and dissipate the rest as heat energy. It is known that temperature increases can cause a thermal degradation in the panel due to thermal stresses, leading the panel to underperform and have a lower life cycle.

Thus, the combination of photovoltaic and solar thermal technologies (PV/T) is considered an appealing concept which can be utilized to increase the performance of a solar system. This excess heat is extracted for water heating, space heating etc. The combination of these two renewable energy technologies creates a unique opportunity for low carbon electricity and heat from the same source, making most efficient use of the surface area of the panels. The systems work typically between 40°C to 50°C, making them suitable for low temperature heating systems operating at the given temperature range. During summer, when the panels operate at peak conditions, temperatures can go up to 80°C which makes them apt for hot water applications as well.

Solar energy harvesting is experiencing a fast evolution since the last few years. Current PV panels can only produce electricity from a restrained part of the solar spectrum, typically 350 to 1200 nm. On the other hand, other systems such as thermal collectors can harvest the heat contained in the infrared part of the solar spectrum.

Figure 7 Photovoltaic modules (left) and a thermosiphon thermal collector (right)

However, in mono and polycrystalline silicon PV modules, the unused infrared irradiation is converted into heat, which causes the electrical efficiency of solar cells to drop by approx. -0.4% per °C temperature rise above 25 °C. In addition, the two collectors cannot be stacked on top of each other in order to harvest both electrical and thermal energy. Recently, photovoltaic/thermal (PV/T) harvesting technologies became the subject of more and more research works. Hybrid PV/T systems simultaneously produce thermal and electrical power, thus harvesting energy from a wider range of the solar spectrum on the same surface. Electrical power is produced by solar cells, and the wasted heat from the solar cells is extracted using a thermal collector filled with a heat transfer fluid, either a liquid or a gas.

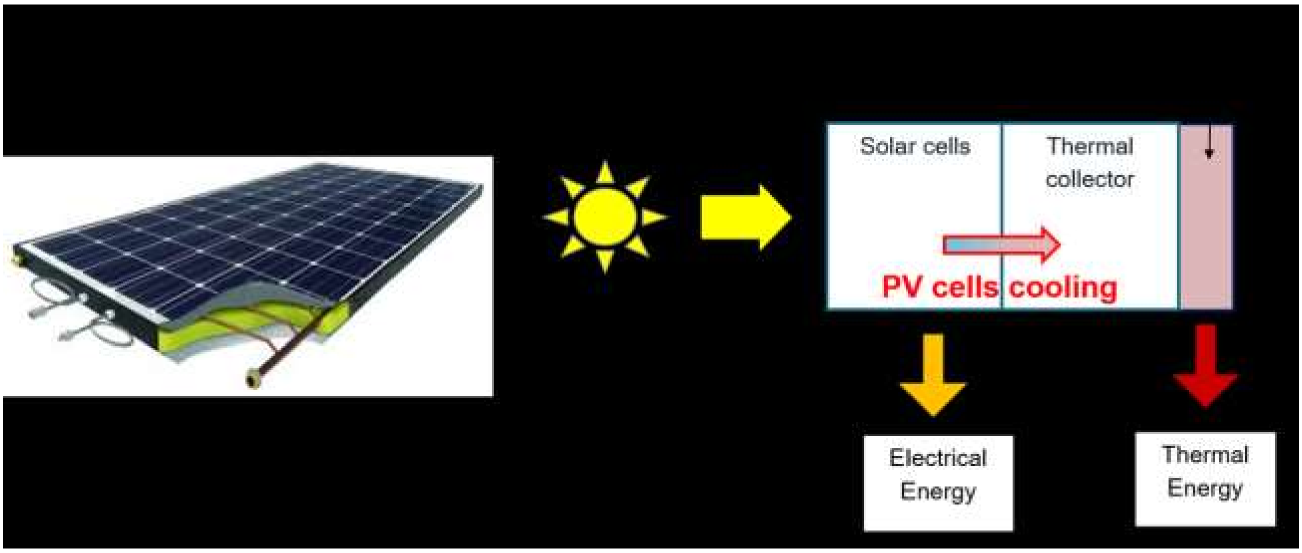


Figure 8 Basic working principle of a PV/T collector

Yet, even if PV/T technologies has been researched since many years, they are still very little in use the 2 Seas region, and manufacturers are still rare. Since the energy sector will continue to integrate more and more renewables, and since heat represents a large part of the final use of energy in domestic and industrial sectors, there is a great potential for PV/T to be developed and integrated in various contexts in the future decades.

Any hybrid PV/T system is composed of three main elements: the solar cells (PV laminate), a heat exchanger with one or multiple fluid channels and a heat extraction fluid. To these elements can be added optionally a concentrating system and a glazing layer. PV/T systems can be classified by the nature heat extracting fluid, the system configuration and design, the type of solar input, as seen on figure below.

The PV cells commonly used in PV/T systems are the typical mono- and poly-crystalline silicon cells. Both can be used equally regarding thermal performances. Typical crystalline silicon cells can absorb incident light from 350 to 1200 nm (with a maximum sensitivity between 850 and 950 nm) in a temperature range of -40 to +85°C. The electrical efficiency (PCE) does not exceed 18 %. In certain cases, amorphous silicon can also be used. Most of the PV/T modules have a flat, layered structure, the so-called PV/T panels. The PV/T modules can use as heat transfer fluid: air, water or a refrigerant.

Solar thermal systems are commonly used/applied in southern Europe with favorable temperature conditions all year. The hybrid PV/T systems are not very common in EU-countries despite their advantages with respect to the PV-installations. In the table below, a brief SWOT analysis of the PV/T panels is made.

Strengths	**Weaknesses**
• Simultaneous, direct thermal and electrical power • Better PV performance due to fluid cooling • Suitable for users with increased thermal needs	• Higher price (W/m2) than PV+T • Heavier than PV panels • Thermal/electrical power ratio is not adaptable
Opportunities	**Threats**
• New state-of-the-art technologies	• Few manufacturers on the market

• EU 1 m2 solar thermal per capita to be reached • Consumers are more interested to directly use thermal energy (easy to store as warm water)	• Bad examples (not performing systems/tech) heavier than PV panels

1.4. FS04 Innovative solar technologies

We can state from the beginning the innovative state-of-the-arte solar technologies are becoming state-of-the-practice after just a few years. For most of the current solar energy installations we can distinguish between the following types of installations:

- Solar photovoltaic PV installations
- Solar collectors installations
- Installations with hybrid PV/T panels

From the point of view of the location of these types of installations they can be:

- solar energy harvesting installations **on buildings**, either roof-top installations or integrated into other parts of the buildings. Most the rooftop installations are on residential building roofs, followed at some distance by agricultural roofs and commercial real estate roofs or facades. Experiments are being conducted with larger scale applications on public buildings facades, but this is not yet a mature application.
- solar energy harvesting installations **on land**. The used land is either agricultural land, a booming and much in the news sector or waste land where no agriculture can be developed. For the use of agricultural land for only the purpose of solar energy production a noticeable social resistance against this segment has emerged since the local and national authorities, governments and local residents are reluctant to sacrifice agricultural land, nature reserves or recreational areas for solely energy production within a solar PV-farm. Therefore recent efforts focus on dual use of of space (eg. agricultural use *and* energy generation, or landscape architecture *and* energy generation). Somehow, the combination of agriculture with solar energy harvesting, agro-voltaics is more appealing to stakeholders and seems to get a start ahead.
- solar energy harvesting installations **on water**. Floating PV installations on water (either still inland water surfaces or open sea installations) are a segment of very recent date with some more success for the installations on the still, inland water surfaces. This segment is enjoying growing interest from PV project developers, particularly because of the problems of the developers in finding a suitable piece of (agricultural) land and the existence of many suitable still water surfaces that can be taken in usage without special problems.
- solar energy harvesting installations **on or integrated into public infrastructure**, like bridges, roads, dikes. Most of these installations are pure PV-installations and it is the smallest segment of the solar energy installations.

Does not matter where and how the solar energy harvesting installations are going to be integrated in our daily life, intense R&D efforts are made to improve the performances of existing solar energy harvesters and come out with new innovations. However, many of the innovations presented below are not yet commercially available, but it is expected that they will be in the near future.

1.4.1. Innovations related to PV-cells and modules (materials, production, …)

In the long term road maps for the future development of PV technology a very optimistic, technological breakthrough scenario has been proposed: the growth of world PV technology will increase in a quadratic fashion to reach almost 9000 GW by 2050. This implies that by the middle of the 2030s several energy storage systems (e.g. Hydrogen Gas, pumped hydroelectric, compressed air energy storage and efficient high-speed flywheel systems) and the infrastructure required to enable the storage of mass PV energy in these storage systems will be developed. The scenario is dominated by the expected expansion of PV systems following development of new technologies and materials post 2025. These technologies and materials are expected to constitute approximately 50% of the total PV market by 2050. To ensure PV moves from a limited share (3% of world electricity generation in 2025) to a major energy source provider in 2050, the PV sector will require the realization and diffusion of new PV materials and devices, and high increases in efficiency and lifetime for all PV technologies" .

Still now, many efforts are put into lowering the costs of the PV-cells and modules since it is expected that PV-based technologies these will remain the main share in the solar energy harvesting technologies, while solar collectors and hybrid PV/T will be less prominent. Despite technology maturity, there is no general consensus on the future of PV technology as there are obstacles to its implementation.

Technical barriers include factors like long lived fossil power plants, unfavorable pricing rules, supply of raw materials, land availability and geographical constraints. Other factors that must be considered to assess possible future cost and environmental performance scenarios for solar PV technologies are cost reduction at cell and module level, increase of efficiency, integration into buildings and integration with energy storage technologies.

