Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in SWITZERLAND 2020

PLANAIR
Ingénieurs conseils en énergies et environnement

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association and the Cop- per Alliance are also members.

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What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "Trends in photovoltaic applications" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2020. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

Commune de Tramelan

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1 INSTALLATION DATA

The PV power systems market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2020 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2020, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

The transformation of the Swiss energy system aimed with the "Energy Strategy 2050+" is a long-term project. The Swiss electorate accepted a revised Federal Energy Act in 2017 in a popular referendum. This new legislation entered into force on 1 January 2018. The aims are to reduce energy consumption, increase energy efficiency and promote the use of renewable energy (www.energystrategy2050.ch).

Until the year 2017, three elements characterized the national regulatory framework for photovoltaic power systems:

- a one-time investment subsidy for systems up to 30 kW
- a feed-in-tariff scheme for systems above 10 kW
- and, applicable since 2014, measures for self-consumption.

With the entry in force of the new Federal Energy Act since the 1st of January 2018, the support scheme for PV systems has changed:

- the one-time investment subsidy is extended to all sizes of PV systems (from 2 kW to 50 MW)
- the feed-in tariff scheme (feed-in remuneration at cost (KEV)) is gradually replaced by a feed-in remuneration closer to the market requirements
- for systems below a capacity of 100 kW, only the one-time investment subsidy will be available
- although the original feed-in tariff support scheme (KEV) can be applied for PV systems up to 2022, due to the long retroactive waiting list (around 35'000 PV projects), only systems announced before June 30, 2012 are expected to benefit from the feed-in tariff support scheme.
- the one-time investment was updated in 2020 from 340 * p(kW) + 1400 CHF to 340 * p(kW) + 10000 for plants < 30 kWp to incentive investments in larger PV capacities and avoid waste of potential with half roof usage.

The added PV capacity in 2020 reaches 475 MWp, representing an increase of close to 50% compared to 2019 with 325 MWp. As shown in **Erreur ! Source du renvoi introuvable.**, 70% of the new installations involve individual houses, but it represents only 30% of the additional PV capacity

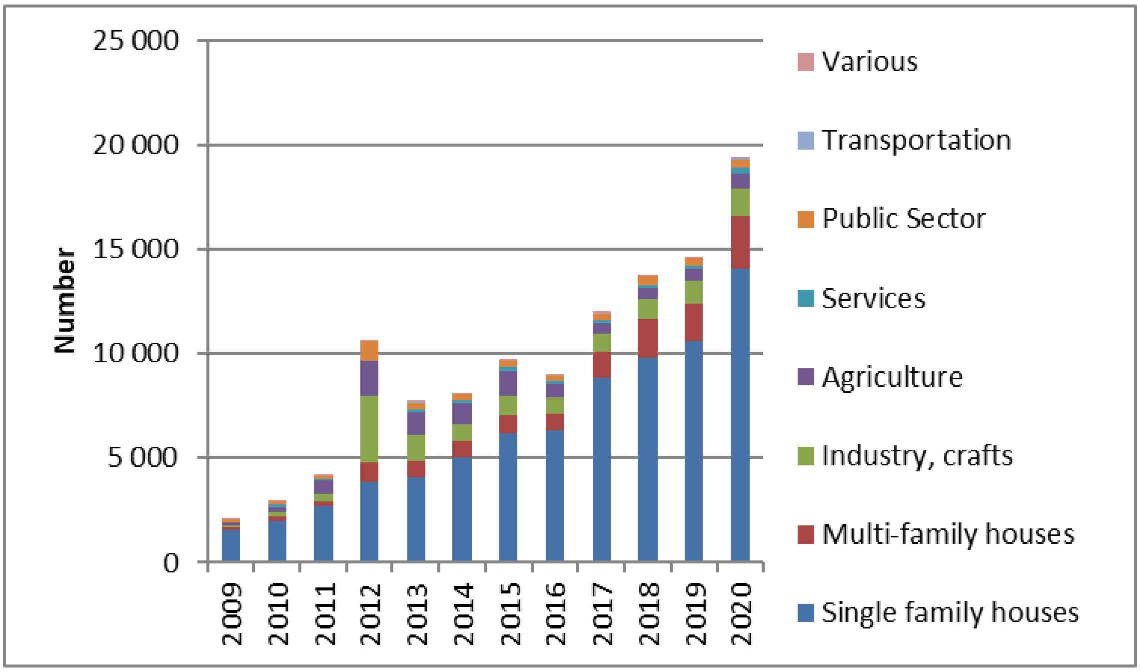


Figure 1 : New PV system per year and per category (source:Swissolar)

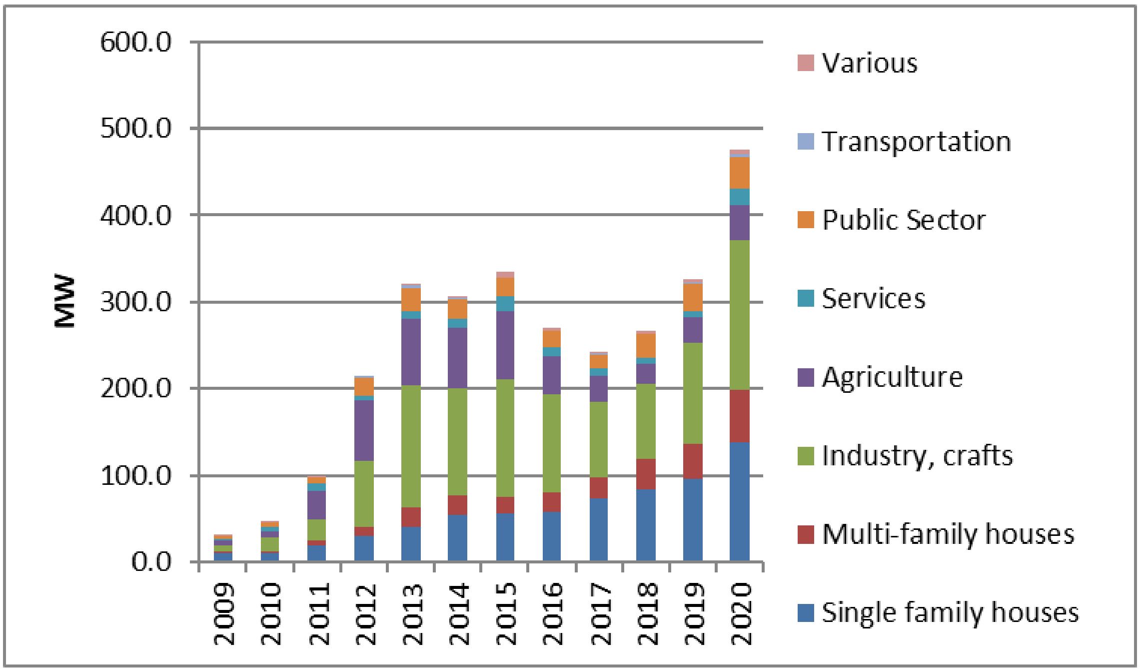


Figure 2 : Added PV capacity per year and per category (source:Swissolar)

Another 30% of the additional PV capacity is installed on industrial sites. The last third includes mainly houses with several apartments, the public sector, and agriculture. As regards this last category, a new Swiss company, Insolight, is reaching the demonstrator stage with their product Theia dedicated to agrivoltaics.

Figure 3 : Insolight Theia solution for agricultural PV - demonstrator stage

Applications of PV in Switzerland are primarily roof-top grid-connected PV systems. Off-grid, ground-mounted, VIPV applications are still very scarce while an increasing number of building integrated and facade PV projects can be observed. This development is still slow, even if we notice technological advancements (color & shape of modules) and increasing awareness of architects to use PV as a building element (thanks to policies making PV compulsory in new buildings).

1.2 Total photovoltaic power installed

On behalf of the Swiss Federal Office of Energy, Swissolar is mandated to survey the Swiss solar market and publish the annual installed capacity in the report: "Statistiques de l'énergie solaire : Année de reference 2020". The data is based on a survey amongst 307 companies active in the PV and solar thermal market. About 95% of installers, importers/distributers and manufacturers are estimated to be covered in this annual market survey

The added PV capacity in 2020 reaches 475 MWp, representing an increase of close to 50% compared to 2019 with 325 MWp.

