Situation du PV: quelques généralités

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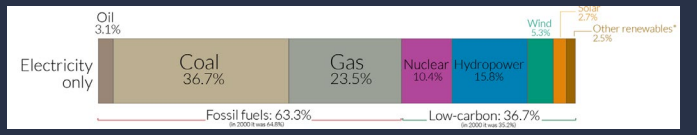
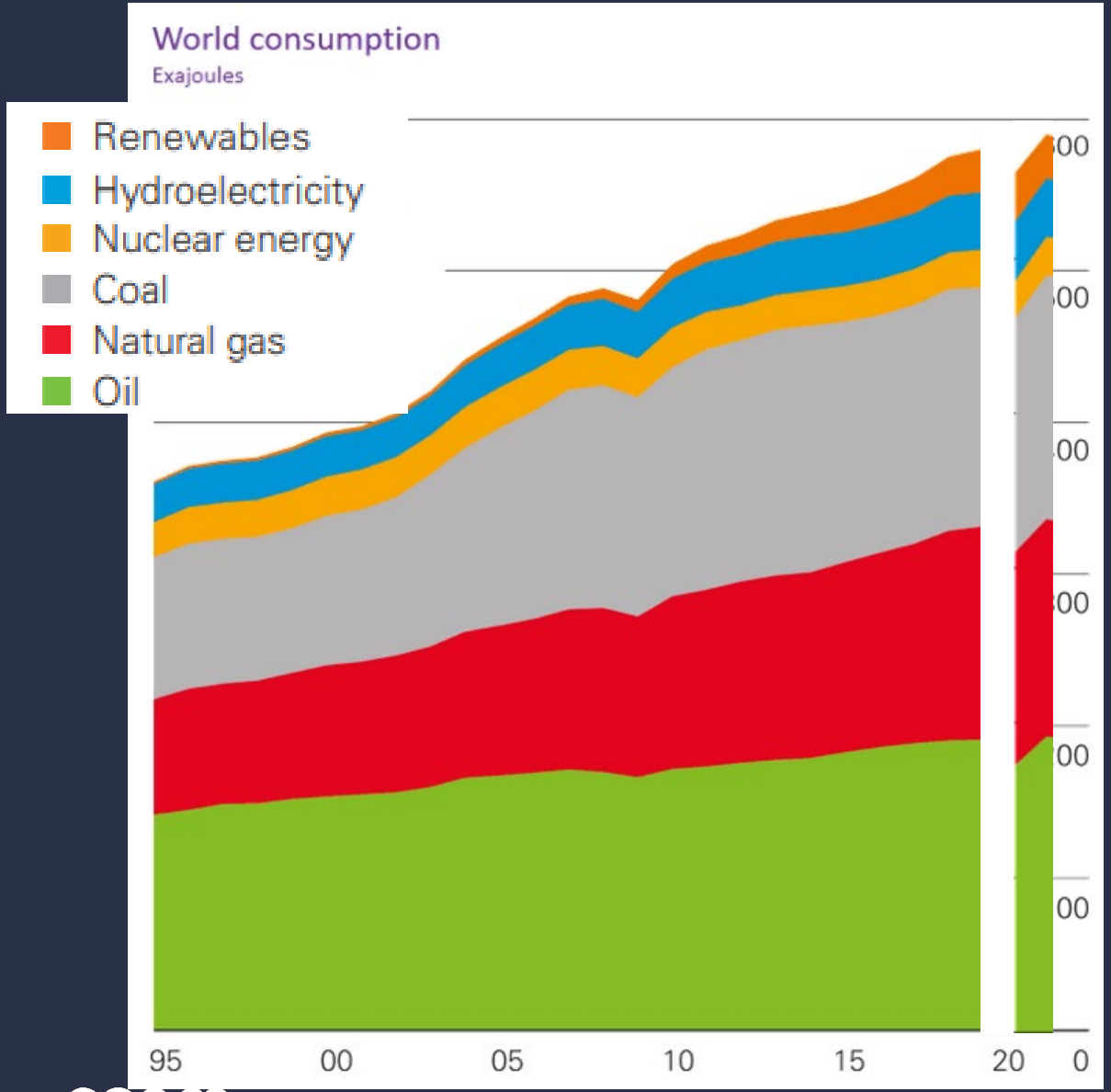
Forum PV, Yverdon, 2021

A long way to go in our energy consumption





166'000 TWh

Still 80% fossile fuel

Hope in the «dark orange part growth»

Electricitiy of biomass, hydro, solar, wind taken with a factor 1/0.38

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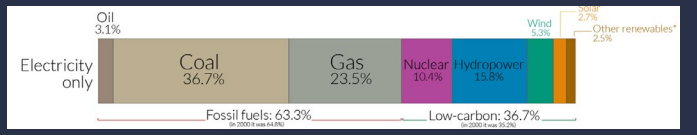
Quick rule of thumbs estimations for the world:



ourworldindata.org

- With a 2% growth in primary energy need → 250'000 TWh in 2050 (around 1000 x austria/ch today)
- Strong electrification of heating/mobility + power to gas (by 2030) with a gain of 2.5 + biomass

→100'000 TWh electrical production by 2050 (in 2020 hydro ~ 4300 TWh Nuclear 2600 TWh, wind 1500 TWh, Solar 700 TWh, Global around 25'000 TWh)

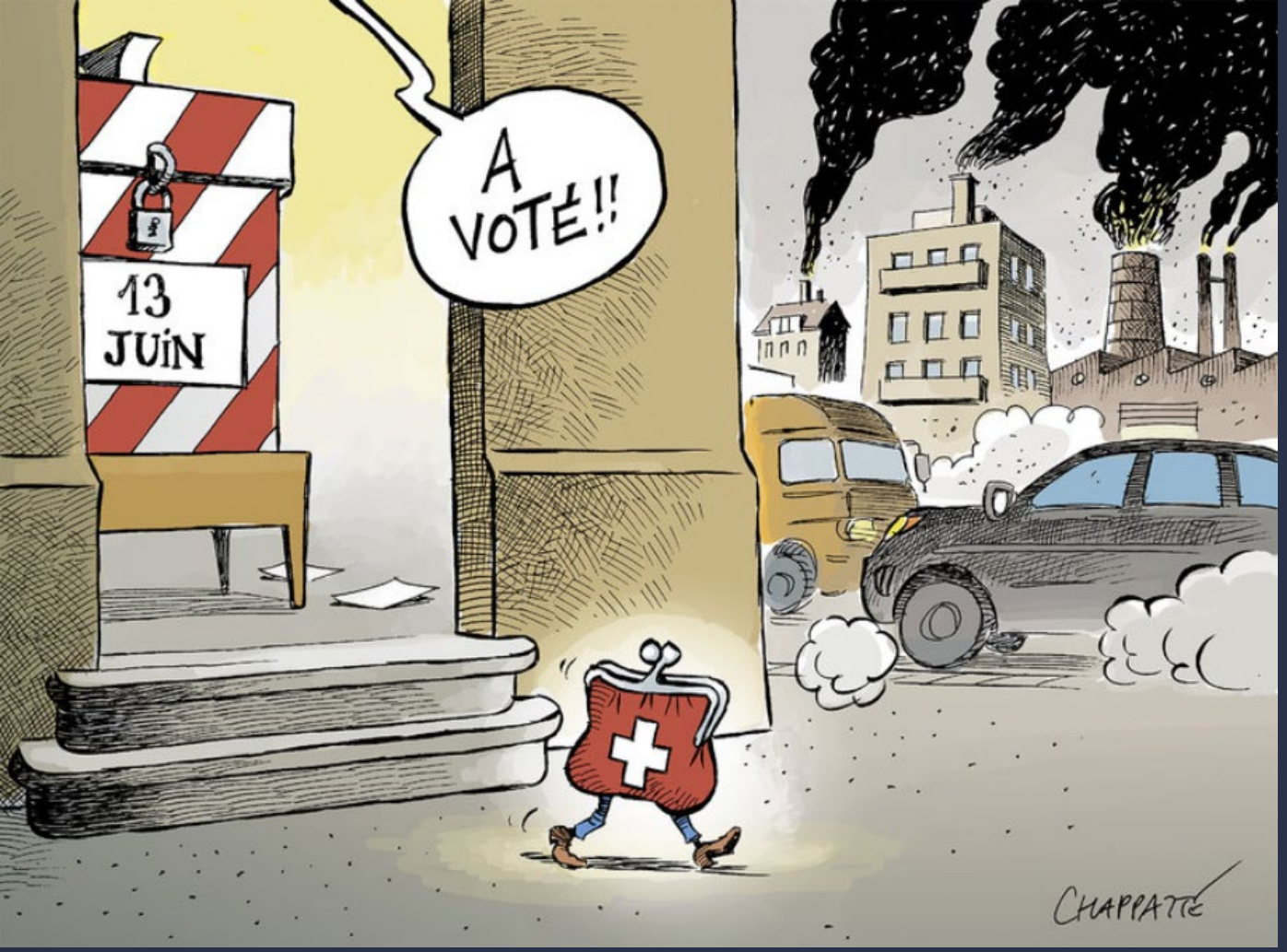
4 major options

a) e.g. 40 TW of Solar and 15 TW of Wind (+ Hydro + Biomass)