Overview of solar PV cell technologies.

PV Cell Technology	Band-gap [eV]	Manufacturing Processes	Efficiency Record [%]	Record Holder/Yr. [Country]	Market Share
Crystalline Silicon					
Mono-crystalline	1.11	Cz-Si, float-zone, HIT	27.6 (26.1)*	Amonix/2005 [US] (ISFH/2018 [DE])	24%
Poly-crystalline	1.11	BCG, block-casting	22.3	FhG-ISE/2017 [DE]	69%
HIT	1.11	Deposition	26.6	Kaneka/2016 [JP]	< 1%
Micro	1.11	PECVD, HWCVD	21.2	Solexel/2014 [US]	
Thin-film					
CIGS	1.7	scr. print, coat, MOCVD	23.3 (22.9)*	NREL/2014 [US] (Solar Frontier/2018 [JP])	< 2%
CdTe	1.5	sputter., HVE, MOCVD	22.1	First Solar/2015 [US]	3%
Amorphous Si:H	1.5–1.8	PECVD	14	AIST/2016 [JP]	3%
GaAs	1.42	VGF, HST, LEC, MOCVD	30.5 (29.1)*	NREL/2018 [US] (Alta devices/2019 [DE])	Non cml.
Multi-junction	multiple	MOCVD, mech.-stacking	46	FhG-ISE/Soitec/2015 [DE/FR]	
Emerging					
Organic	1–4	Roll-to-roll mfg.	15.6	SCUT-CSU/2018 [CN]	
Dye-sensitized	~3.2	Roll-printing	11.9	Sharp/2012 [JP]	
Perovskite	~1.5	spin-coat, scr. print, VD	28 (24.2)*	Oxford PV/2019 [UK] (KRICT-MIT/2019 [KR-US])	

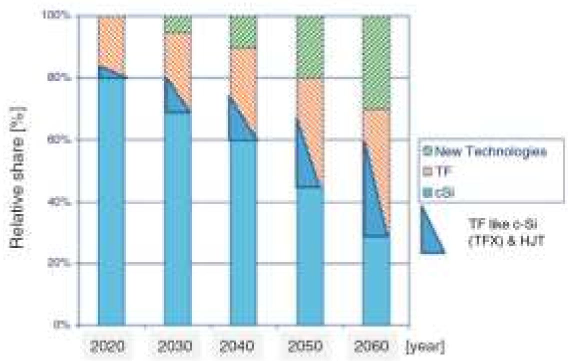


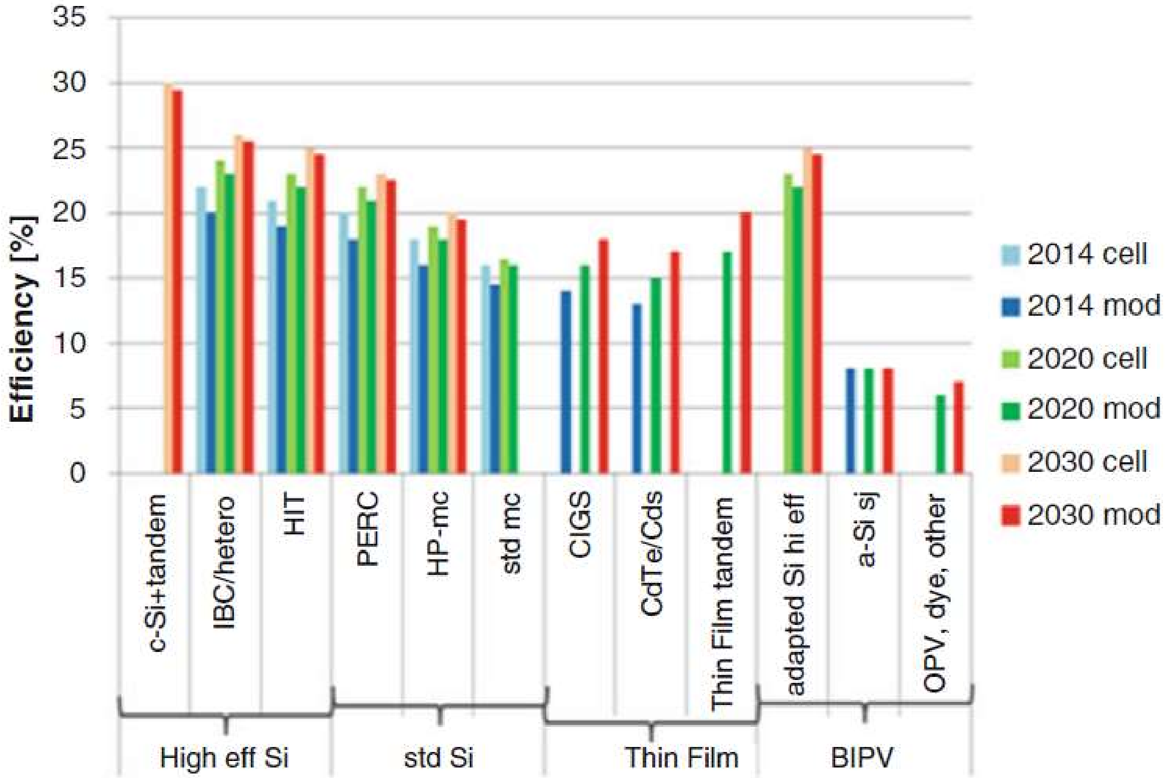
Figure 9 Relative market share for various cell and module technologies

Very recent data and predictions of the future PV-harvesting technologies (see also figures above) suggest that from the new technologies for the PV-harvesters we can retain as the most promising technologies:

- **High-efficiency silicon technologies**
  - Heterojunction cells (HIT)
  - Interdigitated back contact (IBC) and HIT back contact cells
  - Future silicon wafer plus tandem thin-film cells
- **Standard silicon technologies (cSi)**

– Standard multicrystalline cells
– High-performance multicrystalline cells
– PERC (passivated emitter rear contact) cells

- **Thin film (TF) technologies**
  – CIGS (copper indium gallium selenide)
  – CdTe/CdS
  – Thin-film tandem
- **Building-integrated products (BIPV)**
  – Adapted silicon cells (and also adapted thin film)
  – Amorphous silicon
  – OPV, dye, and others



Among the most promising innovations we can summarize:

1. **<u>Bifacial solar cells</u>** that are designed to allow light to enter from both sides. The front design is typically a standard one, with the main difference being the structure of the rear surface contact, where a 'finger' grid is employed to capture rear radiation. The silicon material used for bifacial solar cells must be of superior quality and transparent encapsulating materials are required on the both sides of module. Historically, bifacial solar cells were targeted towards BIPV applications or in areas where much of the available solar energy is diffuse sunlight which has bounced off the ground and surrounding objects, including extreme latitudes and snow-prone regions. This 'double-peak' profile can better match onsite electricity use, especially for residential and commercial installations. This unconventional approach can go

one step further if east-west-facing bifacial modules are vertically installed, which would produce two generation peaks, but would also benefit from the additional diffuse light entering the module from the indirect side.

2.

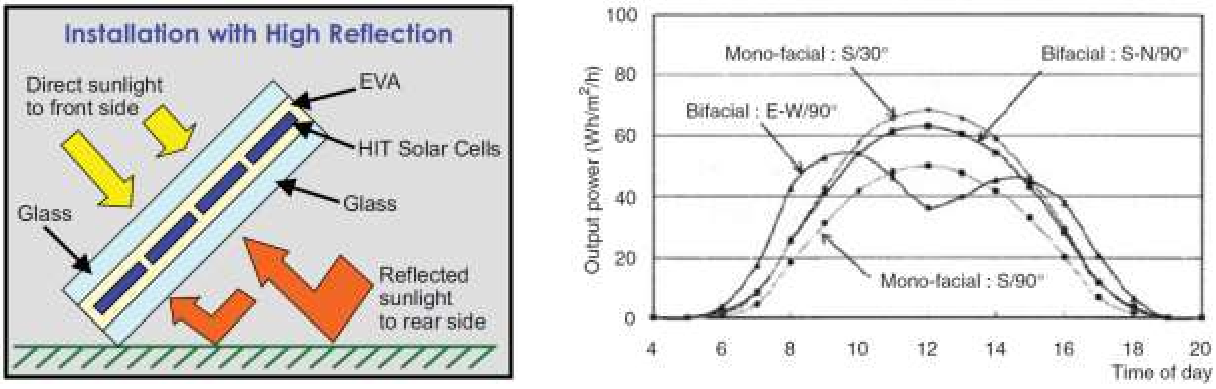


Figure 10 Simulation results: daily generated power distribution of vertically installed bi- and mono-facial modules

3. **CSP or CSTP(Concentrated Solar Power)** By concentrating solar radiation a source of heat is provided to generate a hot fluid for a downstream energy conversion process. This can be used to produce electricity, solar fuels or directly use process heat for industry or for chemical applications. The fundamental part of the technology is the solar collector, the most common types being parabolic trough, linear Fresnel, central receiver and paraboloidal dishes. The majority of existing plants are parabolic troughs using oil to generate steam for steam turbines. Presently, however, there is a strong emerging interest in central receivers (power towers) due to their ability to produce much higher temperatures at higher efficiency power cycles, and ultimately lower cost. The key for concentrating solar power lies in its ability to incorporate thermal storage and thus provide dispatchable solar power, which will also benefit the penetration of other renewables such as photovoltaic and wind. It is likely that the future for concentrating solar power will involve more high efficiency power cycles and high temperature storage for electricity generation, and solar fuels for transport and industry. Solar energy harvesting systems that concentrate the solar radiation to produce sufficient heat at the required temperature for electricity generation from heat engines are called concentrated (or concentrating) solar thermal power (CSTP, or CSP without the word 'thermal'). Concentration can also benefit electricity generation from photovoltaic modules in locations that are usually cloud-free, so it may distinguish between CSTP (concentrating solar thermal power) and CSPP (concentrating solar photovoltaic power), although these abbreviations are not common.