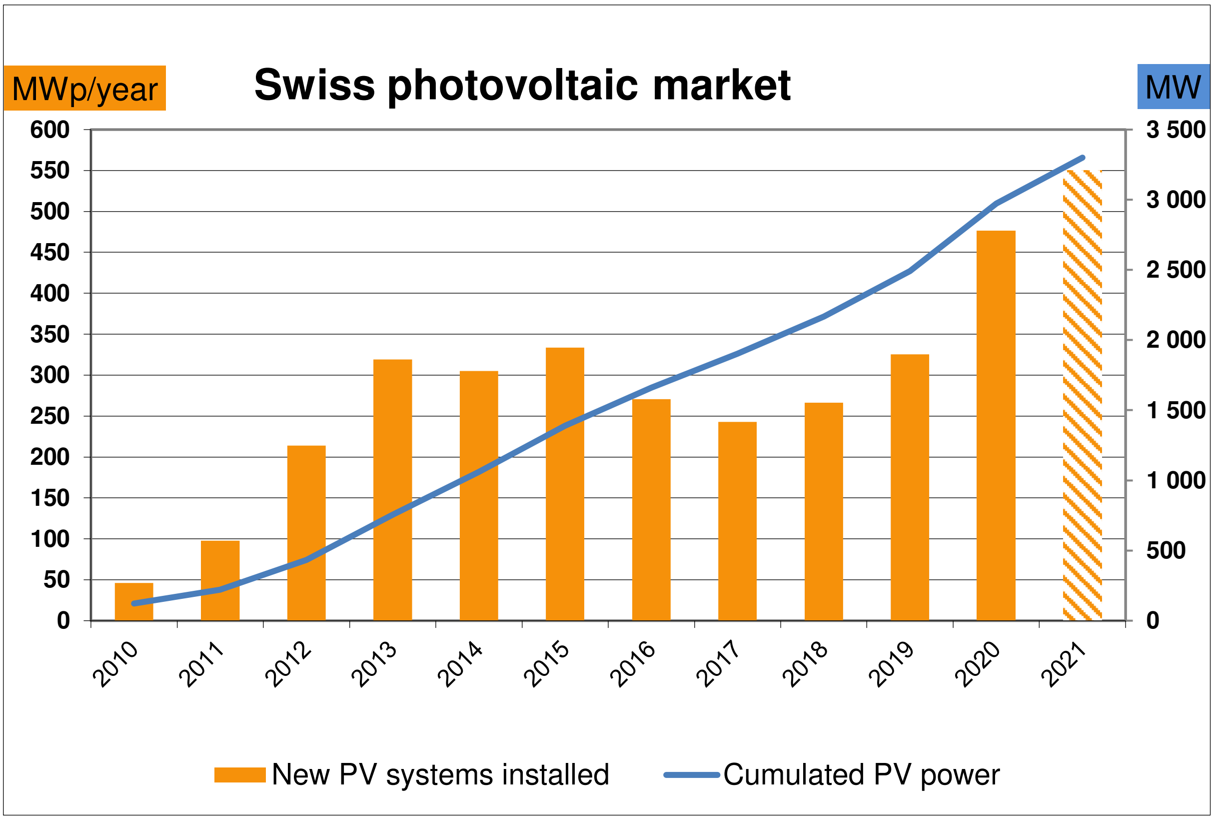


Table 1: Annual PV power installed during calendar year 2020

		Installed PV capacity in 2020 [MW]	AC or DC
	Decentralized	475.1	DC
	Centralized	0	DC
	Off-grid	0.3	DC
	Total	475.3	DC

Table 2: PV power installed during calendar year 2020

			Installed PV capacity [MW]	Installed PV capacity [MW]	AC or DC
Grid-connected	BAPV	Residential	419.2	163.5	DC
		Commercial		67.0	DC
		Industrial		188.8	DC
	BIPV	Residential	55.8	21.8	DC
		Commercial		8.9	DC
		Industrial		25.1	DC
	Utility-scale	Ground-mounted			
		Floating			
		Agricultural			
Off-grid		Residential	0.25		DC
		Other		0.25	DC
		Hybrid systems			DC
Total			475.3		DC

Table 3: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	Data are collected in DC

Is the collection process done by an official body or a private company/Association?	The data collection process is done by Swissolar (Swiss Solar Professional Association) on behalf of the Swiss government. It is based on a questionnaire sent to all importers, installers and manufacturers. It is estimated that about 95% of the market is covered with this survey. To validate the data, there is a compulsory registration for systems above 30 kVA since the beginning of 2013 (Guarantees of origin and electricity labeling). The Swiss Federal Office of Energy has been surveying the solar market in Switzerland for more than 20 years. Due to this long experience, the quality of the data has been maintained, thanks as well to all the installers and distributors who are willing to complete the annual questionnaire.
Link to official statistics (if this exists)	Solar Energy market survey (DE/FR): https://www.swissolar.ch/fr/lenergie-solaire/faits-et-chiffres/statistique-de-lenergie-solaire/ Electricity Statistics (DE/FR): https://www.bfe.admin.ch/bfe/fr/home/approvisionnement/statistiques-et-geodonnees/statistiques-de-lenergie/statistique-de-l-electricite.html Overall Energy Statistics (DE/FR): https://www.bfe.admin.ch/bfe/fr/home/approvisionnement/statistiques-et-geodonnees/statistiques-de-lenergie.html
	The quality and accuracy of the data are expected to be better than +/- 10%.

Table 4: The cumulative installed PV power in 4 sub-markets

Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralized [MW] (Ground, floating, agricultural…)	Total [MW]
1990	0.4	2.1		2.5
1991	0.6	3.1		3.7
1992	0.7	4.1		4.8
1993	0.9	5.1		6.0
1994	1.0	6.1		7.1
1995	1.2	7.1		8.3
1996	1.4	8.4		9.8
1997	1.6	9.7		11.3
1998	1.8	11.1		12.9
1999	2.0	12.4		14.4
2000	2.2	13.7		15.9
2001	2.2	16.1		18.3

2002	2.3	17.9		20.2
2003	2.4	19.5		21.9
2004	2.5	21.8		24.3
2005	2.6	25.7		28.3
2006	2.7	27.4		30.1
2007	2.9	34.5		37.4
2008	3.0	46.4		49.4
2009	3.0	76.5		79.5
2010	3.0	122.4		125.4
2011	3.0	219.9		222.9
2012	3.0	433.5		436.5
2013	3.2	752.4		755.6
2014	3.7	1056.9		1060.6
2015	3.9	1390.1		1394.0
2016	4.0	1660.2		1664.2
2017	4.1	1902.3		1906.4
2018	5.6	2167.6		2173.2
2019	6.1	2492.0		2498.1
2020	6.4	2967.1		2973.4

Table 5: Other PV market information

	2020
Number of PV systems in operation in your country	Around 117660
Decommissioned PV systems during the year [MW]	< 0.5 (estimation)
Repowered PV systems during the year [MW]	0.6

Table 6: PV power and the broader national energy market

	2019	2020
Total power generation capacities [GW]	**22.06 GW total** (15.54 GW Hydro ; 3.33 GW nuclear ; 3.19 GW Thermal & RE)	**22.42 GW total** (15.57 GW Hydro ; 3.33 GW nuclear ; 3.5 GW Thermal & RE)
Total renewable power generation capacities (including hydropower) [GW]	**18.54 GW total** (15.54 GW hydro, 2.5 GW PV, 75 MW Wind. 422 MW waste)	**19.08 GW total** (15.57 GW hydro, 3.0 GW PV, 87 MW Wind. 422 MW waste)
Total electricity demand [TWh]	57.2 TWh (-0.7%)	55.7 (-2.6%)
New power generation capacities installed [MW]	+ 325 MW PV + 186 MW Hydro	+ 475 MW PV + 30 MW Hydro + 17 MW Wind
New renewable power generation capacities (including hydropower) [GW]	+ 325 MW PV + 186 MW Hydro	+ 475 MW PV + 30 MW Hydro
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh]	2'178 GWh	2'599 GWh
Total PV electricity production as a % of total electricity consumption	3.81%	4.67%
Average yield of PV installations (in kWh/kWp)	960	985

1.3 Key enablers of PV development

	Description	Annual Volume	Total Volume	Source
Decentralized storage systems In [MW,MWh or #]	+ 39.4% of added capacity and +56.1% of total capacity compared to 2019	**Added capacity**: 28'400 kWh (including 70 kWh lead battery) **Added number:** 2'497 (including 7 lead battery)	79'055 kWh (including 1'255 kWh lead battery)	https://www.swissolar.ch/fr/lenergie-solaire/faits-et-chiffres/enquetes-de-marche/
Residential Heat Pumps [#]	Among the added systems, 15'401 (55%) in the range 5-13kW, 8'492 (30%) for 13-20 kW and 3096 (11%) for 20-50 kW)	+28'064 added systems (it was +23'980 in 2019 so +17.0% increase in added volume))	395'107 (+7%)	https://www.fws.ch/fr/nos-services/statistiques/
Electric cars [#]	In 2020 19'163 (8.23%) are BEV and 14'145 (6.08%) are PHEV have been registered	+33'306 new BEV or PHEV (+93% compared to 2019)	-	https://www.bfe.admin.ch/bfe/fr/home/approvisionnement/statistiques-et-geodonnees/statistiques-des-vehicules/statistiques-des-motorisations-alternatives-des-voitures-neuves.html
Electric buses and trucks [#]	A Support program has been put in place until at least 2030 to encourage the use of hybrid or electric buses with national CO2 certificates			https://www.myclimate.org/fr/