b) 11'000 x 1 GW nuclear power plants (or 100'000 MACR SMR)

c) Carbon sequestration

d) Don't care



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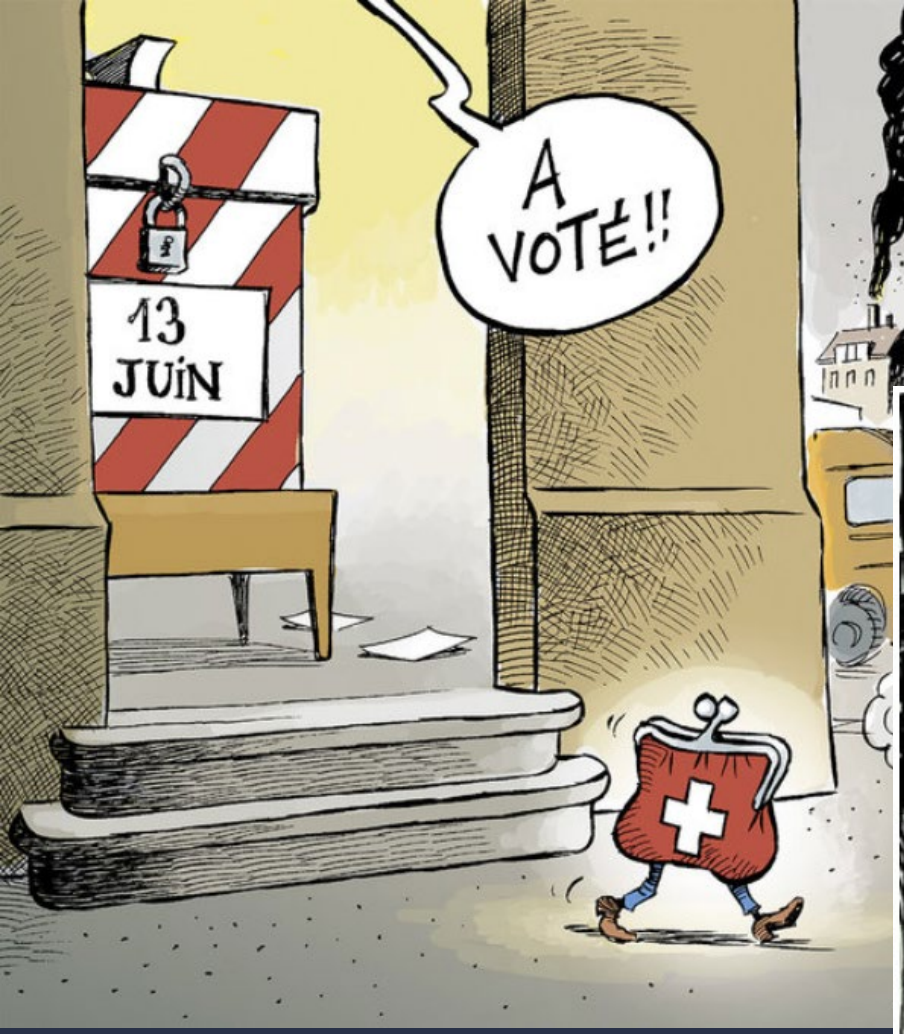
A VOTÉ!!
13 JUIN


LES CHANGEMENTS CLIMATIQUES SONT CAUSÉS PAR DEUX CHOSES: L'ACTIVITÉ HUMAINE ...
... ET L'INACTION HUMAINE
Time to act!
COP26
CHAPPATTE

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Today's «Guardian» front page

'Reality check' /
Global CO2 emissions shooting back to record levels

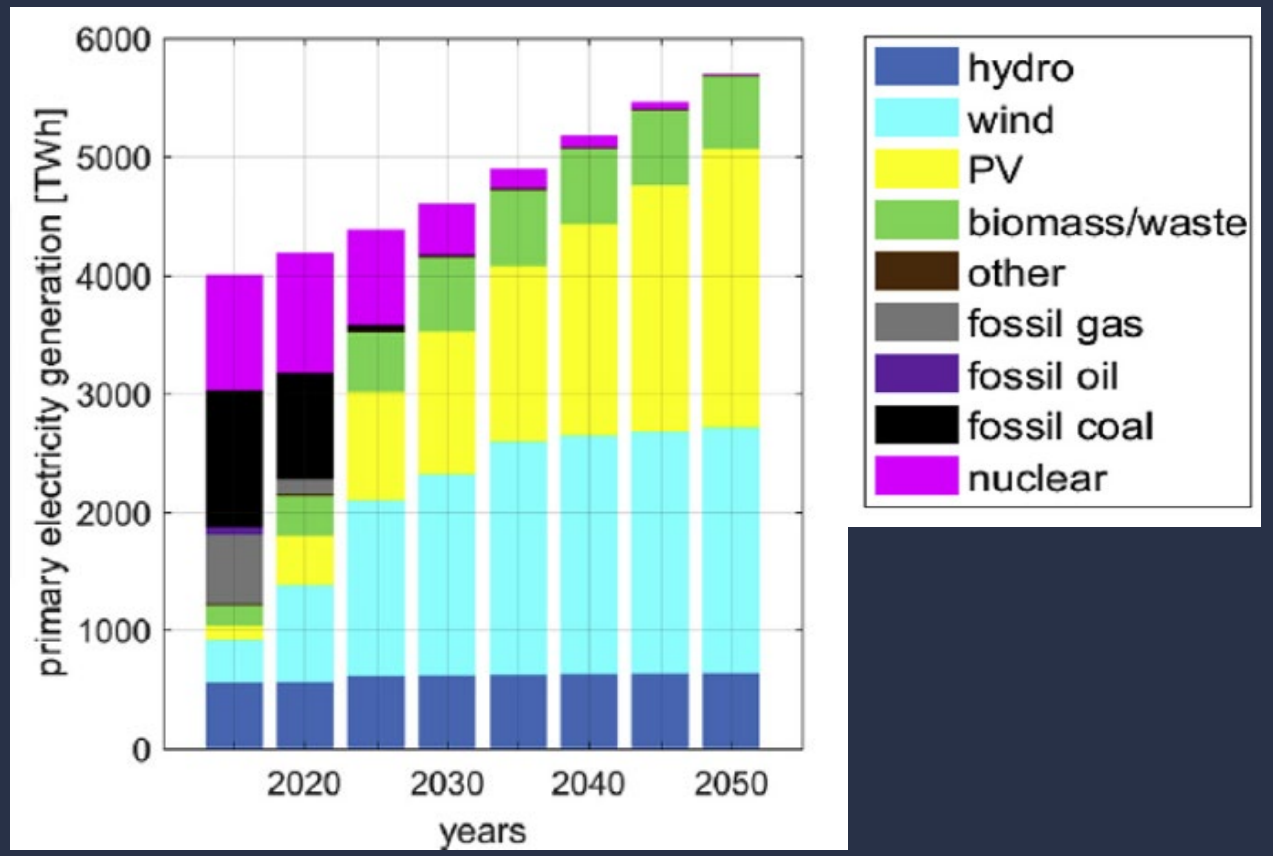
Fossil fuels are surging in post-pandemic recovery as scientists warn 1.5C emission limits will be reached in 11 years