1.5. FS05 Smart grids associated with solar energy

Based on D.1.3.1, report that describes cutting edge technologies and the current situation in the 2Seas region, together with the SWOT analysis regarding smart grids (components: inverters, meters, actuators, thermal/electric storage and energy management systems) and integration of solar systems in smart grids..

1.5.1. What is a smart grid in the context of solar energy?

The electric grid which includes two way communications, new measurement and metering devices as well as modern software and IT, as compared to traditional grid is known as smart grid. Smart grids detect local changes in power usage and reacts automatically without the need of human intervention. It allows two-way communication between grid and consumers. It allows real time communication between consumer and utility so that consumers can tailor their energy consumption based on individual preferences such as price and/or environmental concerns. Smart grid is developed using modern digital communication technologies.

<u>SG characteristics:</u>

- *Adaptive and self-healing*: SG has less reliance on operators, particularly in responding rapidly to changing conditions and it has the capability of automatically repair or remove potentially faulty equipment from service before it fails, and has the ability of reconfiguring the system in such a way to ensure continuity of the energy to all customers.
- *Flexible:* SG has the ability to rapid and safe interconnection of distributed generation and energy storage at any point on the system at any time.
- *Predictive:* SG has the ability to apply operational data to equipment maintenance practices and even identify potential outages before they occur.
- *Integrated:* It is an important characteristic in terms of real-time communications and control functions.
- *Interactive:* SG is capable of providing appropriate information regarding the status of the system not only to the operators, but also to the customers, that is, both consumers and prosumers, to allow all key participants in the energy system to play an active role in optimal management of contingencies and also to facilitate the interaction between customers and markets.
- *Optimized:* This can be achieved by knowing the status of every major component in real or near real time and having control equipment to provide optional routing paths that provide the capability for autonomous optimization of the flow of electricity throughout the system with the aim of maximizing reliability, availability, efficiency, and economic performance.

1.5.2. What are the SG main benefits and drawbacks (related to solar energy projects)?

Following are the benefits or advantages of Smart Grid:

- It reduces electricity theft.
- It reduces electricity losses (transmission, distribution etc.)
- It reduces electricity cost, meter reading cost, T&M operations and maintenance costs etc.
- It reduces equipment failures due to automatic operation based on varying load conditions. Demand-Response reduces stress on assets of smart grid system during peak conditions which reduces their probability of failure.
- It reduces sustained outages and reduces consecutively associated restoration cost.
- It reduces air emissions of CO_2, SOx, NOx and PM-2.5. Hence smart grid contributes to keep environment green.
- It reduces oil usage and wide scale black-outs. Hence, smart grid provides security to the people by providing continuous power.
- Smart grid is capable of meeting increased consumer demand without adding infrastructure.

The following are the drawbacks or disadvantages of Smart Grid:

- Communication network should be continuously available.
- During an emergency situation, network congestion or performance are important challenges in smart grid system.
- Cellular network providers do not provide guaranteed service in abnormal situations such as wind storm, heavy rain and lightning conditions.
- Some smart meters or other network connected items could in theory be hacked introducing false data into the system.
- It is expensive to install smart meters as compared to traditional old electricity meter.

1.5.3. What are main key-technologies for smart grids: definitions/explanations?

Communications and Networking:

The SG introduces a bi-directional exchange of information and energy between producers and consumers. It is defined as the union of a telecommunication network and an electricity distribution system, which allows management of the electrical distribution grid in a smart way, trying to minimize the perturbations, and the deviation of the voltage from its nominal value. Furthermore, the SG aims to increase the integration of renewable power generators, trying to overcome the problems of distributed generation and allowing the users to play a more active role in grid management. We can talk about ICT integration, a communication infrastructure that consists of public networks, such as the Internet, cable, cellular or telephone and private utility communication networks, such as meter mesh networks, radio networks, etc. This communication system enables a bi-directional exchange of data between users and grid operators to overcome or attenuate the problems relating to distributed generation, through automation of the control of generation and demand.

Advanced Metering Infrastructure (AMI):

An AMI is an integration of several technologies that provides an intelligent connection between consumers and system operators. It facilitates the supply to consumers with the necessary information they need to make intelligent decisions, the ability to execute those decisions and a variety of choices leading to substantial benefits they do not enjoy under conventional electrical network environment. Additionally, AMI enables system operators to greatly improve consumer service by refining utility operating and asset management processes based on the data provided by AMI. The three main components of AMI systems are smart meters, communication network and data reception and management system.

Microgrids:

Given the role that microgrids play in enabling utilities to gradually introduce smart grid technologies into their distribution system, one could recognize the need for controlled interconnection of microgrids into a much larger system, commonly called supergrid. In this regard, each microgrid is assumed capable of managing its own loads based requirements (synchronization, protection, power quality, etc.) with the larger grid. Here one needs to emphasize the term interconnection rather than integration as each microgrid is empowered to determine its own degree of centralized control and management in response to external stimuli by following its own set of operational objectives and requirements. From a size-agnostic point of view, one could see three different types of microgrids emerging today: Urban microgrids, Remote microgrids and Agile microgrids (temporary microgrids).

Demand response and real time pricing:

Considering the operational and economic challenges that the utilities are facing, the industry has begun looking beyond current technologies toward a future in which such issues would be resolved. In the smart grid of the future, generation will not follow consumption (as is the case today). In other words, when demand rises, the preferred solution would not be more generation. Rather, the utility will look at gaining more efficiency with their existing assets (i.e., minimizing losses), managing end-user demand (i.e., load control), and partnering with consumers to roll back the load (i.e., conservation). All of these approaches will ensure that consumption follows generation. The smart grid of the future will be able to optimize the use of its assets, reduce losses, curtail unnecessary load, and ensure sustainable rationality between what could be economically generated and the load that has to be serviced.

Active network management:

Wide-area monitoring and control has as its main function the real-time monitoring and it also makes it possible to show the performance of power system elements over wide geographic areas, in order to help the network operators to optimize the use of power system components. These technologies, together with advanced tools, such as wide-area adaptive protection, wide-area monitoring systems and wide-area situational awareness, control and automation, improve reliability and transmission capacity, provide information to system operators and attenuate wide-area disturbances.

Many components can improve the behaviour of the transmission system. Some of these components are the FACTS, which are able to optimize the power transfer capability and the control of the transmission system. There are also the high-voltage direct current lines (HVDC), which are able to connect areas separated by many kilometers, or to connect large off-shore wind farms and solar plants with the transmission grid. Another important component is the DLR (dynamic line rating), which is a system that identifies the real-time current transport capability of sections of grid, increasing the exploitation of transmission assets. Finally, there are high-temperature superconductors, which can reduce power losses and limit current faults.

The electrical vehicle charging infrastructure manages the charging of electrical vehicles connected to the grid during low energy demand. In the long term, new functionalities will be implemented, such as the participation of batteries in the network regulation, provision of capacity reserve and peak-load shaving.

The customer-side systems encompass energy management systems, smart appliances,

distributed generation and energy storage devices, with which it is possible to manage the electrical consumption at the residential, service and industrial levels.

Electrical energy storage (EES) systems:

Electrical energy storage (EES) systems have been used in conventional systems for

- reducing the electricity costs by storing electricity obtained during off-peak load at which the electricity price is low, to be used during peak load times instead of buying electricity whose prices then are high,
- improving the reliability of the power supply, whereby EES systems support users when, for example, an electrical network is subjected to disruption due to natural disasters,
- maintaining and improving power quality, frequency, and voltage.

Therefore it is expected that the (dispersed) EES systems will play an important role in solving problems related, for example, to excessive power fluctuation and unstable power supply which are particularly associated with the high penetration of renewable energy-based generation. EES systems are also expected to play significant role in the off-grid domain, that is, transport and mobility.

Demand side management (DSM) is another area of importance for EES. The aim is to reduce peak demand and optimize off-peak usage. By combing EES and demand side, whereby the ‘‘storage’’ operates from the supply side while the demand side operates from the ‘‘DSM’’ could potentially lead to operate generation plants (both traditional and renewable) in a more cost-effective way.

1.5.4. What is actual situation related to R&D and application of SG in 2seas countries?

France – with a penetration rate of 25% in 2017 – the metering roll-out is envisaged to finish in 2021, totalling 35 million units installed. However, the national protection authority has raised a concern over the usage of the collected data and consumer privacy, which is holding up deployment.

Reforming the regulatory framework to incentivise spending on digital grid infrastructure will be a key factor in speeding up investment. The clean energy package proposals made by the European Commission in late 2016 emphasize the need for output-based incentive regimes for distribution operators, which would reward spending that reduces the need for more costly capital investments that would normally be recovered through the regulated portion of retail electricity tariffs. In late 2017, the European Council agreed on a directive setting out common rules to ensure more dynamic electricity price contracts to customers, among other regulations pertaining to the internal electricity market in Europe, and specific rules for smart meter roll-outs. These contracts, along with the smart meters, are essential in allowing consumers to participate in demand response programmes.