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 7: Typical module prices

Year	Lowest price of a standard module crystalline silicon [CHF/W]	Highest price of a standard module crystalline silicon [CHF/W]	Typical price of a standard module crystalline silicon [CHF/W]
2005	4.6	4.8	4.75
2006			
2007			
2008			
2009			
2010	2.2	3.6	3.25
2011	1.3	2.5	2.20
2012	0.85	1.3	1.19
2013	0.8	1	0.95
2014	0.57	0.95	0.86
2015	0.55	0.93	0.84
2016	0.5	0.9	0.80
2017	0.45	0.86	0.76
2018	0.4	0.75	0.66
2019	0.36	0.73	0.64
2020	0.35	0.73	0.41

The lowest price for 2020 is the average price for installation above 100 kWp, whereas the highest price is given by the highest module price on the market. The typical module price in 2020 is 0.41 CHF/W. There wasn't any substantial reduction in the module price between 2019 and 2020. The chosen methodology explains this difference. Until 2019 the price was based on field experience. The value for 2020 is computed as the weighted average of average module price for each PV capacity range and market size of each PV capacity range.

2.2 System prices

Table 8: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices [CHF/W]
Off-grid 1-5 kW	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid.	6
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	2.4 to 3.1
Residential BIPV 5-10 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected households. Typically, on villas and single-family homes.	2.6 to 4.7
Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1.3 to 2.4
Small commercial BIPV 10-100 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1.4 to 3.6
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1.0 to 1.3
Large commercial BIPV 100-250 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	1.1 to 2.0
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	0.9 to 1.1 (lowest 0.7)
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	N/A
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	N/A

Table 9: National trends in system prices for different applications

Year	**Residential BAPV** Grid-connected, roof-mounted, distributed PV system 5-10 kW **[CHF/W]**	**Small commercial BAPV** Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[CHF /W]**	**Large commercial BAPV** Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[CHF /W]**	**Centralized PV** Grid-connected, ground-mounted, centralized PV systems 10-50 MW **[CHF /W]**
2010	7.1 - 6.6	6.6 - 5.5	5.5 - 5	-
2011	-	-	-	-
2012	5 - 4.6	4.6 - 3.4	3.4 - 3	-
2013	-	-	-	-
2014	-	-	-	-
2015	4.8 - 3.5	-	-	-
2016	4.8 - 3.5	-	-	-
2017	4.2 - 3.3	-	-	-
2018	3.6 - 2.6	2.6 - 1.4	1.4 - 1.2	-
2019	3.5 - 2.5	2.5 - 1.3	1.3 - 1.2	-
2020	3.1 - 2.4	2.4 - 1.3	1.3 - 1.0	-

The dependence of PV system costs on its size is shown in Figure 4.

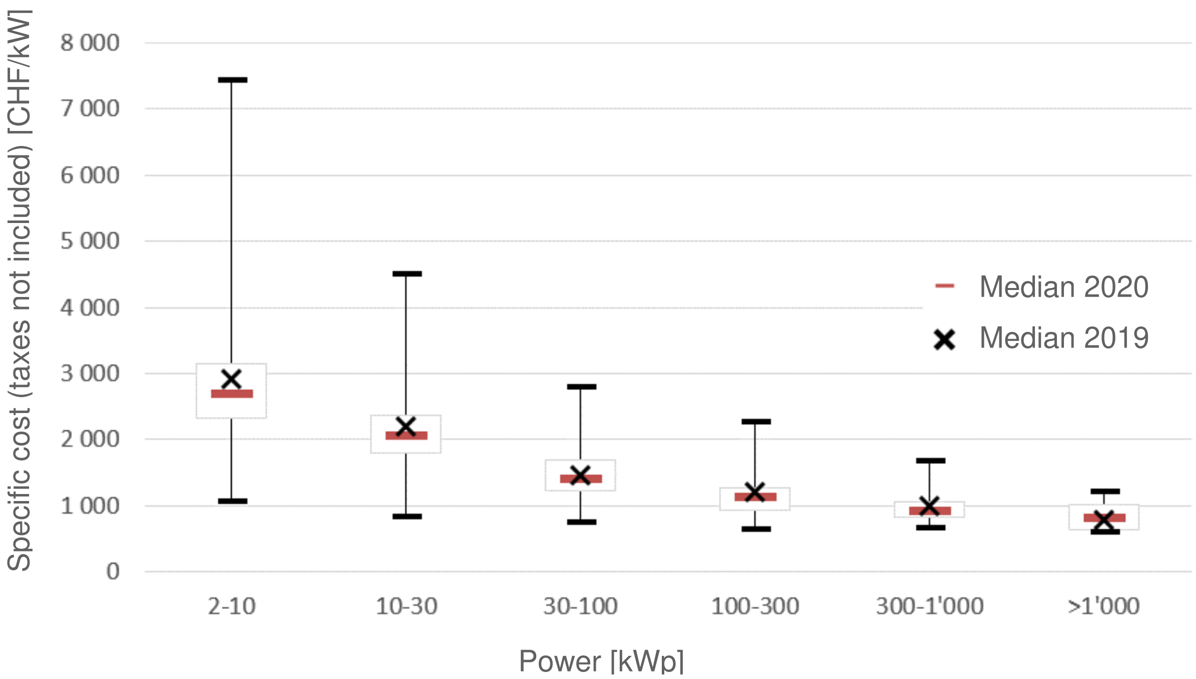


Figure 4 : Grid-connected PV system specific costs (source : *Observation des prix du marché photovoltaïque 2020,* figure 26)

2.3 Cost breakdown of PV installations

The cost breakdown of a typical 5-10 kW roof-mounted, grid-connect, distributed PV system on a residential single-family house at the end of 2020 is presented in Table 10.

The cost structure presented is from the customer's point of view. I.e., it does not reflect the installer companies' overall costs and revenues. The "average" category in Table 10 and **Erreur ! Source du renvoi introuvable.** represents the average cost for each cost category a nd is the average of the typical cost structure. The average cost takes the whole system into account and summarizes the average end price to the customer. The "low" and "high" categories are the lowest and highest cost that has been reported within each segment. These costs are individual posts, i.e. summarizing these costs does not give an accurate system price.

A comprehensive cost survey has been published for 2020. The results are presented in the pie charts below:

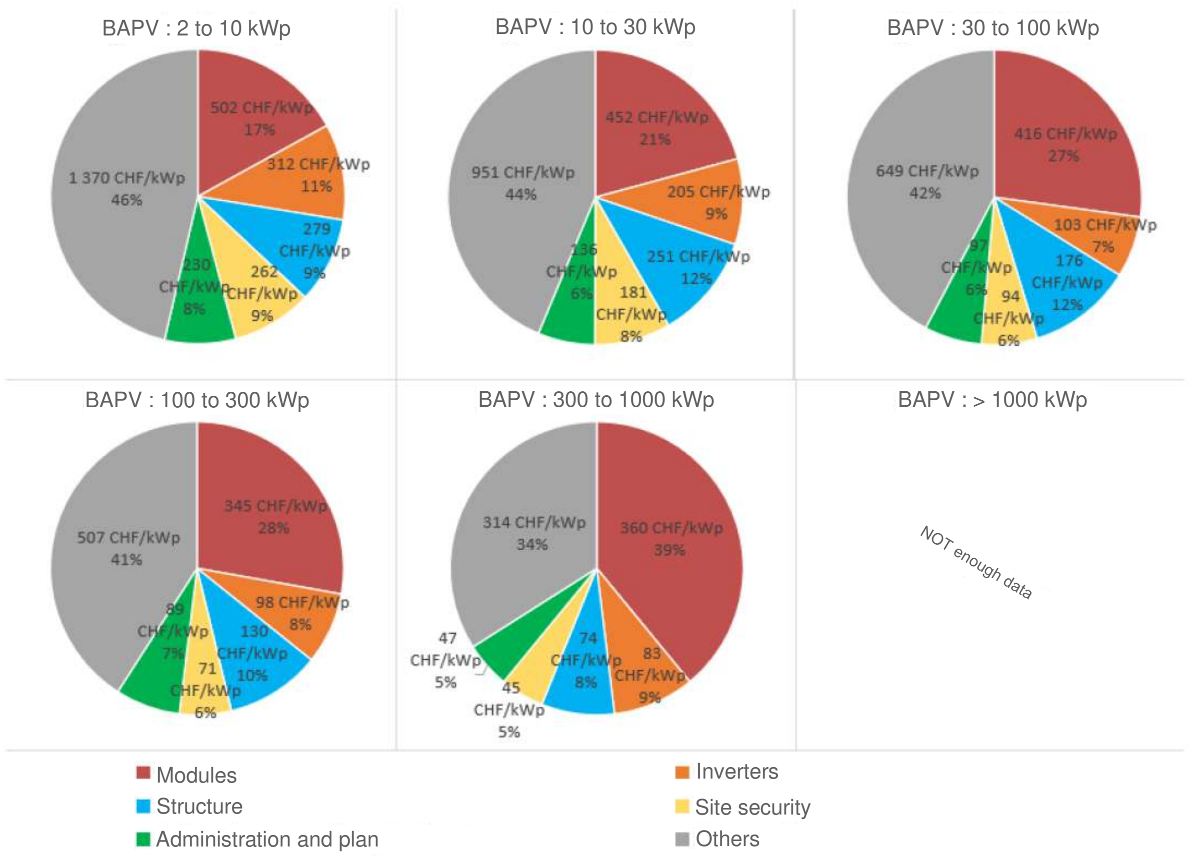


Figure 5 : Breakdown of the costs of added photovoltaic installations, divided into six main categories