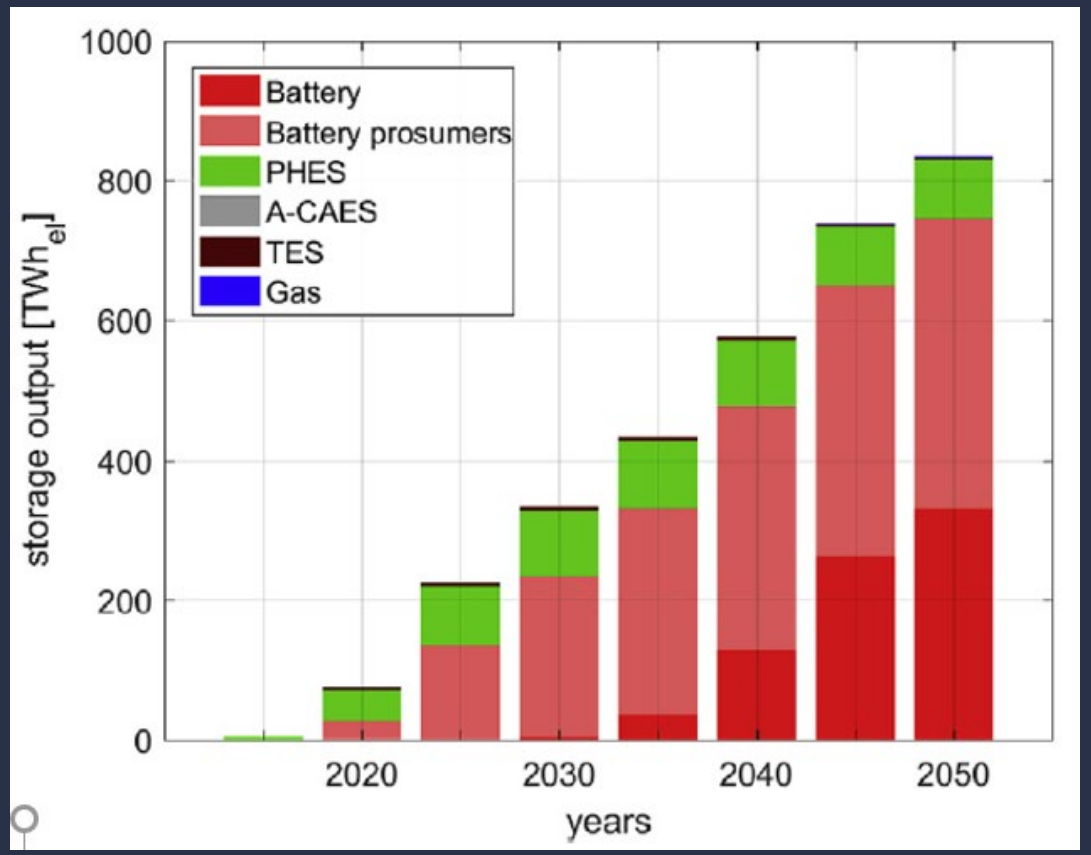
Facebook Climate misinformation on social network 'increasing substantially', study says

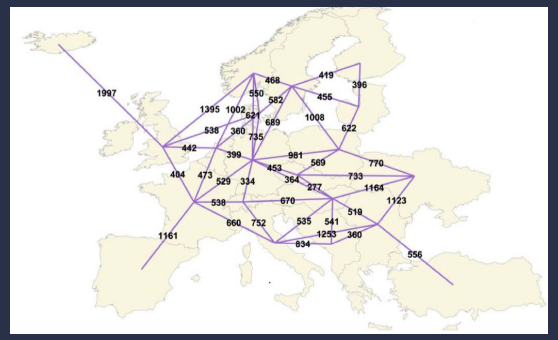
Cop26 More than 40 countries agree to phase out coal-fired power

US Oil giants top list of lobby offenders holding back climate action

A short look at Europe (in a area connected scenario) for clean power sector (with only moderate electrificiation) **







Michael Child, C. Breyer, et al. Renewable Energy 139 (2019) 80-101

Battery storage and pumped hydro necessary to balance the grid on an hourly basis

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Cheaper and greener: unbeatable price for solar and wind in large systems

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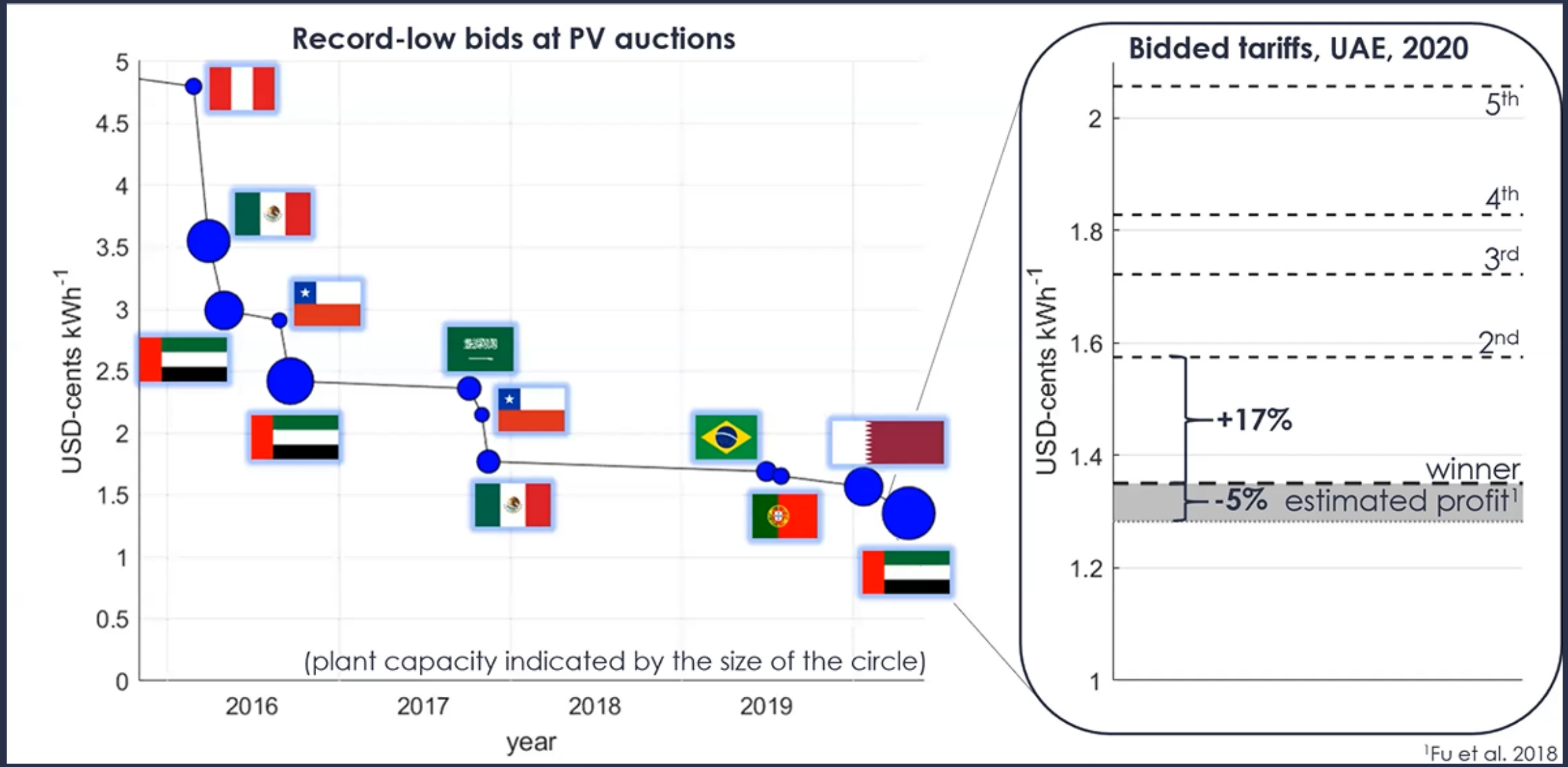