Finally, spending on EV charging facilities, which are connected to the distribution system, held steady at USD 3 billion. Some regulators are increasingly facilitating and promoting the installation of charging stations by utilities. In California, the Public Utilities Commission announced that it would invest nearly USD 750 million in transport electrification across the state, as part of the 2030 goal for clean air and greenhouse gas reduction. Meanwhile, new spending plans are emerging from a number of private actors in markets where the regulatory framework supports such development.

Photovoltaics (PV) is by far the world's fastest-growing electricity generation technology. PV provides clean electricity for a variety of uses ranging from small portable devices (e.g. mobile phones, portable computers) to buildings, public urban spaces and rural communities. As a consequence, PV has become the paradigm for "Distributed Generation" (DG), a term for which no consistent definition exists although it is generally considered as "electric power generation units connected directly to the distribution network or connected to the network on the customer site of the meter". The presence of Distributed Generation is one of the defining characteristics of Smart Grids. As SOLARISE installations will involve PV technology connected to the grid, it can be inferred that these installations will become instances of Distributed Generation in their respective local grids. Moreover, the use of smart inverters to convert the DC power produced by the PV panels to AC which can be interfaced to the local grid is another application of Smart Grid technologies. Some SOLARISE installations will also involve the use of smart batteries which will store energy produced by the PV panels, to be use at a later time, and this represents another instance where Smart Grid technologies will be used in this project. Smart meters will be employed in some of the installations to meter the export of energy from the installation to the local grid.

A visual representation of the Solarise findings can be found in FS04 see Annex2.

1.6. FS06 Guidelines for benchmarking and pilots

Based on the developed survey and the analysis of the database entries to result in guidelines for developing benchmarks and pilots within and beyond the lifespan of the project. The guidelines will account for the specific conditions in each participant country.

The term "benchmarking" is frequently used to refer to the comparison of the energy performance of a building with that of similar buildings. In our case, the purpose of benchmarking is to provide decision makers with the relative energy performance level of an entire solar installation by comparing its energy performance indicators with preset benchmarks. Benchmarking identifies "where you are" but not why; ideally, it would be more action-oriented in nature [1].

1.6.1. What is the needed information in order to develop a reliable solar energy database to be used for defining benchmarking and pilots?

A reliable solar energy database containing data about existent solar energy installations in the EU, even beyond the 2Seas region is needed to support the Solarise benchmarking and pilots. The main information below has to be obtained from trustable sources, be anonymized and still able to preserve some characteristics that make it country/region specific.

1. Name of the project
2. Start year of operation
3. Address of the project
4. Type (Houses / Commercial / Industrial building / Residential Building / Public building / Solar farm)
5. Installation Type (Rooftop flat / Rooftop inclined / Wall / Ground)
6. Orientation of the collectors' surface (South / South –West / South-East / Other)
7. Inclination of collectors
8. Type of ownership (Energy Community (NGO) / Private / Public / other)
9. Total installed power in (kW)
10. Total (ground plane) surface of the installation (m^2)
11. Number of collectors
12. Surface area of collectors (m^2)
13. Number of inverters and total power (kW)
14. Annual energy production –estimated, average (kWh per year)
15. Annual energy production during first operation year (kWh per year)
16. Percentage of self/auto-consumption of energy and percentage going to the grid
17. Storage Capacity (kWh)
18. Historical building (Yes /No)
19. Main use of the produced energy (eg. lighting, battery charging, …)
20. How is the produced energy measured /accounted in the energy bills (Net metering or Smart metering)

21. Type of solar inverters (Central Inverter, 1 for all the panels / String Inverters, 1 per string of panels with or without DC optimizers / Micro – Inverters, 1 micro-inverter per panel)
22. Does the installation have data logging equipment? (No / Yes but it is not available for third parties / Yes and it is public or can be made available upon request)
23. Initial Costs of the installation (EUR)
    - 23.1 Solar PV installation
    - 23.2 Renovation of building roofing/walls
    - 23.3 Land costs
    - 23.4 Grid connection costs
    - 23.5 Other costs
24. Operation and management (O&M) and annual costs during first year and base year (EUR)
    - 24.1 Annual Grid-related costs (transport & other)
    - 24.2 Annual Maintenance and planned replacements
    - 24.3 Annual Unexpected costs (please specify)
25. Subsidies and revenues (EUR)
    - 25.1 Subsidies at installation
    - 25.2 Other incentives and subsidies (cumulative since operation date)
    - 25.3 Revenues (cumulative since operation date)
26. What problems out of the following have been faced and how have they been solved
    - 26.1 Administrative procedures
    - 26.2 Legal issues
    - 26.3 Finance
    - 26.4 Technology
    - 26.5 Maintenance
    - 26.6 Social aspects
    - 26.7 Other
27. Future plans in expansion of PV per year for this project (kWp)
28. Web link for the project
29. Photo/layout of installation

The needed information to develop a reliable solar energy database are also summarized in Table 1.

Table 1. The needed information to develop a solar energy database

Parameter	**Possible choices (if exist)**
Year and month of installation	
Name of the project	
Location of the project (address, city)	
Country	
Type of building	House/ commercial or industrial/ solar farm/ public/ residential

Type of installation	Photovoltaic only/ Solar Thermal only/ Concentrated Solar Power (CSP)/ Building-integrated photovoltaic (BIPV)
Installation	Rooftop flat/ Rooftop inclined/ wall/ other
Installation extra information	
Orientation of collectors surface	
Inclination of collectors	
Type of ownership	Energy community/ private/ public/ other
Type of ownership extra information	
General specifications of the installation	[Total installed power in (kW)]
General specifications of the installation	[Total (ground plane) surface of the installation (in m2)]
General specifications of the installation	[Number of collectors]
General specifications of the installation	[Surface of the collector (m2)]
General specifications of the installation	[Number of inverters]
General specifications of the installation	[Annual energy production in 2017 (kWh per year)]
General specifications of the installation	[Annual energy production during first operation year (kWh/year)]
General specifications of the installation	[Percentage of auto-consumption (100% if not connected to the grid)]
General specifications of the installation	[Electricity Capacity of Storage if any (in kWh)]
General specifications of the installation	[Thermal Capacity of Storage if any (in L)]
In case of building, is it historical?	
What is the main use of produced energy?	
Energy metering? How is the produced energy measured/accounted in the energy bills?	
Energy metering? How is the produced energy is measured /accounted in the energy bills? More info	
Type of solar inverters	Central/ string
More info Type of solar inverters	
Does the installation have data logging equipment?	
More info data logging equipment	
O&M annual costs (EUR)	[Grid-related costs (transport & other)][First year]
O&M annual costs (EUR)	[Grid-related costs (transport & other)][2017]
O&M annual costs (EUR)	[Maintenance and planned replacements][First year]
O&M annual costs (EUR)	[Maintenance and planned replacements][2017]
O&M annual costs (EUR)	[Unexpected costs (please specify)][First year]
O&M annual costs (EUR)	[Unexpected costs (please specify)][2017]
Initial Costs of the installation (in Euro)	[Solar installation]
Initial Costs of the installation (in Euro)	[Renovation of building roofing/walls]
Initial Costs of the installation (in Euro)	[Land costs]
Initial Costs of the installation (in Euro)	[Grid connection]

Initial Costs of the installation (in Euro)	[Other costs]
Subsidies and revenues (in Euro)	[Subsidies at installation][Subsidies & revenues]
Subsidies and revenues (in Euro)	[Other incentives and subsidies (cumulative since operation date)][Subsidies & revenues]
Subsidies and revenues (in Euro)	[Revenues (cumulative since operation date)][Subsidies & revenues]
Barriers / Best Practices.	[Administrative procedures][What problems do/did you face?]
Barriers / Best Practices.	[Administrative procedures][How will /did you solve it?]
Barriers / Best Practices.	[Legal issues][What problems do/did you face?]
Barriers / Best Practices.	[Legal issues][How will /did you solve it?]
Barriers / Best Practices.	[Finance][What problems do/did you face?]
Barriers / Best Practices.	[Finance][How will /did you solve it?]
Barriers / Best Practices.	[Technology][What problems do/did you face?]
Barriers / Best Practices.	[Technology][How will /did you solve it ?]
Barriers / Best Practices.	[Maintenance] [What problems do/did you face?]
Barriers / Best Practices.	[Maintenance] [How will /did you solve it?]
Barriers / Best Practices.	[Social aspects] [What problems do/did you face?]
Barriers / Best Practices.	[Social aspects] [How will /did you solve it?]
Barriers / Best Practices.	[Other][What problems do/did you face?]
Barriers / Best Practices.	[Other][How will /did you solve it?]
Future plans	[Expand with (m2).... by (year) ....][Future Plans]
Future plans	[Dismantle with (m2) .... By (year) ....][Future Plans]
Future plans	[No changes planned][Future Plans]
Document with any additional information (plan, layout, photos, business model, flyer, contact...) about your installation	
Contact information	[Contact Person]
Contact information	
Contact information	[Web link to the project]

1.6.2. Why is it important to have this static survey?

This survey provides dataset for use by citizens, financiers, developers and site operators of solar energy conversion systems, and ultimately reduces deployment cost. Performance guarantees of solar energy conversion systems are based on the available solar systems [2].

Also we can mention that:

- Survey data helps in making better decisions for future installations
- It helps in finding issues that restrict growth
- It helps in solving problems
- It helps to understand the performance of existing installations
- It helps to improve the various processes of installations

- It helps in retrofitting new equipment to existing installations
- It helps in the optimization of future installations (e.g. avoiding oversizing or undersizing)

1.6.3. What do the analysis of the survey entries provided (or will provide) for the development of the Solarise installations?