Table 10: Cost breakdown for a grid-connected roof-mounted, distributed residential PV system of 5-10 kW

Cost category	Average [CHF/W]
Module	0.502
Inverter	0.312
Mounting material	0.279
Other electronics (cables, etc.)	0.296
Subtotal Hardware	**1.389**
Planning	0.230
Installation work	0.854
Shipping and travel expenses to customer	0.076
Permits and commissioning (i.e. cost for electrician, etc.)	0
Project margin	0.21
Subtotal Soft costs	**1.370**
Total (excluding VAT)	**2.759**
Average VAT	7.7%
Total (including VAT)	**2.971**

2.4 Financial Parameters and specific financing programs

Table 11: PV financing information in 2020

Different market segments	Loan rate [%]
Average rate of loans – residential installations	1.25 - 1.40 *
Average rate of loans – commercial installations	2.30 - 3.20 *
Average cost of capital – industrial and ground-mounted installations	2.25 - 3.15 *

* Depending upon secured/unsecured, the specifics of the project and the duration

2.5 Specific investments programs

Table 12: Summary of existing investment schemes

Investment Schemes	Introduced in Switzerland
Third party ownership (no investment)	Yes. More and more companies and utilities offer contracting solutions for PV, either with a fixed contractual percentage of self-consumption (risk bared by the user) or without (risk bared by the investor)
Renting	No
Leasing	Yes. Various business models are explored, including leasing options, even for households.
Financing through utilities	Yes. Utilities are getting more active in the PV business. They finance PV installations either for their own portfolio or as contracting solutions for end-consumers. They are actively integrating PV in their business, including buying PV installation companies. Most utilities have now their own PV installations department
Investment in PV plants against free electricity	While this investment scheme has been employed by some utilities (investment per m2 of modules, production corresponding to the investment is deducted from the electricity bill), is it not compatible with the regulation. If still employed, it is mainly against PV green certificates.
Crowd funding (investment in PV plants)	Yes. Similar to above but usually mainly for green certificates, niche market. For investment, mainly cooperative society and crowdlending.
Community solar	Yes, it is growing thanks to the new possibilities of collective self-consumption introduced in

	2018. Community solar is increasing significantly for new residential buildings. Another possibility is cooperatives that invest in PV plants and repay the invested capital with a small dividend based on the annual performance.
International organization financing	Not applicable

2.6 Additional Country information

Table 13: Country information

Retail electricity prices for a household [CHF/kWh]	0.2071
Retail electricity prices for a commercial company [CHF/kWh]	0.1872
Retail electricity prices for an industrial company [CHF/kWh]	0.1414
Liberalization of the electricity sector	Currently, only large consumers (>100MWh/year) have access to a liberalized electricity market. However, an amendment of the law (LApEl) is currently under consultation to allow all consumers to freely choose their electricity supplier.

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

Table 14: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2020	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	Yes	-	Yes	-	-	-
Feed-in premium (above market price)	Yes	-	Yes	-	-	-
Capital subsidies	Yes	-	Yes	-	-	-
Green certificates	Yes	-	Yes	-	-	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	Yes	-	Yes	-	-	-
Self-consumption	Yes	-	Yes	-	-	-
Net-metering	-	-	-	-	-	-
Net-billing	Yes	-	Yes	-	-	-
Collective self-consumption and delocalized net-metering	Yes	-	Yes	-	-	-
Sustainable building requirements	Yes	-	Yes	-	-	-
BIPV incentives	Yes	-	Yes	-	-	-

3.1 National targets for PV

The transformation of the Swiss energy system aimed at with the "Energy Strategy 2050" is a long-term project. Electricity production from photovoltaics is one of the key pillars in the strategy for the future Swiss electricity supply. The latest objective called 2050+ aims to generate 34 TWh from photovoltaics in 2050. The 2020 record installation rate of 475 MWp/year is not sufficient to reach this objective by 2050 and should be raised to approximately 1000 MWp/year without taking into account the replacement of the installed capacity. Considering the replacement, the installation rate should reach 1100 MWp/year, corresponding to the steady-state rate to maintain a photovoltaic generation of 34 TWh. As this rate is not expected to be reached from next year, a higher rate will be required before slowing down to the steady-state rate in 2050.

A forecast of renewable generation per year is shown in Figure 6.

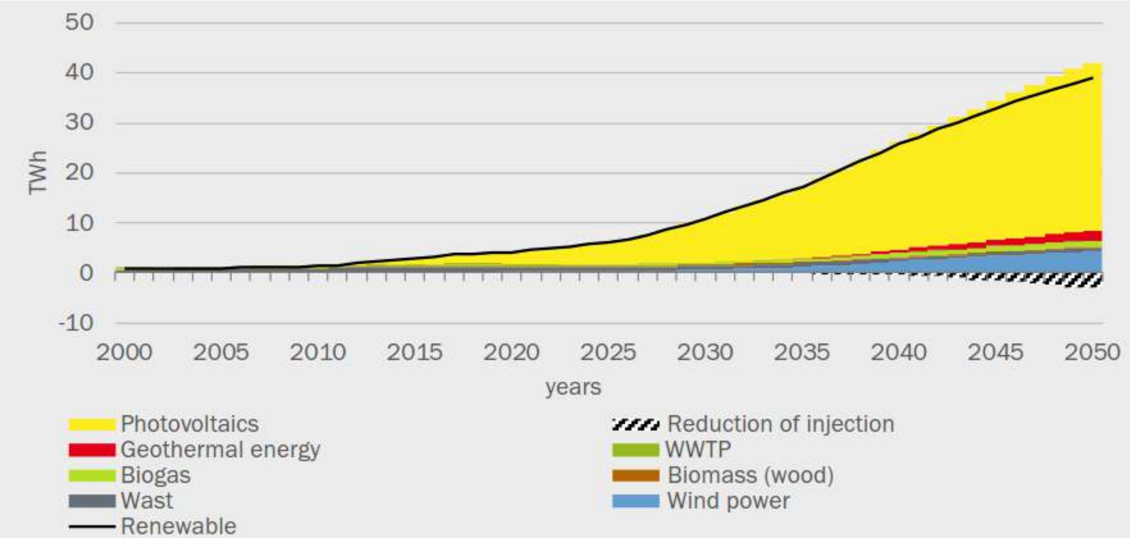


Figure 6 : Production of electricity from renewable energy sources. Source : Prognos SA / TEP Energy Sàrl / INFRAS SA 2020

The Swiss Federal Office of Energy announced in September 2018 that the PV potential on the Swiss roof was about 50 TWh. The evaluation is based on the national maps for PV roofs (www.toitsolaire.ch) and selecting the most suitable roofs. The tool is online for all of Switzerland and is translated into English. It is possible to have an evaluation of the approximate PV potential of every single roof in Switzerland. Since April 2019, it also includes the potential of façades of 17 TWh. This potential is considered somewhat optimistic. A more detailed analysis estimates the Swiss roof-top PV potential to be 24 ± 9 TWh. Therefore, the potential of façades and others surfaces (parking, floating PV, …) will probably need to be exploited.

3.2 Direct support policies for PV installations

3.2.1 One-time remuneration

At the national level, the primary support measure is a one-time remuneration. This direct subsidy depends on the installed capacity, as detailed in the Table below. It allows reducing the investment cost by 20%-30%. This support measure is financed through a levy on electricity consumption. In 2018, this network surcharge was increased from 1.5 ct/kWh to 2.3 ct/kWh

One-time remuneration as a function of commissioning date:

BAPV	01.04.2018-31.03.2019	01.04.2019-31.03.2020	01.04.2020-01.04.2021	Since 01.04.2021
Base contribution (CHF)	1400	1400	1000	700
Additional contribution (CHF / kW)				
< 30 kW	400	340	340	380
< 100 kW	300	300	300	290
> 100 kW	300	300	300	290

3.2.2 BIPV development measures

The one-time remuneration scheme is approximately 10% higher for BIPV than BAPV for PV installations smaller than 100 kW. This difference is being reduced, especially from 2020 onwards.