In 2030. less than 1 cts/kWh in Sunny country and hydrogen for < 1$/kg

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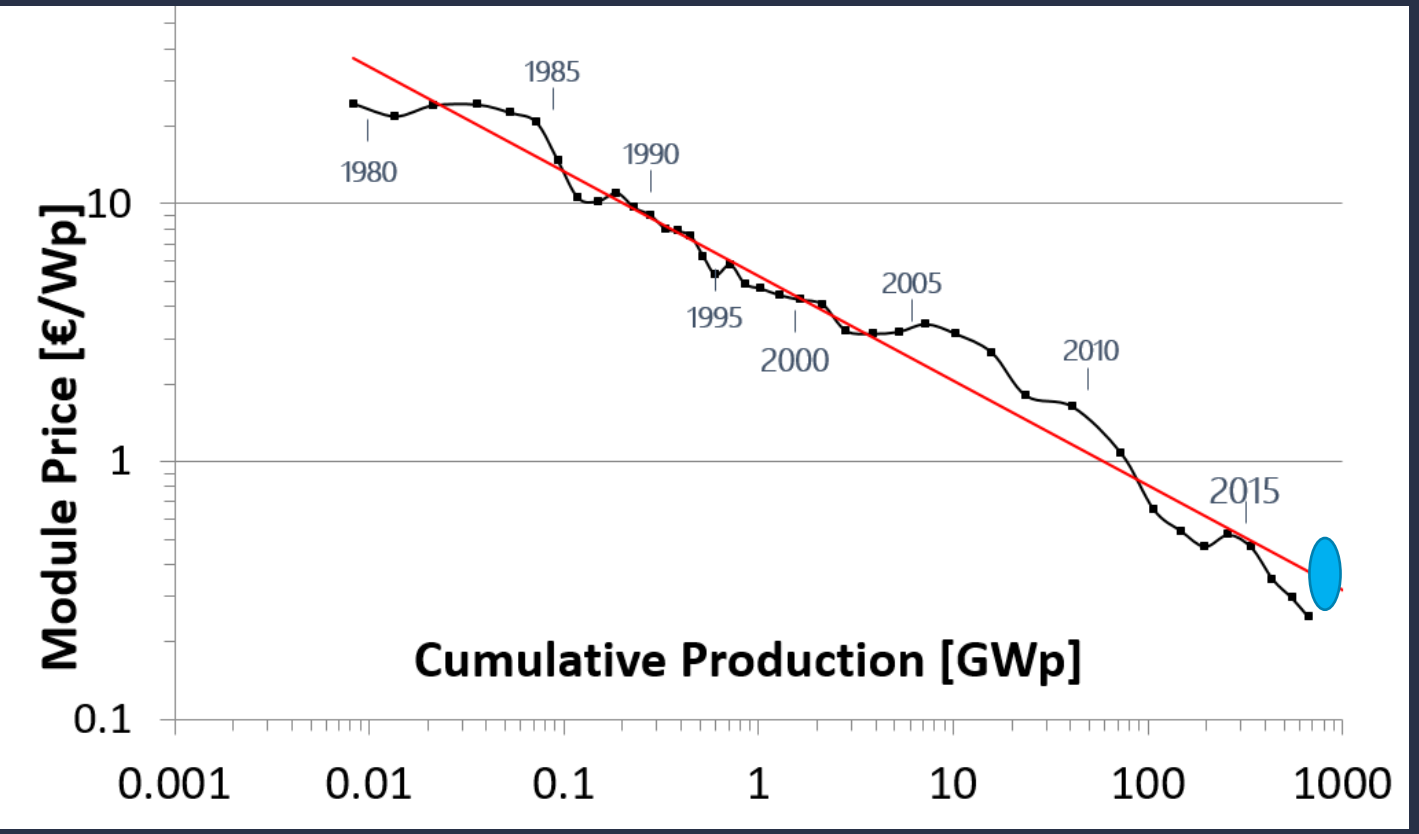
At the core of PV systems: learning curve of PV modules



- Current «increasing» standard PV module price down to 30 cts/Wp ~ 40-60 CHF/m^2

- 2021: 1 m^2 of 20% module ~ 60 CHF → 6000-9000 kWh EU over 30 years
- PV modules better by a factor 15-20 in terms of energy import costs vs gasoline **

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**1 W PV modules -> 1cts/kW, 1 liter oil imported
(3kWh mechanical in combustion engine) 60 cts → 20 cts/kWh useful

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But

- Temporary price increase because of shortage (polysilicon, glass, silver) brings mainstream PV prices higher…. (from 20 to 30 cts in one year)

Scenario for a decarbonised future

Implication for PV

- If the world is serious: at least 30-40 TW of PV by 2050 (CH 40-50 GW)
- Increase production volume to 1 – 2 TW annual from 0.15 TW/year today

- How much does it cost to put in place 1.5 TW of production ? (from sand to modules): with recent «CAPEX» decrease ~ 120-150 M€/GW → 180 billions € or 18 billions per year over 10 years

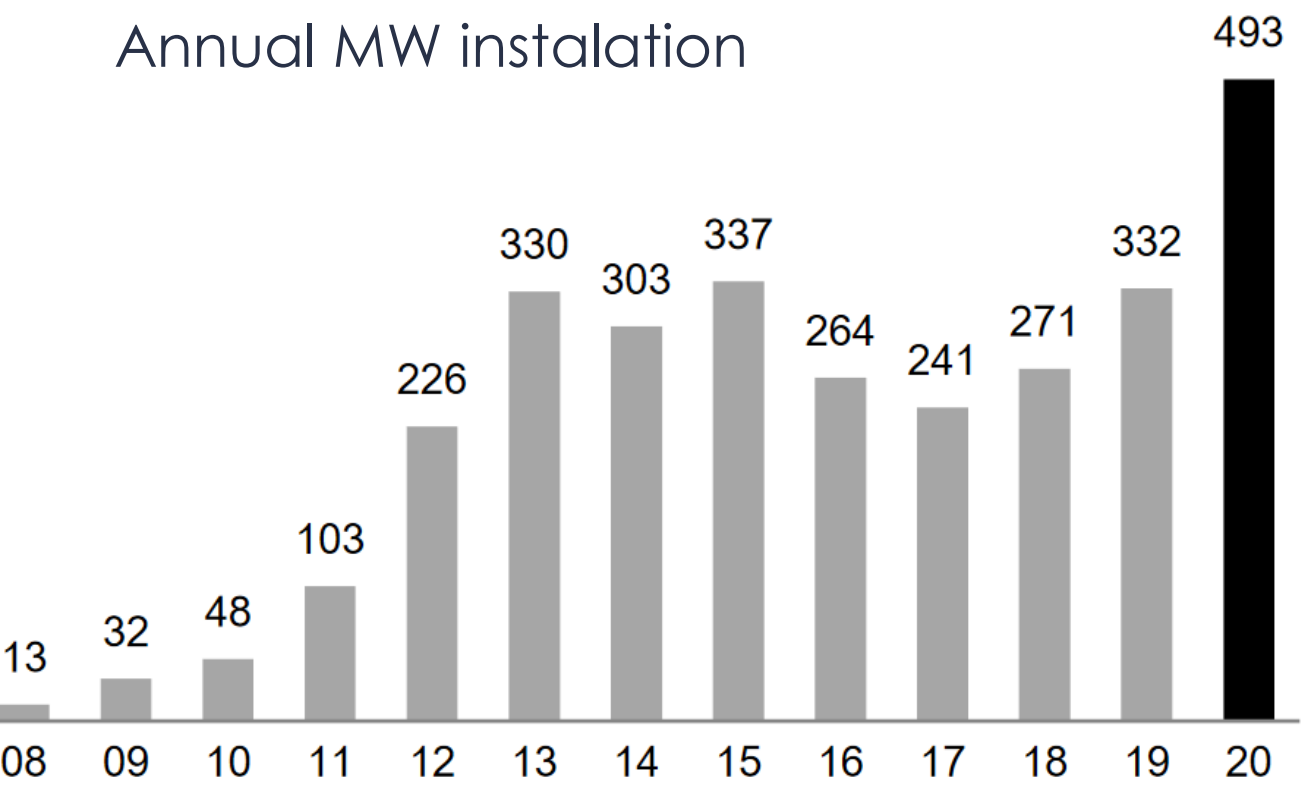
- Still a lot place for research and innovation !