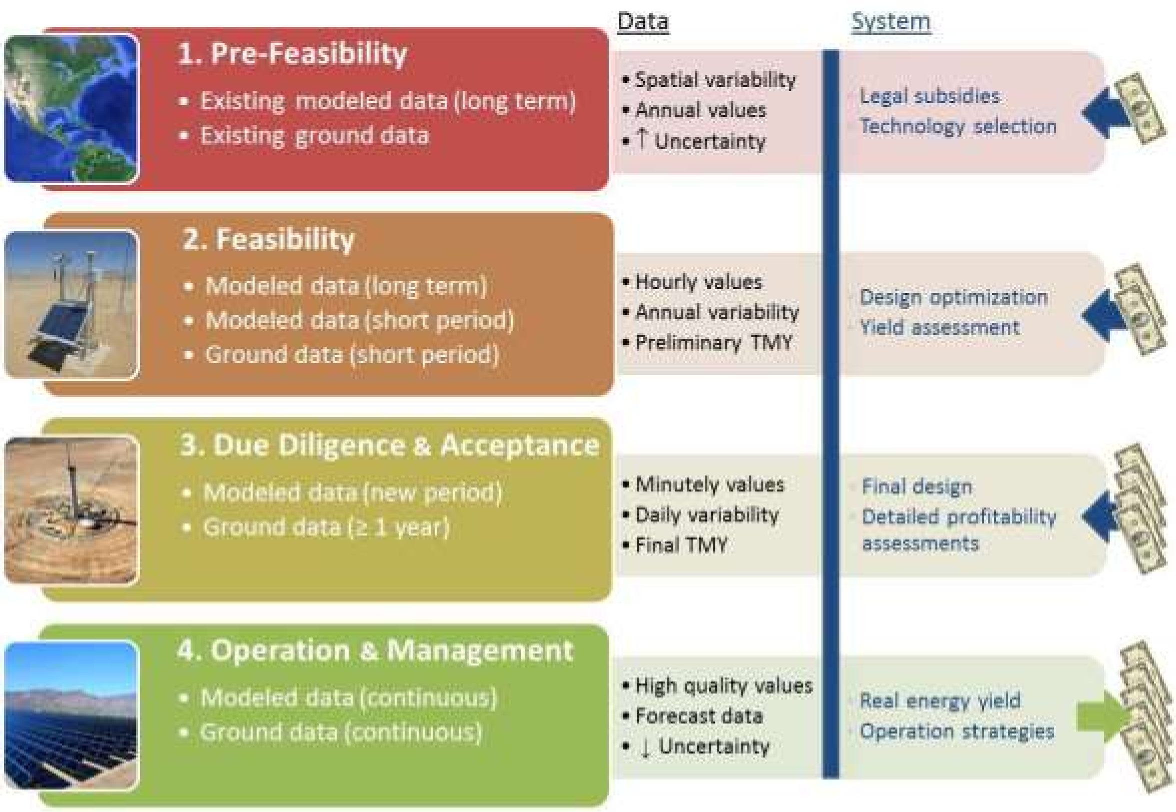
The results of this survey can provide an idea to the local, regional actors about the solar capacity in the two seas region. They can also be used for a post performances evaluation of the SOLARISE installations.

This tool will also allow overcoming a major technical barrier towards increasing the use of solar energy in the two seas region. It is critically important to the citizens, developers, investors, lenders and policy makers to have a suitable and appropriate decision making tool. Additionally, it may trigger large variation towards the use of this energy source and overall financial/economic viability of solar energy projects.

- It will help in retrofitting new equipment to existing solar installations (e.g. battery storage)
- It will help to solve problems that may emerge with the SOLARISE installations
- It will help for making decisions when planning the installations
- It will help in the optimization of SOLARISE installations (e.g. avoiding oversizing or undersizing)

1.7. FS07 SOLARISE Database: Inventory of existent pilots, benchmarks, good practices in the 2Seas

Data is essential at different stages of any solar project as illustrated in the following figure:



Data application techniques for the various stages of project development [1]

Some data such as ones related to meteorology or irradiance are hopefully quite easy to access and are generally available when using a solar plant design software. On the contrary, Information about individual solar installations is seldom available due to privacy aspects. However, the website https://www.bdpv.fr of the BDPV association is an interesting tool of existing PV installations in different regions including the 2 Seas. This database is based on inputs from stakeholders (PV owners, installers…). BDPV.fr will be the main database reference and tool for the SOLARISE project and as such will be promoted to collect data of PV installations in the Seas.

Solar Installations (BDPV.fr)

A database of solar installations is a set of structured data used to collect useful information about the installations. In general, only installations producing electricity are concerned because they have direct or indirect effect on the national production. Indeed, solar installation with only thermal production are for local use even when they supply a district heating system.

Citizen, owners, installers, decision makers, energy providers can get very useful information from a pv database such as number of pv installations for a given area, type of panels and converters, average production. These information may give confidence or not to potential locations and users.

1. What are the entries in the pv-installation database?

In a PV installations database, entries can be classified into the following categories:

- Identification: location, type, date of installation, ownership (when, what, where, who).
- Finance: Investment, incentives, costs of operation, maintenance, management...
- Energy features: installed power, energy production, storage, grid connection.

2. How is the privacy of the data ensured?

The European General Data Protection Regulation 2016/679 ensures the privacy of the data. For solar installations, data privacy is ensured since the identity of the owner and the exact location are not known.

3. How the stakeholders can provide correct/complete input for the database?

A database is generally accessible to registered users who fill-in the information needed through a specific form. These users have the possibility to logon in order to update their inputs.

4. How can the database be of further/open use for stakeholders? How the inputs can be processed?

The BDPV database is open and free to use. Statistical analysis of the data are processed.

5. Other useful resources

The following table gives a short description of some useful tools related to PV installations.

Link	Functions	Access Option
https://navigator.irena.org/index.html	Provide a quantitative overview of solar PV installations without any qualitative way. But it gives the link to several interesting tools.	Free access
http://www.polis-solar.eu/	Provide a strategic approach by the municipality can enhance the expanding integration of small-scale, decentralized energy applications into the built environment.	Free access
https://solargis.com/	Provide reliable and accurate solar, weather and solar electricity data that are used in the whole lifecycle of solar power plants, from prospection to development and operation	Free trial version; software should be purchased.
https://www.energysage.com/solar/solar-operations-and-maintenance/solar-monitoring-systems/	An interesting tool that gives an deep economic analysis of a future solar installation. However, it is only valid for USA.	Free access
https://www.renewables.ninja/#/country	Provide the potential of solar energy of a location in a global way	Free access
https://open-power-system-data.org/background/	Provides an open platform for data required by energy system	Free access
https://www.data.gouv.fr	Provides global data of the installed PV and wind power in France	Free access
http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html	This tool allows evaluating performance of grid-connected PV plant.	Free access

Table Useful tools for solar installations post-evaluation

Best Practices: The Solarise project has identified the following items for good practices

- Governance and participation of stakeholders, citizens, end users…
- If PV in buildings: Architectural integration (building or neighborhood scale)
- Economic profitability but not speculative
- If self-consumption: smart systems to reduce peaks and overproduction
- Visibility from public space and education

2. Solarise – Best practices examples

During the last 10- 20 years a lot of solar energy harvesting projects have been developed worldwide and they have functioned for years as best practices examples. However, along the years the technology is changing and also the legislation, business models together with the installation, O&M and EOL costs of a solar energy project.

Providing a one-fits-all' solution is not possible since many types of installations are possible.

Within the Solarise project a database of relevant and more recent solar energy projects have been started. Some of these projects can be seen as best practices, hoever they have a limited applications I onther parts of the EU.

To come up with relevant best practices that can be of interest to the Solarise consortium and beyond, the project partners have decided to provide best practices only for these **criteria**:

1. *Governance and participation of stakeholder, citizens, end users*… the efective participation of citizens (economic participation or all other type of participation in the process of decision), stakeholders, NGO, firms, architects…
2. Architectural integration of rooftop PV-installations at building or neighboorhood scale
3. Self-consumption and smart systems to reduce peaks and overproduction
4. Economic, not speculative profitability of solar energy (UPJV)
5. Visibility of PV-systems in public spaces and in education
6. Solar thermal and hybrid (PV/T) installations
7. Solar farms in no competition with agricultural lands
8. CO_2 impact of the installation (production of PV, transport, recycling…)

After careful consideration and discussions with the consortium partners, provided that only a limited number of relevant best practices could be gathered in short time, it has been decided to restrict the best practices only to 5 criteria. Each of these criteria are elaborated shortly and accompanied by a few examples provided by the consortium partners.

2.1. Best Practices: Governance and participation of stakeholders (citizens, end users)

Solar energy projects (harvesting, storage and use) have many stakeholders. Each type of stakeholders has specific characteristics and different levels of control and interest/implication in a solar energy harvesting project. The stakeholders can be divided into two main categories:

- **internal stakeholders** are those stakeholders who have responsibilities and roles to execute in the project during the planning and implementation phases.
- **external stakeholders** are those who are affected by the project or whose actions directly or indirectly have an effect on the project.

The **strategic actions undertaken by the stakeholders** during the course of a solar energy project to put forward their objectives are: inputs withholding, inputs compromising, communication, direct action, coalition building, conflict escalation and credibility building. In a practical context, these strategies are usually used in combination and the most commonly used order is communication, direct action and conflict escalation.

Knowledge of these strategies helps in modelling the stakeholder interactions and in understanding whether the influence of a particular stakeholder is in favor or against the respective solar energy project. It is important to classify the stakeholders and study their potential impact because even an external stakeholder who cannot act directly can compromise the course of a project mostly due to credibility loss, miscommunication and mismanagement. It has been shown that engaging with the stakeholders at the early stage of the project ensures a better active participation.