One-time remuneration as a function of commissioning date:

BIPV	1.4.2018-31.3.2019	1.4.2019-31.3.2020	01.04.2020-01.04.2021	Since 01.04.2021
Base contribution (CHF)	1600	1550	1100	770
Additional contribution (CHF / kW)				
< 30 kW	460	380	380	420
< 100 kW	340	330	330	320
> 100 kW	For systems larger than 100 kWp, the one-time remuneration is the same as the one for BAPV			

In addition to the federal subsidies for BIPV, some communities also give incentives for PV facades (e.g. bonus of 50% compared to roof-top).

Also, several innovative BIPV projects (such as using specifically designed modules for protected buildings or resulting in energy self-sufficient buildings) have been supported by a special fund for pilot and demonstrator projects from the government. BIPV projects are also incentivized by constraints set by the building permit process for buildings having a cultural value.

3.3 Self-consumption measures

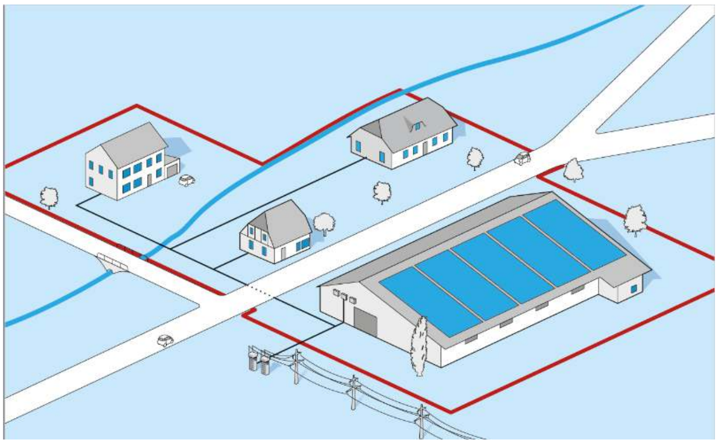
Table 15: Summary of self-consumption regulations for small private PV systems in 2020

PV self-consumption	1	Right to self-consume	Yes, since 2014
	2	Revenues from self-consumed PV	Savings on electricity bill (which is 2-3 times higher than feed-in tariffs), almost 90% of the bill is directly or indirectly related to energy (kWh), making self-consumption very profitable
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	No, some DSO charge for installing a bi-directional energy meter. It is currently being debated to attribute a larger part of the grid fee to power and not to energy in order to increase the contribution of self-consumers to grid cost
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Depending on DSO (range of 5-15 cts/kWh, average price around 9ct/kWh), often including the revenue for green certificates.
	5	Maximum timeframe for compensation of fluxes	Real-time (standard metering timeframe of 15 minutes)
	6	Geographical compensation (virtual self-consumption or metering)	Local with the same user of collective self-consumption.
Other characteristics	7	Regulatory scheme duration	The compensation scheme for excess electricity is adjusted every year (with the exception of the national feed-in tariff, which is fixed over 15 to 25 years)
	8	Third-party ownership accepted	Yes, most utilities are now active to propose PV contracting and self-consumption to their large customers
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Until 2018, some utilities applied a different tariff structure for prosumers (power metering). From 2018 onward, only one tariff structure is allowed for prosumers with an annual consumption smaller than 50 MWh and with a connection to the grid below 1 kV
	10	Regulations on enablers of self-consumption (storage, DSM…)	In some cases, heat pumps or resistive heating systems are remotely controlled by the DSO, but not necessarily in a way that optimizes self-consumption. DSM is common for industries to avoid power peaks but can be used to optimize self-consumption as well. Thanks to more solutions available for DSM, more and more single

			household owners with PV systems are interested in increasing self-consumption. Specific recommendations exist for connection and metering of storage systems
	11	PV system size limitations	No PV size limitations
	12	Electricity system limitations	No
	13	Collective self-consumption, solar communities and similar measures	Collective self-consumption has been allowed by most DSOs, of which there are more than 500, since 2014. Previously, self-consumption was restricted to consumers in the same building or within the same perimeter of land. In this context, the DSO was also responsible for billing every customer. With the new legislation that came into force in January 2018, collective self-consumption opportunities are improved significantly. End-consumers can form a community as long as their land is contiguous and the public grid is not used i.e. it is a single grid-connection, acting as a unique connection point towards the DSO. The internal metering is then under the responsibility of the consortium. This also allows the consumers to access the free electricity market, an additional strong incentive as long as the new self-consumption consortium has an electricity consumption above 100 MWh/year. Collective self-consumption has also been improved to create investment security for third-party ownership in case of a building occupied by tenants. Under specific conditions, the tenant should purchase the collectively produced PV electricity

3.4 Collective self-consumption, community solar and similar measures

Collective self-consumption has been allowed by most DSOs (Switzerland has more than 600 DSOs) since 2014, but it used to be restricted to consumers of the same building or within the same perimeter of land. In this context, the DSO was also responsible for billing every customer.



With the new legislation that came into force in January 2018, collective self-consumption opportunities are improved significantly. End-consumers can form a community as long as their land is contiguous and the public grid is not used i.e. it is a single grid-connection, acting as a unique connection point towards the DSO.

The internal metering is then under the responsibility of the community. An additional incentive for collective self-consumption communities is the possibility to access the free electricity market if its consumption is above 100 MWh/year. Collective self-consumption becomes an enabler of a new step of market liberalization for small customers. It has also been improved to create investment security for third-party ownership in case of a building occupied by tenants (under a set of conditions, the tenant has to purchase the collective PV electricity).

Two types of collective self-consumption communities are available in Switzerland. The RCP (Regroupement de consommation propre) and the CA (Communauté d'autoconsommation). The Table below details the difference between these two options :

	RCP	CA
Number of consumers (seen by the DSO)	One	Many
Internal pricing for PV self-consumption	Strict rules	No rule
Minimum PV capacity	10% of the grid connection power	-
Consumers can leave the community whenever they want	No	Yes
Solidarity debtors	Owner	Consumers
Interests for the DSO		Data for each consumer
Interests for the consumer	Better prices Access to the free electricity market (if the RCP reaches a consumption of > 100'000 kWh/year	

This new measure allows for more flexibility for self-consumption and fosters the integration of PV in the local electricity grid.

The figure above illustrates a collective self-consumption community with 198kWp of PV and a self-consumption above 95% thanks to local battery storage.

More general information and examples can be found on the Suisse Energie platform: https://pubdb.bfe.admin.ch/fr/publication/download/7964

3.5 Tenders, auctions & similar schemes

There are no tendering schemes for PV systems in Switzerland. There are, however, several auction platforms for selling/buying green certificates (guarantee of origin). The price for those certificates has constantly dropped over the past years.

3.6 Other utility-scale measures including floating and agricultural PV

There are no specific utility-scale measures in place in Switzerland.

3.7 Social Policies

Public buildings are often considered for PV installations. It is mainly because law or recommendation mentions that public authorities have to put themselves in the spotlight and show the example.

There isn't any specific subsidy for low-income electricity consumers.

3.8 Retroactive measures applied to PV

No retroactive measure was applied in 2020.

3.9 Indirect policy issues

3.9.1 Rural electrification measures

No specific rural electrification measures are in place in Switzerland.

3.9.2 Support for electricity storage and demand response measures

There is no support scheme for electricity storage on a national level, however, some cantons (Thurgau, Appenzell Ausserrhoden, and Vaud) have introduced, for some times, direct subsidies for local storage solutions. Support sheme in Vaud and Appenzell ended in 2020.

There are ongoing discussions of some DSO for introducing new tariff designs that would allow for partial recovery of the investment costs if the storage system owner is willing to let the DSO party manage the storage unit. More and more utilities are also offering solutions for virtual storage. For a fee (fixed or per kWh), the owner of a PV system can use the DSOs grid as virtual storage for his PV production and use it later (basically a net-metering solution).

3.9.3 Minimum renewable energy for new buildings

In the framework of the MoPEC "modèle de prescriptions énergétiques des cantons" some cantons have chosen to impose a minimum renewable energy production for new buildings. For instance, in the canton de Vaud, 20% of the normalized electricity needs of new buildings should be directly covered by local renewable energy production such as photovoltaics.

3.9.4 Support for electric vehicles (and VIPV)

There is no direct national support scheme for electric vehicles in Switzerland.