Should

BFE

now

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra



Installation at ~500 MW per year

3 GW end 2020

4-5% of 60 TWh

Should move to 700 MW/Year

(BFE with current support)

(→ 20 GW by 2050)

A factor at least 2 not enough

(even though ok for CH 2035 current target)

- Incentive not sufficient
- Perspective not sufficient

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How to solve the «winter problem»

- **Put more quickly more photovoltaics everywhere and curtail (easy)**
- **Put more PV on facades and in the alps (less easy but useful)**
- **Increase some dams height, optimise for Swiss autarcy not costs**
- **Promote wind more** / reduce time to construction and opposition
- **Build peakers gas/hydrogen turbines or HF small plants, with short operation time (only a few weeks per year)**
- **Do not stop safe nuclear powerplants too early**
- Store biomass, use for district heating, store heat in Summer, geothermal for winter
- Rely on EU grid, supply and assets (e.g. close to 300 GW gas which could turn to hydrogen, strong wind growth). Import/export will continue
- Reduce consumption for a few critical weeks in Winter (e.g. maintenance of industrial assets, reduction of heating, high current peak price), why not reduce confort (18°C for three weeks is good for health)

Sustainability

- No worry, but good practice required
- Enough silicon for PV panels
- Enough materials for batteries and electrolysers
- Possible temporary bottlenecks
  (→ a Marshall plan to prepare the supply)

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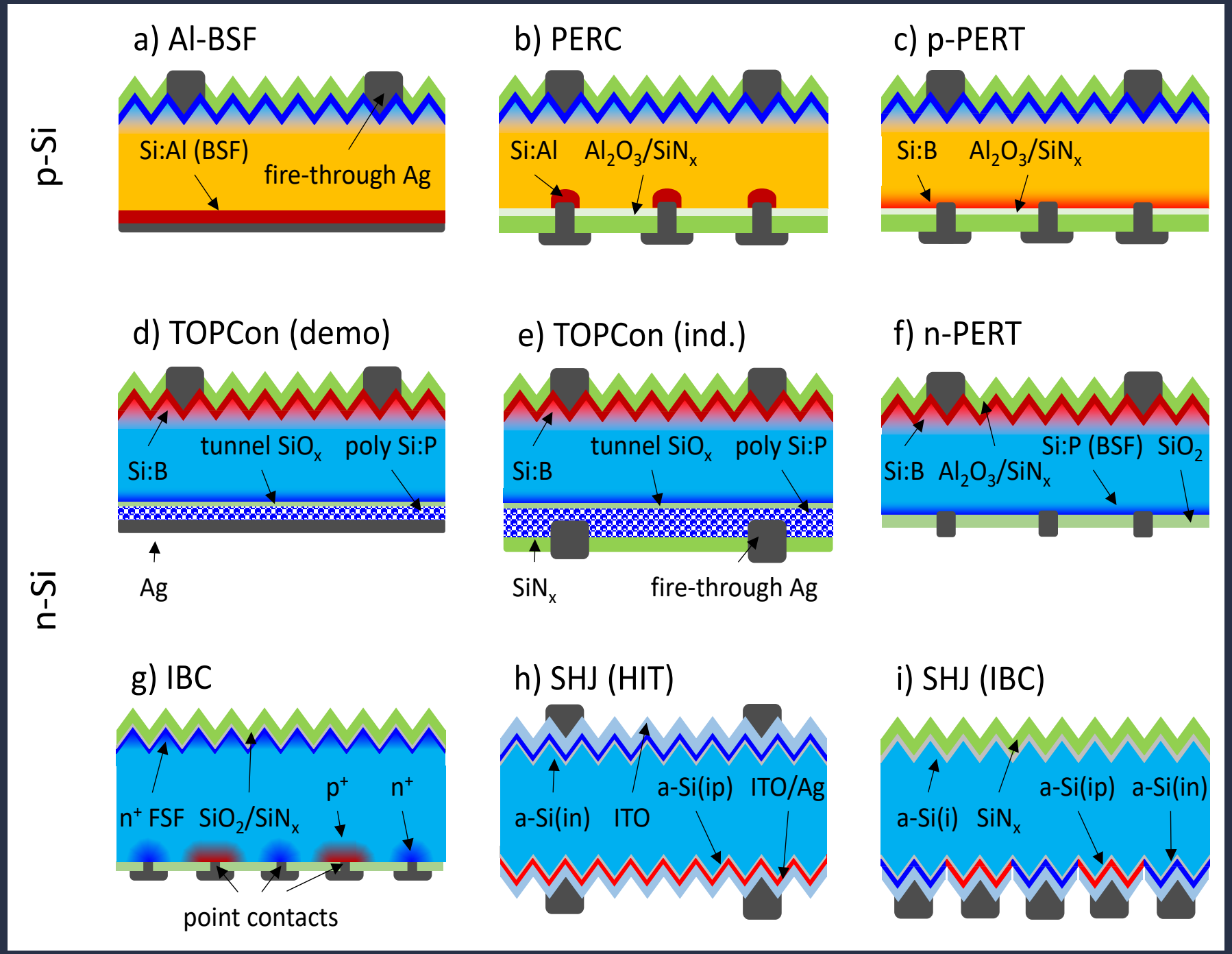
The various types of silicon technologies



Source:

Ballif/Haug et al.