The **main steps in stakeholder engagement/participation** are: stakeholder identification and analysis, information disclosure, stakeholder consultation, negotiation and partnerships, grievance management, stakeholder involvement in project progress monitoring, reporting to stakeholders and monitoring and management functions, as can be seen in figure below.

The first step means thus to identify all the stakeholders involved in the project and position them on a chart in accordance to their **level of interest and influence on the project**.

+ Influence -	Keep satisfied	Manage closely
	Monitor	Keep Informed
	- Interest +	

PV Best practices

Criterion : participation

Title : Enercoop Hauts-de-France

General information :

Enercoop is a cooperative committed to the energetic transition, seeking to promote a 100% renewable energy; a sober energy model, local, organized in the framework of a shared, transparent and democratic governance.

Enercoop is at the same time a supplier of electrical energy (eligible by any final consumer in France), and in turn is a network of regional cooperatives that accompany energy projects in their territories.

From the beginning, Enercoop has chosen the legal form most appropriate to its values. Of private form and public interest, the status SCIC (Cooperative Society of Collective Interest) is part of the current of the social economy and solidarity, economic system that places the human at the heart of project.

Participative governance :

The basis of a SCIC is the principle 1 person = 1 vote.

In this way, individuals and organizations decide together on a democratic, transparent and citizen model.

The assemblies are the main organ of decision on the present and future of the cooperative, in which there is a meeting of 6 stakeholder's collegues: Producers, consumers, employees, partners, project leaders and local authorities, each college is represented as well in the board of directors by one or more directors.

Producers and energy projects :

Enercoop has a direct and close link with his electricity producers. This link ensure the energy short circuit, that makes possible to guarantee a traceability of the sources of supply. Producers are individuals, sometimes SMEs and local authorities for 40% of production.

Enercoop also contributes to the development of citizen projects for the production of renewable energy in the territory, like the photovoltaic , by investing alongside various local players, supporting the technical side (sizing of the installation), fundraising or communication.

PV Best practices

Criterion : Governance, participation

Title : Local Energy Strategy (LES)

General information about the solar installation :

Country : the Netherlands

City : Heerhugowaard

Owner : -

Date (works, putting in service, investiture...) :in progress

Price : -

Type of solar energy : -

Governance and participation at developing the LES

While Heerhugowaard, with the Suncities «Stad van de Zon» solar-energy project is already performing well, the new local energy strategy (LES) also is focusing on solar energy as one of the main components. Governing the increase of solar-energy capacity, a so-called solar-ladder is applied, which basically names approx. 140 MWp of roof-top solar-PV capacity as base that needs to be harvested first and may be at a later point followed by solar-PV projects around infrastructural facilities or even a new solar-PV farm. Hybrid solar-PV-warmth project are named possibilities for individual houses. This solar-ladder aims to prevent using valuable and limited farm-lands for solar-installations. Further, different scenarios for meeting the future energy-demand are developed within the LES, which are scored along a scoring matrix that aids in governing the energy-transition in Heerhugowaard and making good and informed choices. However, aiming at fully meeting local demand from wind and solar-energy, large scale installations are named as being inevitable in the city since this provides the biggest potential capacity. Given the high importance of citizens in the energy transition is the LES painting the general picture while the concrete realization that also includes participation of citizens is following the LES in a roadmap that is to be developed once the LES is finalized. Finally, the important step of storage will be also picked up in this roadmap.

PV Best practices

Criterion : technical, environmental and participation

Title : St. Martin's Church in Wavrin

General information about the solar installation :

Country : France

City : Wavrin

Owner : SCIC SOLIS Métropole

Date : Works : May 2016 / Puting in service Mars 2017

Price : € 75,000, of which 30% is grants

Type of solar energy : Photovoltaic on roof

Description of the installation :

- Steel container roof / structure JORIS IDE
- Installed power: 33 kWp
- Module 110 SYSTOVI monocrystalline photovoltaic solar panels of 300Wc (France)
- Inverter: FRONIUS
- Energy production (/ year): 31,456 kWh
- Selling price: 132,7 €/Mwh
- CO2 avoided (/ year): 13,840 kg

The Solis association, which specializes in citizen's installation of photovoltaic power stations, is responsible for the site, in conjunction with a cooperative society of collective interest, SCIC Solis Métropole (with subscriptions with a yield of 1.5%). The project has received citizen funding.

2.2. Best Practices: Architectural integration of rooftop PV-installations at building or neighboorhood scale

When solar energy harvesting is applied in buildings with special characteristics, like eg historical buildings or buildings designed as show-case for solar energy harvesting, there is special attention needed for the architectural integration of the solar energy harvesting installations, either PV, PV/T or solar collectors.

PV Best practices

Criterion : Architectural Integration solar PV

Title : Kuijpers Helmond

General information about the solar installation :

Country : The Netherlands

City : Helmond

Owner : Kuijpers Installatie BV

Date : 2018

Price : undisclosed

Type of solar energy : Esthetical façade with integrated photovoltaics and programmable LED

Description of the installation :

In this project an attempt was made to fully design a façade that combines multiple functionalities. Number one functionality is the façade design itself. Besides meeting all building regulations and standards and protecting the building from the weather and environment, a façade gives a building a certain identity. Design freedom for architects is of crucial importance. By embedding programmable LEDs in the façade the building can be illuminated in a color matching the seasons. Finally, PV is embedded to generate electricity. By primarily focusing on the other functionalities of the façade, the PV itself is a last 'add-on' to the façade that can be integrated with little additional costs.

PV Best practices

Criterion : Architectural integration

Title : Supermarket Maastricht

General information about the solar installation :

Country : The Netherlands

City : Maastricht

Owner : Albert Heijn supermarket

Date : 2017

Price : undisclosed

Type of solar energy : Façade integrated PV

Description of the installation :

Façades do not *always* have to be colorful and custom-made. In some locations the black color of a PV panel is not harmful to the appearance of a building. Such was the case for the Albert Heijn supermarket in Maastricht, The Netherlands.

A best practice for facades is to opt for mat (non-shiny) thin film PV panels. These panels are available for the same price as 'ugly' crystalline silicon panels. But the looks are far superiors. Even for experienced PV professionals it is hard to recognize these panels from a distance. They are truly disguised as black façade panels.

This installation holds 144 solar panels, good for a total peak power of 20 kWp.

PV Best practices

Criterion : Sexxxx

Title : Biesenhof

General information about the solar installation :

Country : The Netherlands

City : Geleen

Owner : Brasserie Biesenhof

Date (works, putting in service, investiture...) :

Price : undisclosed

Type of solar energy : Invisible solar thermal collectors

Description of the installation :

It is very difficult to use roofs of historic buildings for energy generation. Most solar energy harvesting systems will dramatically alter the looks of a building. An exception is the system of Q-Roof. It uses invisible heat extraction from beneath the roof tiles. A downside of this technology is the low temperature heat that can only be extracted in the summer. There is a very good match with outdoor terraces such as Biesenhof. These terraces tend to get crowded when the weather is good and the sun is shining. The kitchen will have a continuous demand for warm water. These invisible solar collectors can provide a part of that heat.

(One notion of warning : Be very careful with directly connecting these collectors to a heat pump and use them for space heating. The temperature of the collectors must never be cooled down to values below the dew point, or condensation might occur below the roof tiles which is an unwanted sitiuation. It is better to only use the system as a domestic hot water solar collector such as in this example of Biesenhof.)

2.3. Best practices: Self-consumption and smart systems to reduce peaks and overproduction

In the last years worldwide attention has been given to 'self/auto-consumption' of harvested solar energy, either in the form of electricity or as stored heat/cold. Self-consumption means that the harvested energy is used to supply the user's electricity/heat/cold needs instantaneously or at a later moment without much use of the grid electricity and/or other sources of electricity and heat. The EU-statistics show that the solar PV and PV/T installations in the 2Seas region are grid-connected installations so the electric energy may flow in both directions, from the installation to the grid and vice-versa.

Since the electric/thermal energy production pattern of the solar energy (with peaks during the daytime) does not match with the regular usage pattern of the **residential end-users** (large energy needs in the morning and afternoon/evening) measures should be taken in order to avoid overproduction peaks during daytime (and consequently grid overloading) and still allow the end-users to deliver sufficient energy to the grid during daytime to compensate for the energy taken from the grid at night and at periods with insufficient solar energy production.

The solar installations on **public/commercial buildings and infrastructure** have less problems with overproduction since their usage pattern (large energy needs during daytime) matches better (but not completely) the energy production patters.

However, for solar systems with or without electric/thermal energy storage at the end users, smart energy management systems to decide on the energy flow direction and the amounts of energy bought/sold/stored at any moment are needed. Prediction of the energy production and consumption based on extensive and long-term studies of existent installations is of crucial importance.

Many of the R&D state-of-the-art smart grids (SG) and smart systems cannot be implemented at large scale yet due to the still existent problems that may have many negative consequences on the national electricity grid. However, some efforts are put into simulation and/or small scale projects to show the feasibility of specific SG and smart systems concepts.