Fully electric vehicles do not pay the automobile duty of 4%, and of course, since they do not run on fossil fuels, there is no petroleum tax to pay (as such, EVs do currently not contribute to road infrastructure). Electric vehicles also often pay reduced vehicle taxes, but there are significant differences from one canton to another.

Some communities give financial incentives for the installation of local charging stations (e.g. 20% subsidy). Since 2017, Swiss eMobility (Swiss Association for Electric Mobility) awards each year a prize (golden plug) to communities and cities with exceptional effort to push electromobility.

https://thedriven.io/wp-content/uploads/2019/04/55164.fr_.en_.pdf

3.9.5 Curtailment policies

For PV installations over 3MWp or production over 5000 MWh per year, the DSO is not bound to buy the injected energy, which restricts the number of such installations.

It is often difficult to obtain a permit to install PV systems elsewhere than on buildings because of the territory management laws currently in place, thus limiting the size and number of the installations.

Grid reinforcement and curtailment policies are so far rarely necessary because most development is based on the self-consumption ratio. Therefore, some PV installations are not even exploiting the full roof potential of building.

In a long-term perspective, it is discussed that the incentive (mainly the one-time remuneration) should focus on promoting the reduction of the AC-DC ratio of PV installations to reduce the need for complicated curtailment policies.

3.9.6 Other support measures

Minergie, a leading building standard organization supported by the cantons and the Swiss Federal Office of Energy and the building industry, revised its building standards in 2016. PV has become quasi-mandatory to fulfill the requirements for the nearly zero-energy standards. Since for a Minergy labeled building, only 40% of the grid-injected electricity can be counted for the overall energy requirements, there is an additional incentive to optimize self-consumption (DSM, battery).

These voluntary building standards helped pave the way for the new building standards defined by the cantons (10 Watt PV per square meter of heated area in new buildings).

Since 2015, the Swiss government has published a recommendation for the energy policies in cantons. These regulations should include a requirement for PV in every new building. In some cantons (e.g. Vaud), a requirement of including about 10 W PV per square meter of heated area for new buildings is already implemented, others are expected to adapt their cantonal energy acts accordingly in the coming years. It is also recommended to include 10% renewable energy when the heating system has to be retrofitted. PV can be an option, among others.

A negative measure hindering PV development are the restrictions on installing PV systems in some cities (for example for places listed as UNESCO World Heritage), enforce restrictions on installing PV systems on roofs (color of modules/frames, module layout) and sometimes purely reject ridge, orientation, or even pure rejection), which also hinders PV development.

National researches (Extract from the PVPS Annual report 2020)

The Swiss Federal Office of Energy (SFOE) runs a photovoltaic RTD programme that involves a broad range of stakeholders. The programme is part of the long-standing coordinative activities by the SFOE to support research and development of energy technologies in Switzerland, where funds deployed in a subsidiary manner aim to fill gaps in Switzerland's funding landscape. Grants are given to private entities, the domain of the Swiss Federal Institutes of Technology (ETH), universities of applied sciences and universities.

The focus of the photovoltaics programme lies on RD&D from basic research, over applied research, product development, pilot and demonstration projects. On average, the volume of the SFOE programme support (including pilot and demonstration) is in the order of 10% of the total public support for photovoltaics research in Switzerland, which is in the order of 36 MCHF per year (including roughly 30% from European projects) (https://pv.energyresearch.ch/projects).

The SFOE photovoltaics programme supports research and pilot & demonstration in different areas of photovoltaic cell technologies (namely c-Si, CIGS and perovskites), in the field of photovoltaic modules and building integration of photovoltaics, as well as in the topics of system aspects of photovoltaics such as grid integration, quality assurance of modules and inverters or battery storage technology. Other topics are life cycle analysis, solar forecasting and performance monitoring. International co-operation on all levels, related to activities in the Horizon 2020 programme of the European Union, the European PV Technology and Innovation Platform, the European SOLAR-ERA.NET Network, the IEA PVPS Technology Collaboration Programme and in technology co-operation projects is another key element of the programme.

3.10 Financing and cost of support measures

National PV incentives (one-time remuneration and feed-in tariff) are financed by a network surcharge paid on a kWh-basis by all electricity consumers. Under certain conditions, companies for which electricity cost exceeds 10% of their gross value can be reimbursed.

In January 2018, the network surcharge was increased from 1.5 ct/kWh to 2.3 ct/kWh. This corresponds to a burden of 103.5 Swiss francs per year (67.5 in 2017) for an average household consuming 4'500 kWh.

In 2020, the following amount was paid for the two incentive measures:

- One-time remuneration: 262 Million CHF (to 20'190 small installations and 1'200 large ones – 1'400 more large installations were promised to receive the remuneration later in 2021)

4 INDUSTRY

4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

There is no feedstock, ingots, and wafers production in Switzerland

4.2 Production of photovoltaic cells and modules (including TF and CPV)

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

Total PV cell and module manufacture together with production capacity information is summarised in Table below.

Table 16: PV cell and module production and production capacity information for 2020

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe, CIGS)	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Megasol Switzerland *	Mono Perc	-	no data received	-	no data received
3S Solar Plus**	Mono Perc	-	~15 MWp (75’000m²)	-	60 MW (300’000 m2)-
Thin film manufacturers					
Flisom	Flexible CIGS	-	No data provided	-	15 MW pilot line
Totals		0	55 MWp	0	140 MWp

* Megasol also has a production facility of 130 MW capacity in Ningbo, China, for standard high-performance modules, they produced 120 MW in 2019. In Switzerland, they installed a production line (40 megawatts expanded to 80 megawatts in 2016) in Deitingen SO since 2013, which specializes in glass-glass modules and small series / custom-made products (size, shape, and color).

There is no cell production in Switzerland, except for pilot lines for new technologies such as SmartWire connection Technology SWCT (Meyer Burger) or CIGS (Flisom)

**Swiss manufactures are specialized in BIPV products. 3S Solar Plus (previously Meyer Burger) produces its Megaslate module (a roofing material consisting of roof tiles, PV tiles, and thermal tiles.) as well as hybrid (PV and solar thermal) collectors. Due to a growing number of complaints related to the glare of PV installations, 3S Solar Plus has developed a special glare free module (MegaSlate Satinato).,

(Extract from the PVPS Annual report 2020)

2020 was a year of transformation for the Swiss company Meyer Burger with a complete reorientation from a supplier of equipment to a manufacturer of solar cells and modules based on its own heterojunction/smart-wire technology, developed in Switzerland over the past 13 years in strong collaboration with Swiss research institutions. In order to be able to finance the transformation, the company successfully completed a capital increase of 165 MCHF, following the approval of the shareholders at the extraordinary general meeting in July 2020. Meyer Burger selected the traditional solar locations in Germany (Bitterfeld-Wolfen in Saxony-Anhalt and Freiberg in Saxony) to set up production facilities. Production start is planned for the first half of 2021, with 400 MW solar cells and 400 MW solar module. Expansion of the production up to 5 GW is planned.

4.3 Manufacturers and suppliers of other components

Switzerland has a strong industry for BOS-components. Among them are the following companies:

Inverter

Studer Innotec manufactures inverters and chargers for stand-alone and storage solutions, mostly for remote sites without grid access all over the world.

Junction Boxes/Connectors:

Stäubli Electrical Connectors (former Multi Contact AG) is the leading manufacturer of cables and connectors for PV Systems. They claim that over 200 GW of PV is connected using their connectors and to have market share of 50% with module connectors.

Cables

Huber & Suhner and Heiniger AG have been offering a variety of dedicated PV cables for several decades.

Supporting Structures

Montavent offers mounting systems for profiled metal and corrugated roofs.

ALUSTAND has mounting structures for tilted and flat roofs.

dhp technology AG offer flexible solar folding roof

Ernst Schweizer produces in-roof mounting systems (Solrif) as well as structures for flat and pitched roofs. They also produce solar thermal collectors for roof-top and façade applications.

Storage Batteries

Leclanché develops and produces energy storage systems with large format lithium-ion cells and has specialized in storage systems based on Lithium titanate technology.

Components for customized PV modules

Solaxess develops a nanotechnology-based film for producing white and colored solar panels without visible cells or connections.

SwissInso produces colored solar glass (Kromatix ™) by plasma processes for building integrated PV.

Most actors in the PV research & Technology in Switzerland are shown in Figure **7**. A list of the actors can be found on page indicated in the caption.