To be published

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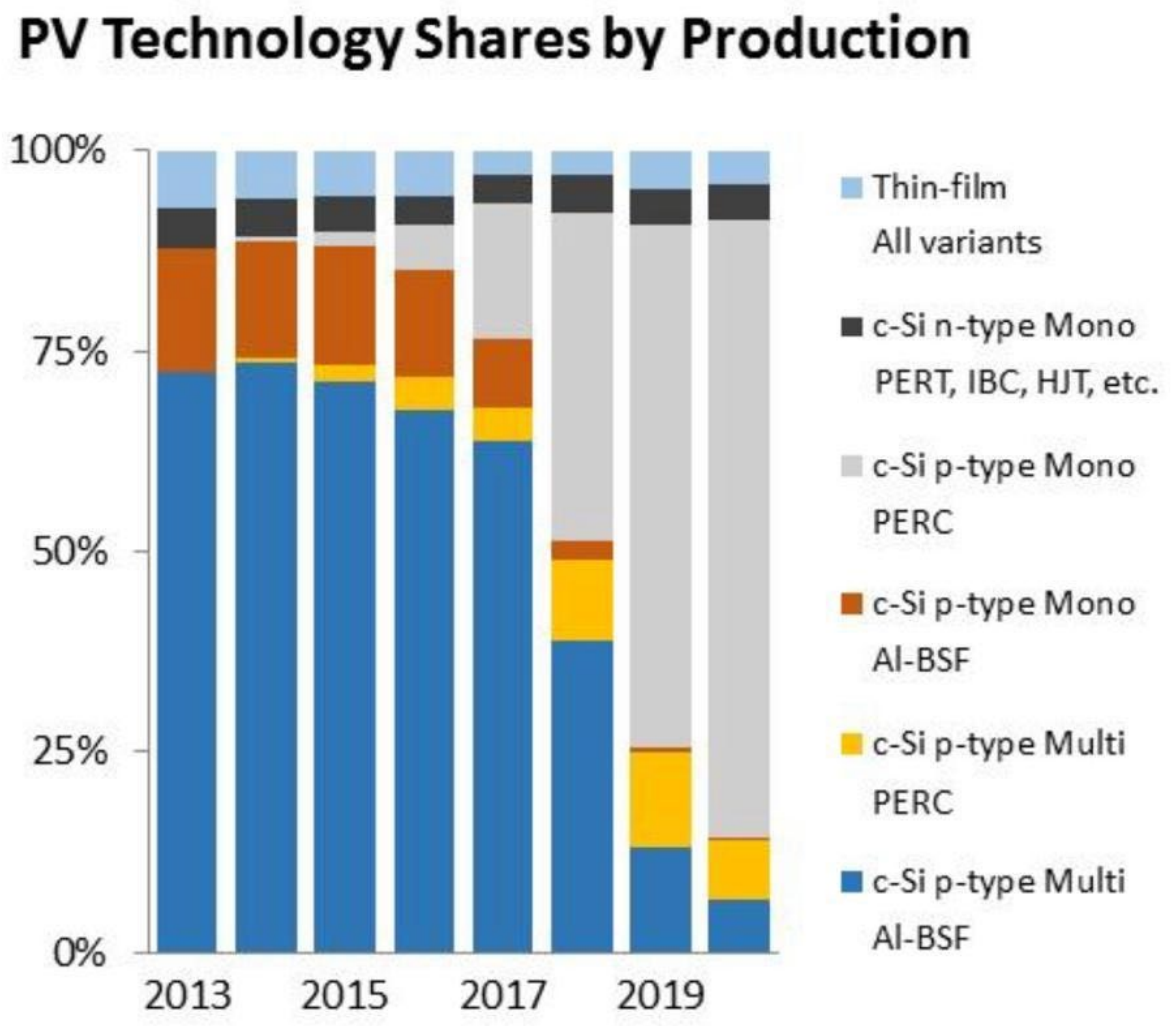
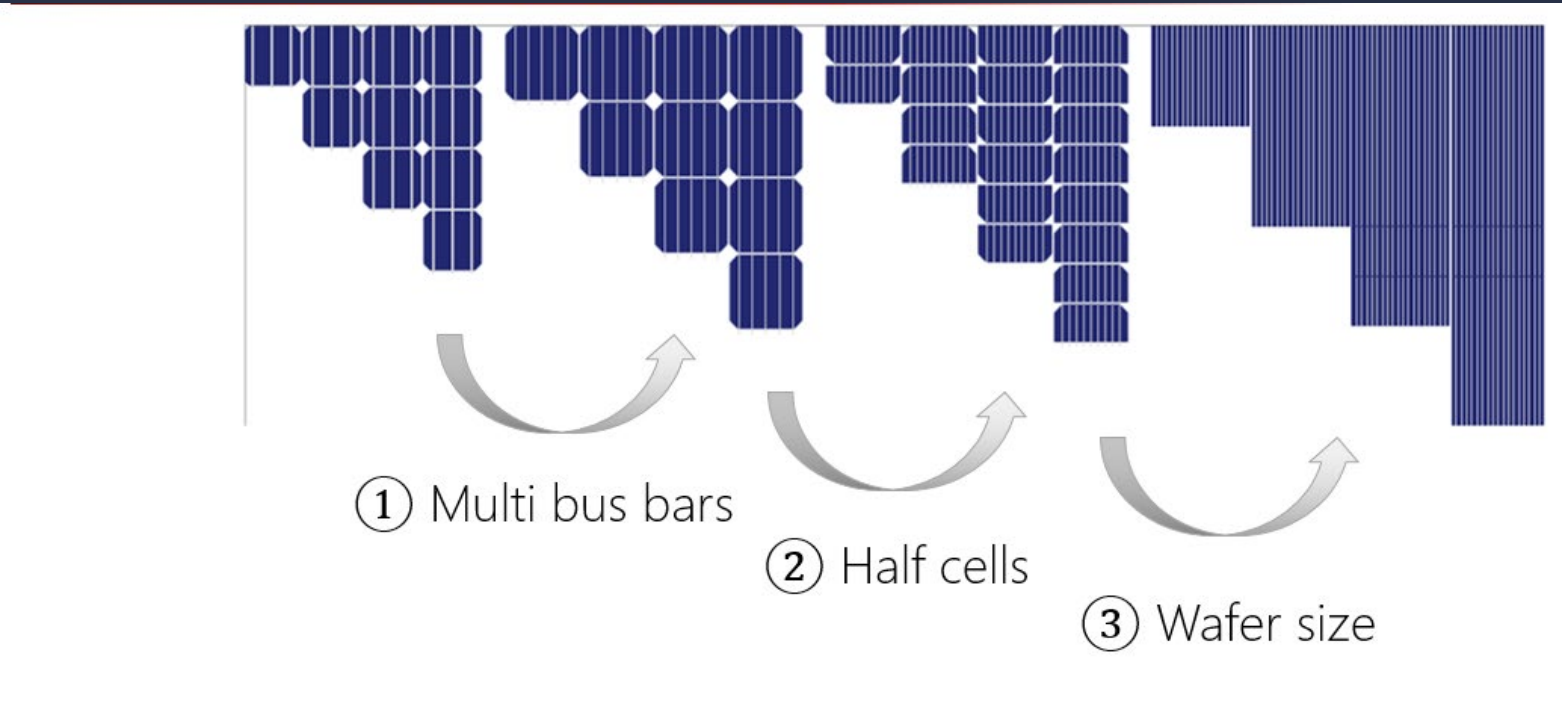
A drastic change in the PV industry lead by need for higher efficiecny



Source : PV tech

- **PERC solar cells are taking >90%** of the c-Si market. Typical cells at 22-23% in production, module at 20-21%, record cells at **23.7-25%** full cells (Q-cells)
- **TOPCON** and **Heterojunction** as high higher efficiency products pulling, with efficiency in the 23.5%-24% in production , with reccord at **25.4%** (Topcon, Jinko) and **25.6%** (Heterojunction, Maxwell/Sundrive) full front-contacted cells
- **IBC** up to 25% in production (Sunpower)

Why efficiency increase ?



b) Module design change

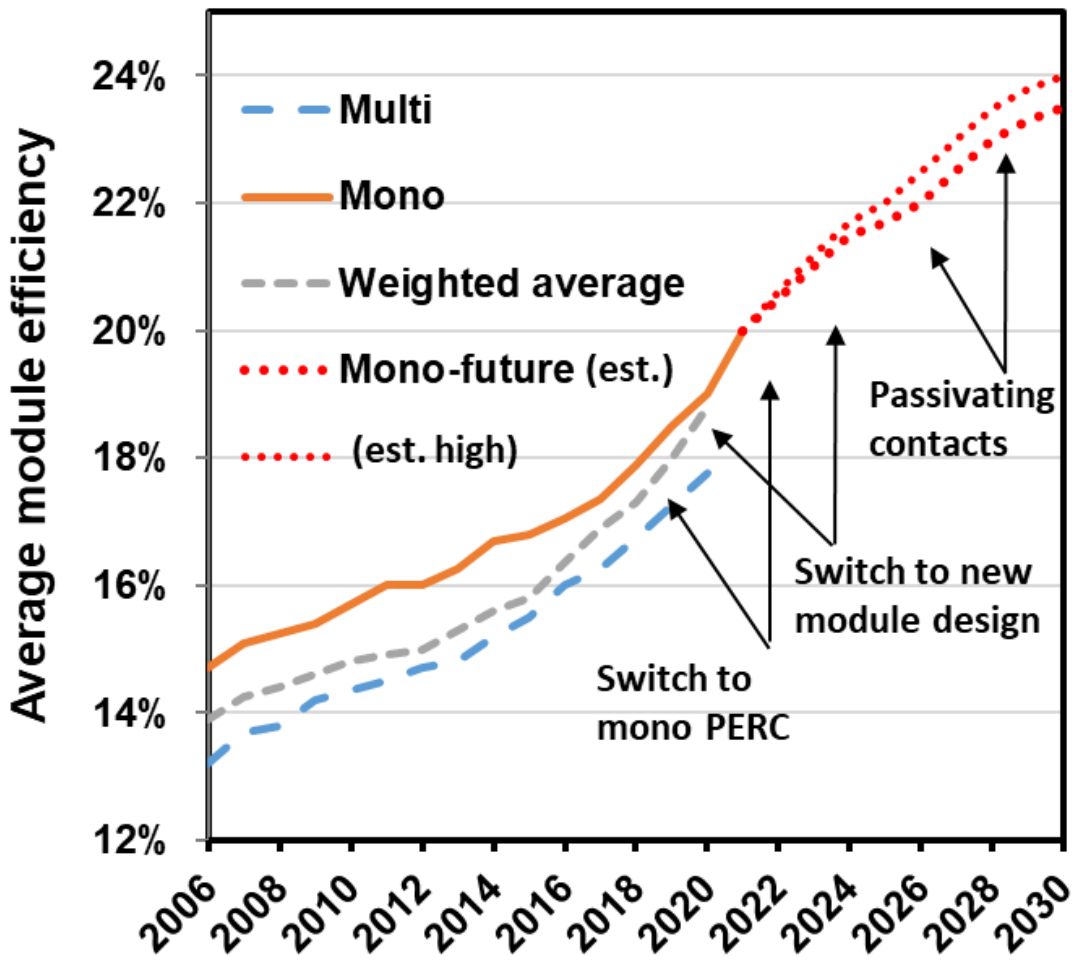
(0.5-1.5% absolute gain)