PV Best practices

Criterion : Self-consumption

Title : PV installation on a private company combined with charging of electric vehicles

Map : location of the installation in the 2 seas region (location in West-Flanders, Belgium)

General information about the solar installation :

Country : Belgium

City : Roeselare

Owner : Private company

Date (works, putting in service, investiture…) : to be installed

Price : 145.340 Euro TVA excluded

Type of solar energy : PV panels

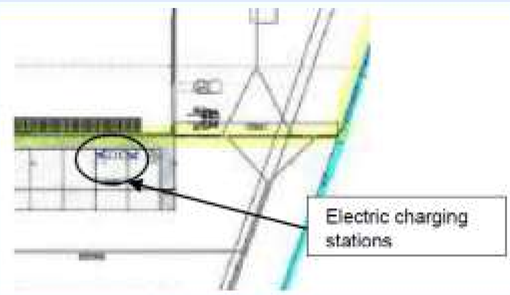
Description of the installation :

Technical details :
A PV installation of 134 kWp can be installed on the roof. The auto self consumption is estimated to be 59%. The electricity produced by the solar panels is only 36% of the total electricity use of the company.

Financial details :
- investment cost : 145.340 Euro TVA excluded
- Project-IRR : 9,8%
- Benefit after 20 years : 165.277 Euro TVA excluded

Smart system to reduce peaks and overproduction :
The company has 2 charging stations for electric cars. In total 3 employees use them to charge their electric car. The charging stations can also be used by 1 one visitor.
Eventual overproduction can be used to charge the electric cars.

General placement of installation



PV Best practices

Criterion : Self-consumption

Title : Apartment Building Oostburg

General information about the solar installation :

Country : The Netherlands

City : Oostburg

Owner : Private

Date : 2017

Price : undisclosed

Type of solar energy : Flat roof PV installation

Description of the installation :

Flat roofs are the 'low hanging fruit' of the energy transition. Flat roofs allow fast, large and low-cost PV installations to be installed on them. They should be the primary focus of any municipality that wants to start working on the energy transition. The problem is: How to convince the building owners to put PV on their roof? And, in case of apartment buildings, How to decide where the energy flow goes and who gets the benefit? This building in Oostburg is a former high school transformed into an apartment building.

PV Best practices

Criterion : Self Consumption

Title : Westhampnett Solar Farm

Map : location of the installation in the 2 seas region

General information about the solar installation :

Country : England

City : Chichester, West Sussex

Owner : West Sussex County Council (WSCC)

Date : Work started in 2013 and Power Production started in Oct 2018

Price : £ 23m

Type of solar energy : PV Solar Panels

Description of the installation :

Techinal Details :

Installed Capacity : 7.44 MWp
Battery Storage : 4.06 MWh
SMA Inverters : 4.4 MW
Land : 35 acres
Orientation of Panels : South Facing
Number of panels : 27,665
Annual Energy Production : 50.7 MWh
Income : £230,000 per year expected
Self Power Consumption : 25% of the annual WSCC corporate energy demand
CO_2 Emission Reduction : Reducing the WSCC annual CO_2 emissions by approximately 20%
Land usage : Solar farm is built on a closed landfill site
Ecology Survey : Site has also cleared the ecology survey

Smart Systems :

1. The installation has smart facility to limit power output to avoid overproduction.
2. Solar electricity reduces the peak load on national grid.
3. Grid scale battery bank stores the excess solar power and releases when required.
4. Battery storage can also be used as a stand alone battery bank to provide frequency response services to the national grid.
5. The installation has both qualities : self-consumption and power export to grid.
6. Battery storage will enable WSCC to effectively become a small scale energy provider; receiving an income through price arbitrage/ peak shaving and also receiving an income from response services such as EFR/ FFR.

General picture of installation

2.4. Best practices: Economic, not speculative, profitability of solar energy

Introduction & definitions

The profitability analysis is based on estimating investment parameters [1] such as:

- Payment;
- Duration;
- Service (or economic) life.

Payment can be estimated using PVCALC [2] (see Annex 3.1), and the life span would be 25 years according to market criteria and the installation company's recommendation [1].
For the economic profitability evaluation, the following criteria are commonly used

- NPV: Net Present Value,
- IRR: Internal Rate of Return,
- Payback time (number of necessary years to cover the cost of the initial investment) are necessary [3].

The NPV (€) of a PV project is the difference between the present values of the cash flows (in and out) generated throughout the lifetime of the project [1]. It is expressed as follows:

$$NPV = -D + \sum_{i=1}^{n} \frac{F_i}{(1+k)^i}$$

Where D represent all the expenditures required to set up the investment, n is the economic life of the investment, and F is the cash flows of each year measured by the difference between charging and payments. Payments include the installation's opportunity cost. Finally, k measures the updating rate for the investment.

The IRR is the value of the updating rate (k) that leads to NPV= 0 and it represents the average earning power of the money used in the project over its lifetime. It can be calculated by:

$$0 = -D + \sum_{i=1}^{n} \frac{F_i}{(1+IRR)^i}$$

Financial investments

For a PV installation, the investments could be classified into three main categories:

- Site preparation;
- Construction;
- Electrical work and maintenance work.

A list of possible investments for a PV installation is illustrated in Table 1.

Table 1. List of possible investment for a PV installation

Type of investment	Investment
Furniture	PV panels
	Mounting frame
	Inverters
	Wires, electrical boxes & protection devices
	Site monitoring
Electrical work	Electrical wiring
	Commissioning of the installation
Logistic	Crane of frames and equipments
maintenance	Inverters replacement
	Installation cleaning & maintenance

Subsidies can reduce the total investment of the PV installation, where the subsidy amount varies according to the local policies. Another important financial resource is the cash earned from electricity production. The latter depends on whether the produced electricity is consumed locally or exported to the grid since the electricity price is not the same when purchased or exported the grid.

Case study: economic and financial study of the future installation at the campus of the Picardie Jules Verne University

The studied site is located in the city of Amiens city in France (GPS: 49°52'35.0"N 2°15'50.0"E). The technical specifications of the adopted solution are listed in Table 2

Table 2. Technical specifications of the adopted solution (PV panels on the roof-top)

Parameter	value
Total power	111,02 KWp
Number of PV panels	427
Number of inverters	7
Total surface of installed panels	715 m²
Total sun irradiance	798 628 kWh
Total PV energy	122 062 kWh
Inverter input energy	109 433 kWh
Produced PV energy	103 845 kWh

This feasibility study was carried out by considering that all the produced energy is locally consumed. The following assumptions have been made:

- The cost of electricity at the beginning of January 2018, for this site, is € 97.05 (excluding taxes) /MWh;

- An update of the cost of energy of 4% per year;
- A deterioration of the efficiency of photovoltaic panels by 0.5% / year;
- An annual maintenance cost that includes replacing the inverters and cleaning the panels twice a year. This amount corresponds approximately to € 3534 (excluding taxes)/year
- Subsidies are excluded from the study, but can be incorporated if exist.

The cash flow of the UPJV future installation over 25 years is illustrated in figure 1.

Figure 1. Cash flow of the UPJV installation over 25 years.

Table 3 gives a summary of economical parameters. The gain over 25 years is about 94% when compared to the initial investment. The return on investment time is around 16 years.

Table 3. Economical details of the adopted solution (photovoltaic panels on the roof of buildings)

Investment (excluding taxes)	**Profit on 20 years** (excluding taxes)	**Profit on 25years** (excluding taxes)	**Return on investment time**
163 685 €.	60 800 €.	153 700 €.	16 years

References

[1] I. Guaita-Pradas, I. Marques-Perez, B. Segura and A. Gallego, "Criteria for Identifying More Favourable Areas for Photovoltaic Installations: Case of East Spain," *2018 6th International Renewable and Sustainable Energy Conference (IRSEC)*, Rabat, Morocco, 2018, pp. 1-5.

[2] http://pvcalc.org/pv-price-forecast (accessed on June, 19, 2019)

[3] D.L. Talavera, Emilio Muñoz-Cerón, J.P. Ferrer-Rodríguez, Pedro J. Pérez-Higueras, Assessment of cost-competitiveness and profitability of fixed and tracking photovoltaic systems: The case of five specific sites, Renewable Energy, Volume 134, 2019, Pages 902-913.

[4] W. Short, D.J. Packey, T. Holt, A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies, National Renewable Energy Laboratory, Golden, Colorado (USA), 1995.

PV Best practices

Criterion: Smart, Grid connected

Title: Future solar photovoltaic installation at the campus of the University of Picardie Jules Verne (UPJV)

Map: location of the installation in the 2 seas region

General information about the solar installation:

Country: France

City: Amiens

Owner: UPJV

Date: installation will start in2020

Estimated Price: € 163 685

Type of solar energy: PV Solar Panels

General pictures of the future installation

Description of the installation:

Technical Details:

Installed Capacity: 111 KWp
SMA Inverters: 7×20 KW
Type: building integrated
Solar Panels Surface: 715 m^2
Orientation of Panels: South Facing
Number of panels: 427
Expected Annual Energy Production: 103.9KWh
Income: €15,00K per year expected
CO_2 Emission Reduction: 6.7 Tons expected
Return on investment time: 16 years

Smart Systems:

1. The installation can reduce the peak load on local grid in Amiens.
2. Battery storage system can also be used.
3. The installation allows self-consumption and power export to grid.
4. Possibility to get subsidies from the French local authority.

2.5. Best practices: Visibility of PV-systems in public spaces and in education

PV-systems and large, spectacular solar installations are coming in the news quite often, in order to increase the visibility and impact of solar energy applications.

In the Solarise project, except for other concrete solar installations the realization of **three academic living labs** is proposed. These Solarise living-labs are meant to be 'sociotechnical imaginaries' where state-of-the-art and state-of-the-practice solar technologies can be shown, demonstrated, experimented and learned (theoretically and practically) by various stakeholders. The term 'sociotechnical imaginary' means in this context 'a set of ideas, beliefs, and visions about the future of solar energy harvesting, storage and use' and it fits with the intended use of the living lab, as place to learn and to 'play' with the new technologies and a place to exchange ideas and experiences with other stakeholders.