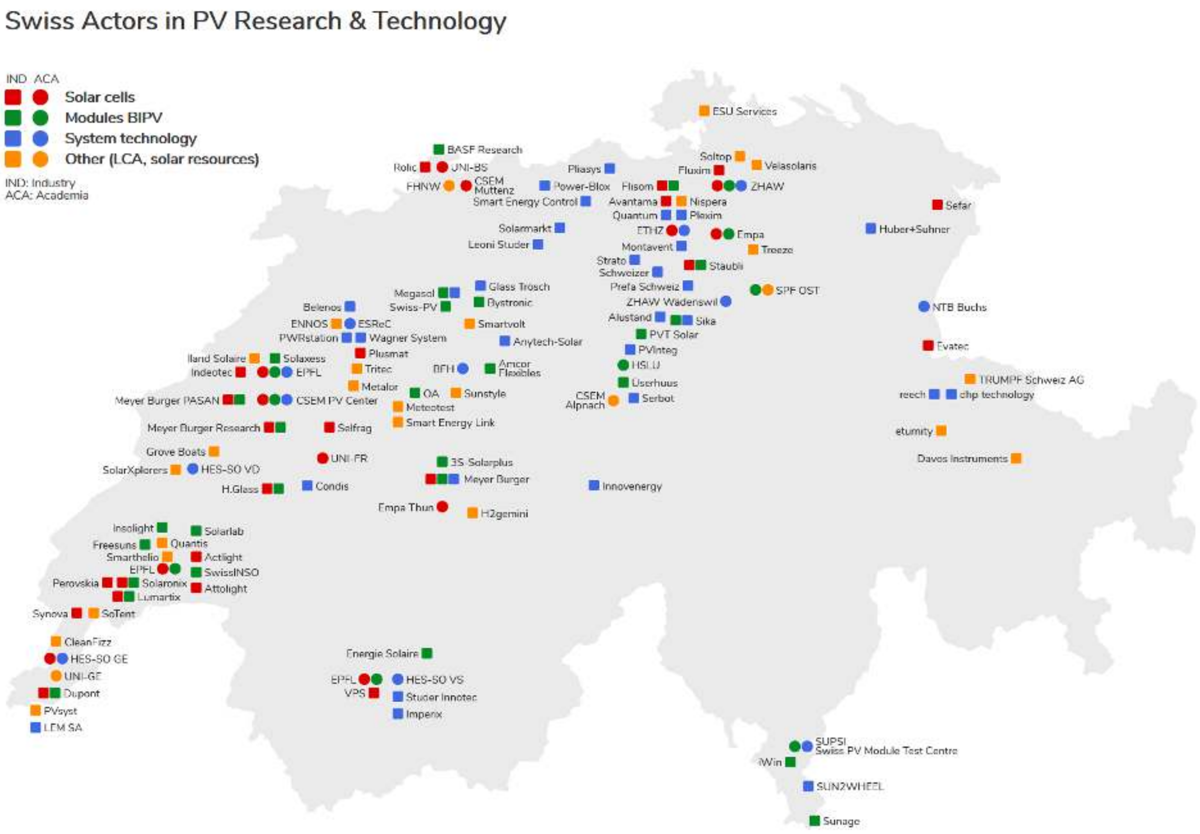


Figure 7 : https://pv.energyresearch.ch/index.php?ID=2000

5 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

5.1 Labour places

Table 17: Estimated PV-related full-time labour places in 2020

<table>
<tr><th>Market category</th><th>Number of full-time labour places</th></tr>
<tr><td>Research and development (not including companies)</td><td>200</td></tr>
<tr><td>Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D</td><td rowspan="2">6’200</td></tr>
<tr><td>Distributors of PV products and installations</td></tr>
<tr><td>Other</td><td>500</td></tr>
<tr><td>Total</td><td>6’900</td></tr>
</table>

5.2 Business value

Table 18: Rough estimation of the value of the PV business in 2020 (VAT is excluded)

Sub-market	Capacity installed [MW]	Average price [CHF/W]	Value	Sub-market
Off-grid	0.25	6	1’500’000	1’500’000
Grid-connected distributed	475.1	1.8	855’090’000	855’090’000
Grid-connected centralized	0	0	0	0
Value of PV business in 2020				856’590’000

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

6.1 Structure of the electricity system

The electricity system in Switzerland is divided into seven network levels, from the high-voltage transmission network (level 1) down to the low-voltage distribution to the end-consumer (level 7).

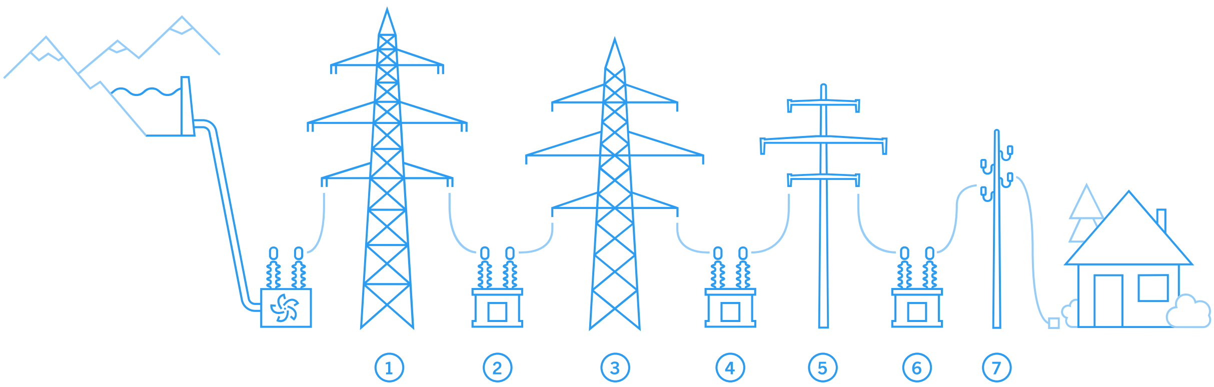


Figure 8 : Network level (source : https://www.swissgrid.ch/en/home/operation/power-grid/grid-levels.html)

Swissgrid is the national transmission grid operator at level 1 (380 kV and 220 kV transmission lines) and is responsible for grid stability and frequency control.

Switzerland's supply of electricity to end-users is made by more than 650 DSO companies. Many of them are also responsible for supplying water and gas. In some cantons and municipalities, a single vertically integrated company is responsible for these supply tasks, while in other cantons, a variety of companies share this responsibility. Some of the utilities may have only a few hundred customers, while others have more than 100’000 customers.

In terms of grid-interconnection of PV, there are national regulations and recommendations, but each DSO may have its specific technical interconnection conditions. There is, however, a tendency for harmonization and simplification, both in administrative and technical terms.

DSOs are required to accept electricity from a PV power plant up to 3’000 MWh per year, and there is a minimal tariff that has to be paid, calculated based on the DSOs procurement and generation cost.

6.2 Interest from electricity utility businesses

An increasing number of electricity utilities are entering the PV business. Especially larger utilities that have their own (non-solar) electricity production facilities have been under increasing financial pressure due to falling electricity prices on the European market and are therefore expanding their business activities. Due to the private-public status of most of the utilities (they are typically owned by the communities and the cantons), this development is not always well seen by the traditional PV installing companies

The following PV business models are implemented by electricity utilities

- Investment in their own PV plants for their production portfolio
- Establishment of subsidiary units for engineering and installation services (sometimes including the acquisition of PV installations companies)
- Offering contracting solutions for PV power plants, selling the PV electricity to the end-consumer
- Providing services for metering and billing within the newly possible (from 2018 onwards) self-consumption communities
- Virtual battery solutions, batteries on district level and EV charging stations

To intensify the exchange between the traditional solar sector (represented by Swissolar, the professional association) and the traditional grid stakeholders (represented by VSE/AES, the Swiss utility association), experts from both sectors meet regularly in working groups to revise recommendations for grid connections, metering requirements, battery exploitation schemes, etc.

6.3 Interest from municipalities and local governments

Municipalities and cities are key stakeholders in pushing the development of PV in their jurisdiction. On the one hand, they are becoming increasingly aware of their huge potential (on infrastructure owned by the local government such as schools, public buildings, etc.) and therefore invest themselves in PV power plants. On the other hand, they can create favorable conditions (simplified administrative procedures, for example) and grant additional local subsidies for solar, storage, or EV to push the development.

Municipalities are often pushing also collective self-consumption and promoting it for new urban developments

There is a label called “Energy City” and “Energy Municipality” which is awarded to cities and municipalities that live and implement a sustainable municipal energy policy. Energy cities promote renewable energies, environmentally-friendly mobility, and rely on the efficient use of resources.