More bubars: reduce losses in siliver finger (gain 0.1-1% relative)

Half-cells: less losses in cupper ribbon interconnects (gain 2% relative)

Larger cells: less empty area, less edges per area (up to 21 x 21 cm2 solar cells) (0.5-1% relative)

Larger modules: less spacinga the edge (1-2% relative for 700 W modules)



Haug, Ballif et all. To be publshed

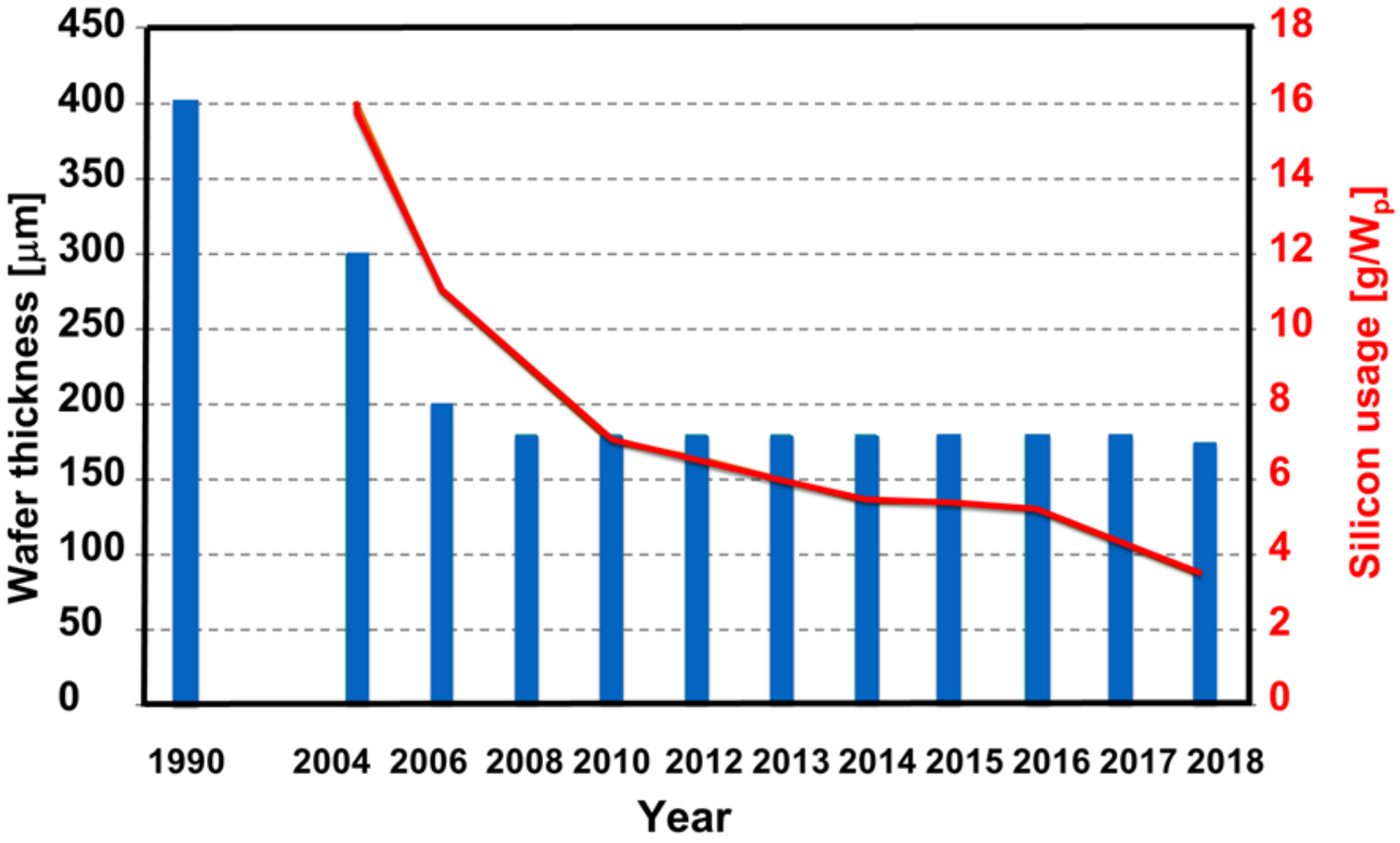
Permanent increase in the module efficiency

- 0.4-0.5% gain per year
- Efficiency of PV modules will further increase

(average 21.5-22.5% in 2025)

- Practical limit at 24-25% for silicon modules

Purified silicon usage per watt



- Improved processes (poly-si)
- Diamond sawing
- Efficiency increase

→From 17 to 3.5 g/W in 20 years,

With low grey energy

System payback in

One year !

Favor the renewal of a large PV industry in Europe ??

Ready to pay more for a product with local content, less CO2 from polysilicon ?

No controversial human rights practice ?

Revive a European Industry ?

Reduce independancy to Asia ?

Invitation to all installers: promote EU products, with EU cells even if more expensive…

Over 1 GW production line installed with heterojunctions (annual capacity) with «CSEM&EPFL inside» technology: Hevel, Ecosolifer, REC, Meyer Burger, ENEL

7 GW announced in Europe (ENEL, MB)

MB interconnections with «smartwires» with much lower Ag content !

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To faciliate the energy transition

All people with enough means should buy local (industry rebuild)

Make people love renewables and solar

SOLAXESS
white solar technology

SOLAXESS
white solar technology

3S Solar Plus

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FREE SUNS
SOLAR ENERGY

Private house Neuchâtel

Courtesy L.E. Perret-Aebi

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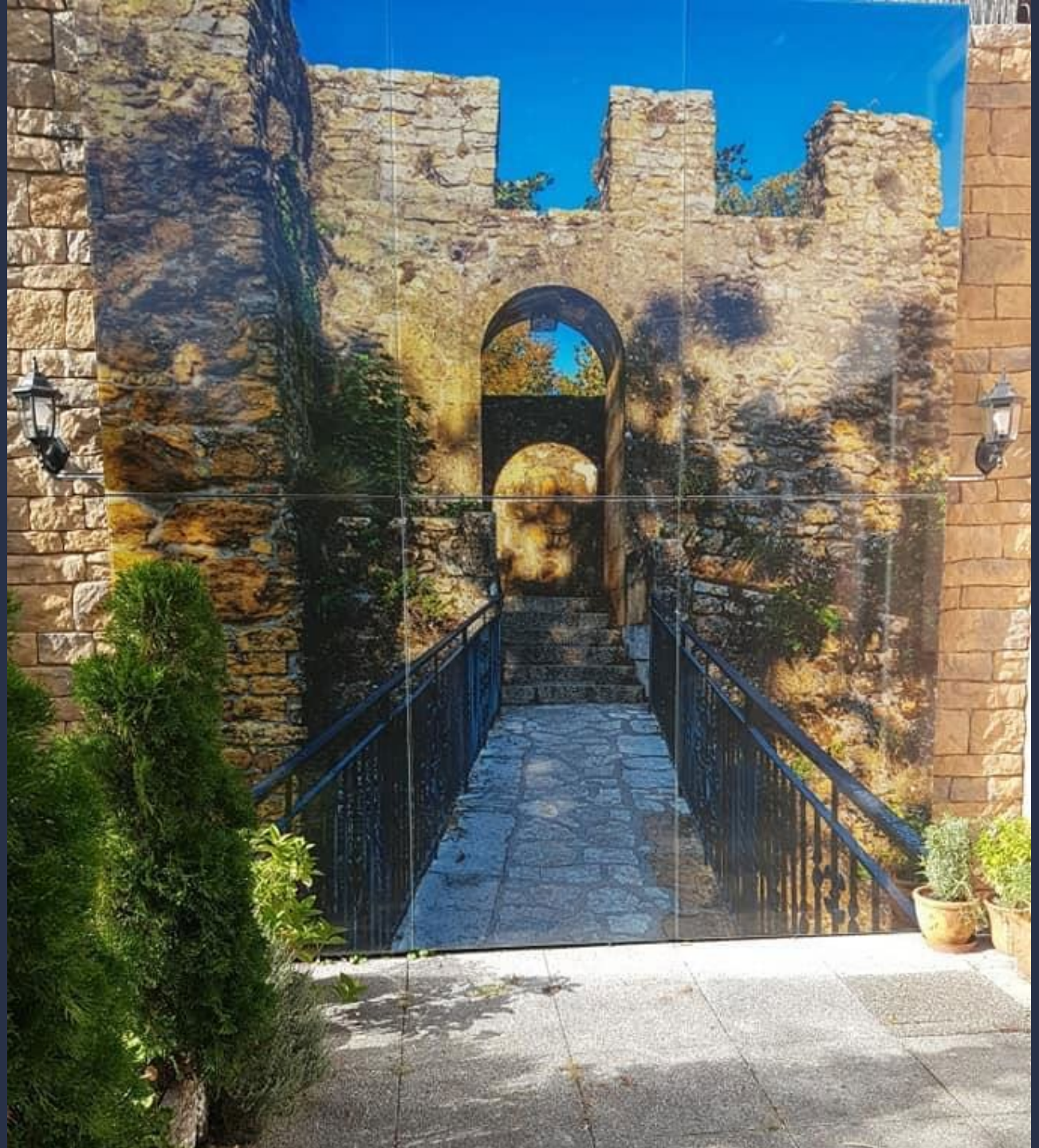
Private garden Neuchâtel