The Solarise living-labs will be embedded in the activities developed at the respective universities by providing a unique combination of research based curricula and practice-based courses with strong links with local industries and communities. The development of such living labs is thus a good practice both for the visibility of PV-systems in public spaces as in education, since in any living lab, the participation of the stakeholders/inhabitants of the living-lab is crucial for understanding the complex processes involved in sustainable energy adoption. Various types of solar harvesting and storage technologies will be combined with specific sensors (both high performance/cost and low cost sensors to show that there is possible to achieve good and reliable monitoring and later on control of energy flow with both types of sensors). The sensor data will be collected and processed using open source or commercial platforms and software, depending on the specific application.

It is known that energy transition is not only a matter of innovating in terms of technologies, but also in terms of **stakeholders involvement** towards understanding and applying these technologies in the right context. Academic research on smart cities and solar energy showed that engagement of the stakeholders is important for a real uptake of sustainable technologies. From an academic perspective, some of the stakeholders that can be targeted through a living lab are described in the table below.

Stakeholders	BSc/MSc/PhD Students	Municipalities	Politicians	Installers	Citizens cooperatives
Affiliation	University	Local authority	Policy makers	SME	None
Objective (stakeholder needs)	Knowledge	Solve problems	Societal relevant	Solve problems Commercial	Knowledge
How (what to offer)	Novelty	Usefulness	Impact	Econ. yield	Usefulness Econ. yield
Stakeholder expertise	Multi-disciplinary	Non-technical Mono-disciplinary	Non-technical Mono-disciplinary	Technical Mono-disciplinary	Non-technical

The proposed living labs will be used as ‘sociotechnological imaginaries’ to:

- Create awareness and knowledge for the energy challenges and various ‘exotic/novel’ types of solar harvesting technologies (hybrid PV/T, BIPV, transparent/bifacial/coloured, …) and associated storage, smart monitoring and control of the harvested electric/thermal energy
- Provide small scale showcases for novel combinations/applications of solar technologies (eg PV & bamboo, PV & ground-bounded green vines/ivy, PV & microalgae)
- Motivate the stakeholders to experiment and apply the new technologies in own (local) context and to co-produce
- Create local visibility and enhance low-threshold contact/interaction with stakeholders As such the living lab should develop an appropriate and flexible mix of show/demo cases together with hands-on/experimental set-ups for a good balance between theory and practice.

PV Best practices

Criterion : Visibility PV-installations public spaces and in education

Title : Future Solarise living-lab at KU Leuven – TC Ghent

General information about the solar installation :

Country : Belgium

City : Ghent

Owner : KU Leuven – Technology campus Ghent

Date : to operate starting on 2020

Price :

Type of solar energy : various kinds of small PV-installations

Description of the installation :

This Solarise living lab at KU Leuven TC Ghent is meant to be 'a **sociotechnical imaginary**' where state-of-the-art and state-of-the-practice solar technologies can be shown, demonstrated, experimented and learned (theoretically and practically) by various stakeholders : students, installers, policymakers, general public.

Specific features :

- ***small installations with 2-3 panels per system*** to allow combination of hybrid PV/T, transparent, bifacial PV-panels, etc. with various inverters (Solax, SMA, …)

- accurate metering and monitoring of all parameters with own metrology

- **easy access** on roof, possible use of walls for BIPV and flexible control of installations

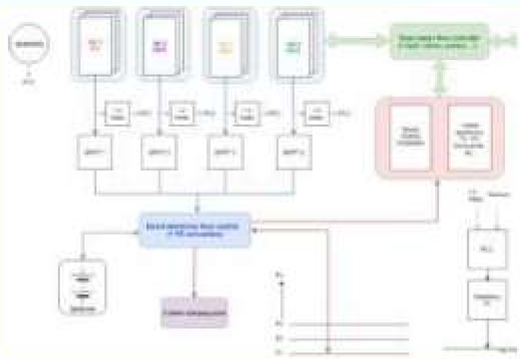
- **visualisations through educational tools**

- **grid-connected** system of max. 5 kWp

- **rain water collection and use** for building heating through hybrid PV/T solar panels

- **education facilities** for hands-on trainings and tests

The temporary building hosting the living-lab (**living units from recycled sea containers**) will be replaced by a **modular, flexible building** developed in CBCI - 2Seas project (Circular Bio-based Construction Industry) using with new construction materials and techniques.



3. Annexes

3.1. PVCalc - The Return (ROI) Calculator for PV solar energy investments

At the link http://pvcalc.org/pvcalc, one gets the following table:

Project Definition			
General Information		**Setup cost (all in)**	
Currency	EUR	Price (per kWp)	2200
Divisor	1	**Running cost**	
Useful life (years)	25	Lease (€/year)	0
Nominal power (kWp)	5	Insurance prem. (%)	0.5
Annual Yield *per kWp* (kWh/kWp)	1000	Maintenance (%)	0.5
Degradation (%/year)	0.5	Inflation rate (%/year)	2
Feed in tariffs		**Financing**	
Years	20	Own funds (%)	25
Price (per kWh)	0.1874	Loan type	Redeemabl
Index linked		Redemption Sched.	Uniform
Own consumption		Years	20
FIT subsidy (€/kWh)	0	Interest rate (%)	4.15
Own consumption (kWh/year)	0	Disagio (%)	3
Electricity price projection		Investment Yield (%)	3.5
		Tax	
Price now (per kWh)	0.18	Tax rate	0
Energy Price Inflation (%/year)	3		help

Calculate Reset

The required steps to get the required results are the following:

1. **General Information:** First of all the appropriate base unit has to be identified. For small projects (kWp) a factor of 1 is best used, for large projects (MWp) a factor of 1000 is better. A PV project has a certain useful life after which it is considered worthless. The nominal power is given in kWp (kilo Watt peak). The annual yield, measured in kWh per kWp, depends on the annual irradiation average of the particular location, an estimate can be obtained by using the PVGIS PV Estimation Utility. Since solar panels degrade over time the degradation per year has to be specified.
2. **Feed in tariff:** Governments worldwide give a price guarantee over a period of time, usually 20 years. Enter the duration of the guarantee and the compensation for electricity fed into the grid.
3. **Income after Guarantee:** After the income guarantee expires electricity can be sold on the energy market. The achievable price is unknown but can be estimated by taking today's energy price (€ per kWh) and applying an energy price inflation (%/year).
4. **Setup Cost:** The fixed cost to build the project has to be entered per kWp.
5. **Running Cost:** The running cost is constituted by the lease for land, the insurance premium and maintenance costs. Insurance premium and maintenance cost have to be given

as a percentage of the fixed cost. Next the inflation rate is needed to make a forecast for the future price increase in costs.

6. **Financing:** Unless the project is wholly financed by own funds financing costs will have to be taken into account. Three loan types are available: "Simple", "annuity" and "redeemable". "Simple" refers to a loan without any features such as redemptions. In this case a reserve has to be built to allow paying off the loan at maturity. "Annuity" refers to a loan that works like a mortgage. "Redeemable" refers to a loan that allows arbitrary redemptions. In this case redemption schedule can be specified. "Uniform" means that the redemptions are chosen such that a uniform dividend can be paid. "Maximum" means that all income is used to redeem the loan as quickly as possible. The costs are determined by the length of the loan in years the interest rate charged, by the fraction of money that is provided by the owner, i.e. own funds. The disagio specifies what amount is actually paid out. The investment yield that the owner can achieve when putting aside reserves in order to pay back the loan at maturity (only required for loan type "simple").
7. **Tax:** Linear depreciation over 20 years is used in order to determine the deductible amount. The taxable income is determined by the income before redemption less the deduction. Then the tax rate is applied to the taxable income.
8. Press submit to generate results, press Clear to remove results and reset form.

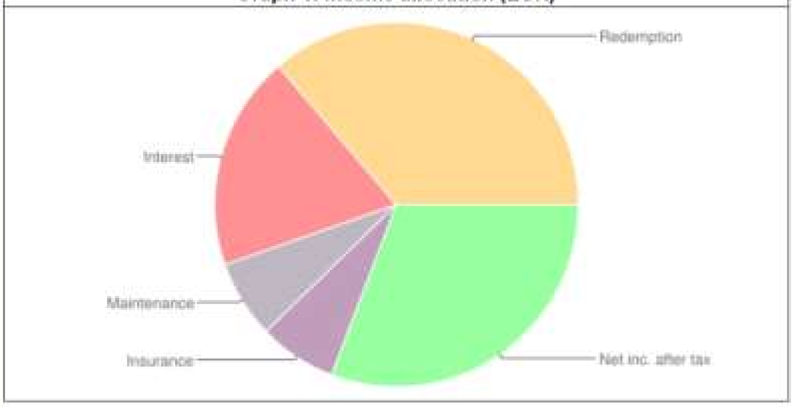
An extract from the results screen is as follows:

Results

Project Summary:	
Nominal power (kWp)	5
Purchase value (EUR)	11000
Own Funds (EUR)	2750
Loan amount (EUR)	8505
Present value of net income' (EUR)	5004
Levelised energy cost (€/kWh)	0.173
Loan type	Redeemable
Amortisation time (y)	15.2
Dividend (EUR)	134.5
Dividend (%)	4.9
IRR before tax (%)	7.3
Eff. tax rate (%)	0.0
IRR (%)	7.3

Download summary as pdf

Graph 1: Income allocation (EUR)



On the same screen, results, one can get the cash flows table and other different parameters that may be useful for the reader.