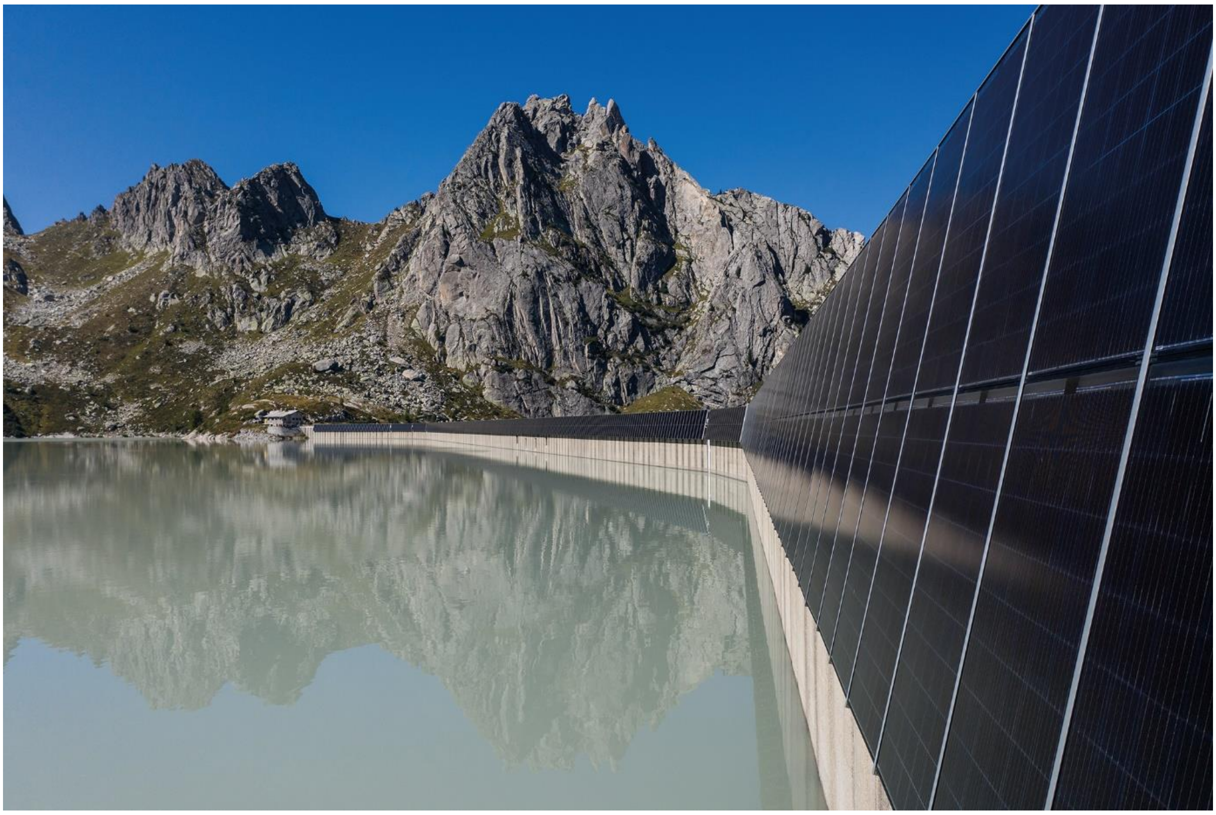
One example is the canton of Geneva that has set the target to produce 100 GWh of PV electricity by 2025.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

Despite the Covid19 pandemic that led to delays on construction sites and file processing, 2020 saw the record of added photovoltaic capacity with 475 MWp installed. This increase of 50% compared to 2019 is a first step in view of the new national energy transition 2050+ that aims to generate 34 TWh from photovoltaics in 2050.

New surfaces have to be considered to reach this objective and compensate for the lack of winter production. The near-vertical410 MWp PV installation on the Albigna dam in the Swiss alps, at an altitude of 2163 m.a.s.l. is a perfect example of this challenge.



7.2 **Prospects**

Figure 9 illustrates the numerous objectives for a climate-neutral Switzerland by 2050.

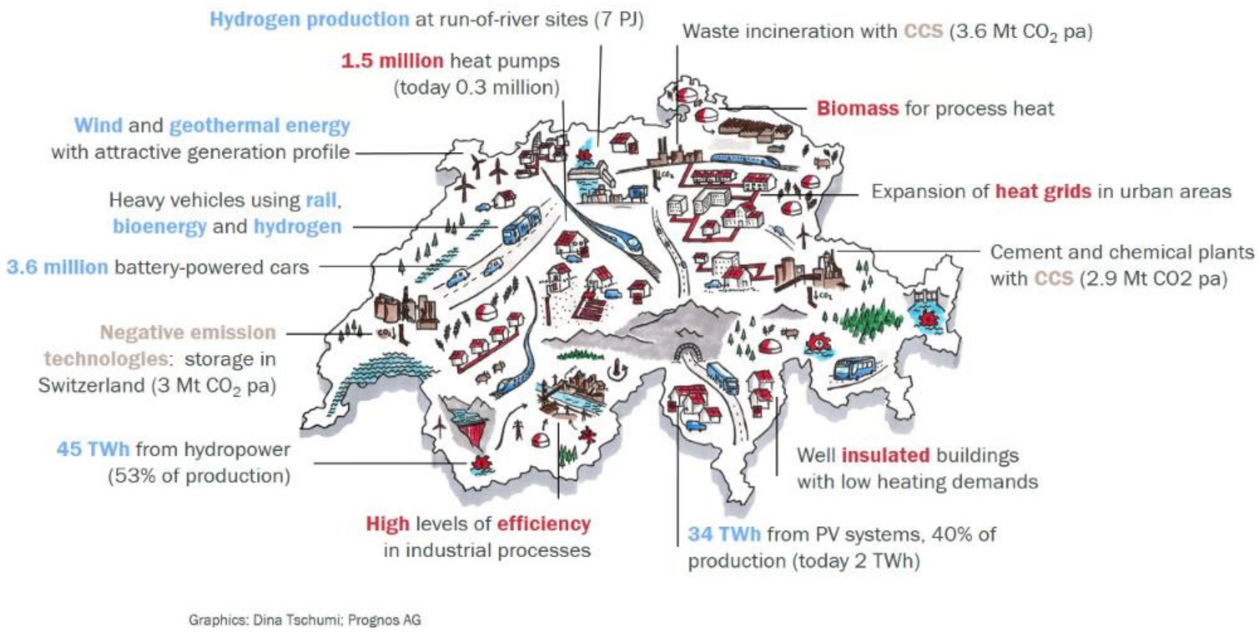


Figure 9 : https://www.bfe.admin.ch/bfe/en/home/policy/energy-perspectives-2050-plus.html

One of them is to generate 34 TWh from photovoltaics to compensate the decommissioning of nuclear power plants and the increase of the electricity consumption led by the transport and heating sectors.

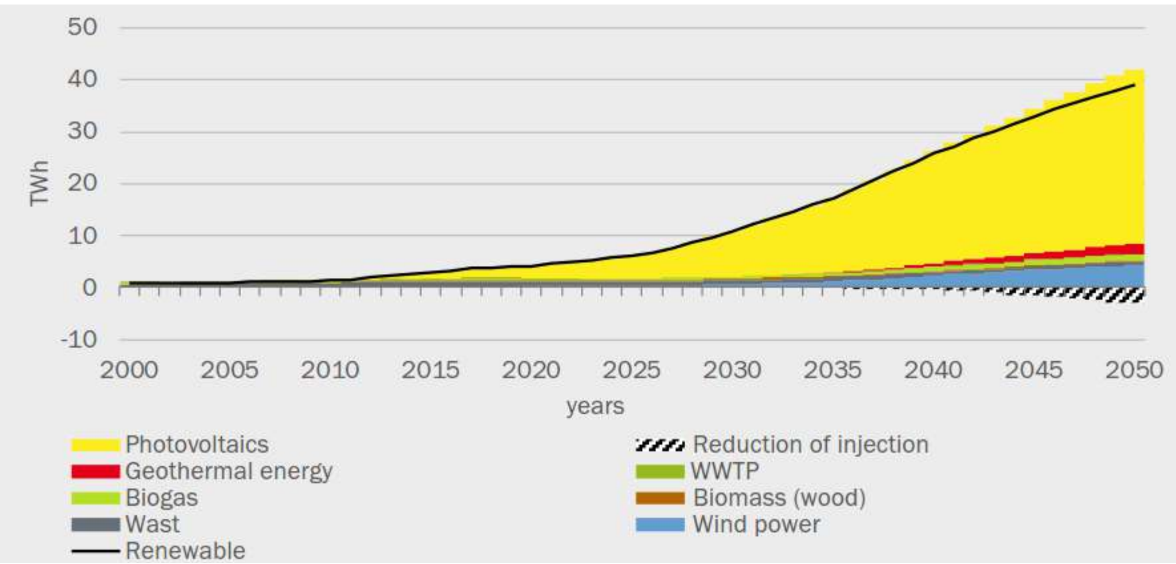


Figure 10 : Prognos SA/TEP Energy Sàrl/INFRAS SA 2020

Technology Collaboration Programme
by iea