compáz

Courtesy L.E. Perret-Aebi

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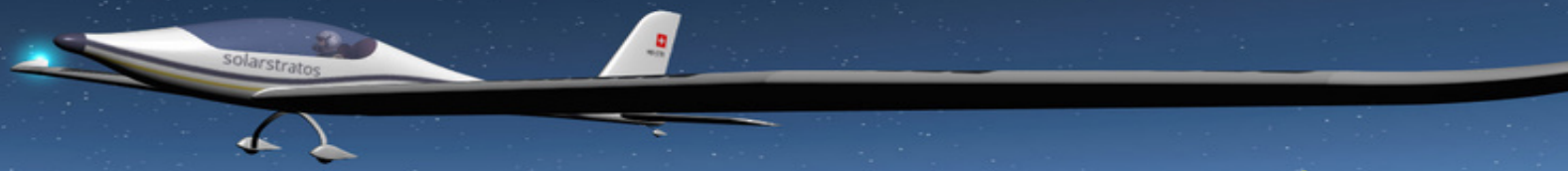
Watt is Art
26.03-25.04.2021
EPFL
Pavilions

Transforming the world, building and cities

Thanks for your attention



Solarstratos

“We need many more E. Becquerel’s Children”
Unknown source

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

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Contact **christophe.ballif@epfl.ch**

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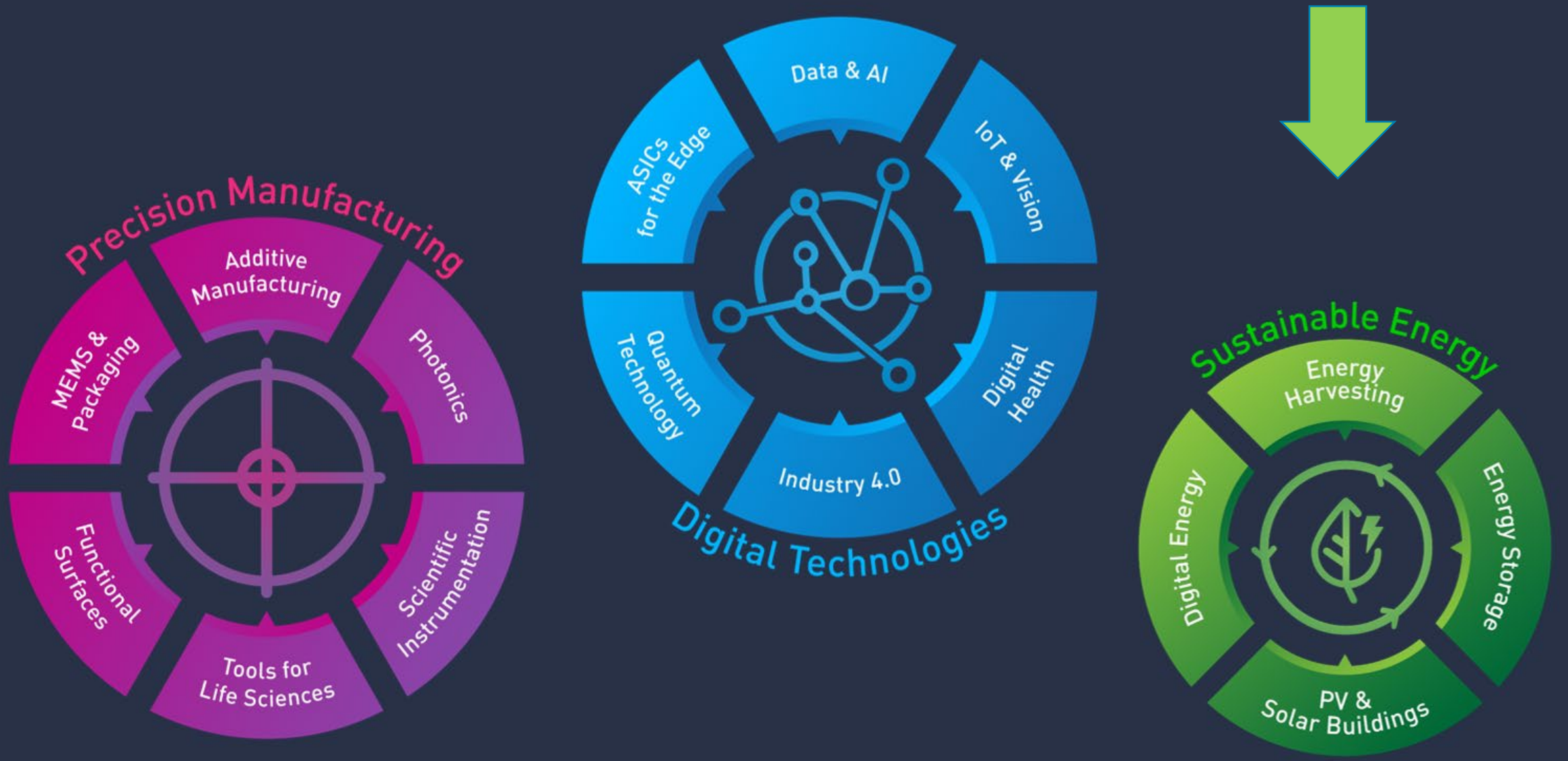
Best scenario for an energy transition

- Developp massively renewable energy production

(wind, solar, hydro, geothermal, biomass)

- Less consumption and more efficiency whenever possible
- Develop storage technologies (short and long term)
- Develop intelligence and flexibility in the grid and sector coupling
- Bring sutainable fuel for industrial processes (e.g. H2)

- Maintain limited assets for reserve energy (e.g. gas powerplants working in mid-term with H2/Biogas)
- (maintain safe nuclear when possible)


Precision Manufacturing
Additive Manufacturing
Photonics
Scientific Instrumentation
Tools for Life Sciences
Functional Surfaces
MEMS & Packaging
Digital Technologies
Data & AI
IoT & Vision
Digital Health
Industry 4.0
Quantum Technology
ASICs for the Edge
Sustainable Energy
Energy Harvesting
Energy Storage
PV & Solar Buildings
Digital Energy

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Technology infra-structure Platforms	Coatings and thin film devices fabrication	Cells Pilot lines	Modules R&D lines	Polymers coumpounding/ extrusion	Batteries fabrication and storage tesing	Data /AI energy management
	Reliability and accelerated aging tests					
	Metrology and characterization					

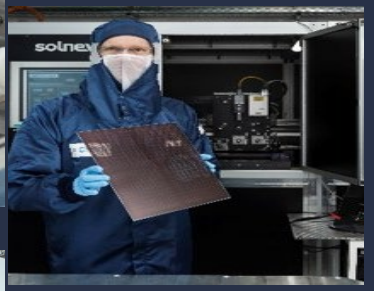
~ 85 people

2000 m2 by end 2021 (+500 in 2021) + access to 800 m2 EPFL PV-lab in NE

2000 m²

RESEARCH

&



PILOTING

CONTRACTS WITH OVER

40 COMPANIES

ALONG

THE CHAIN

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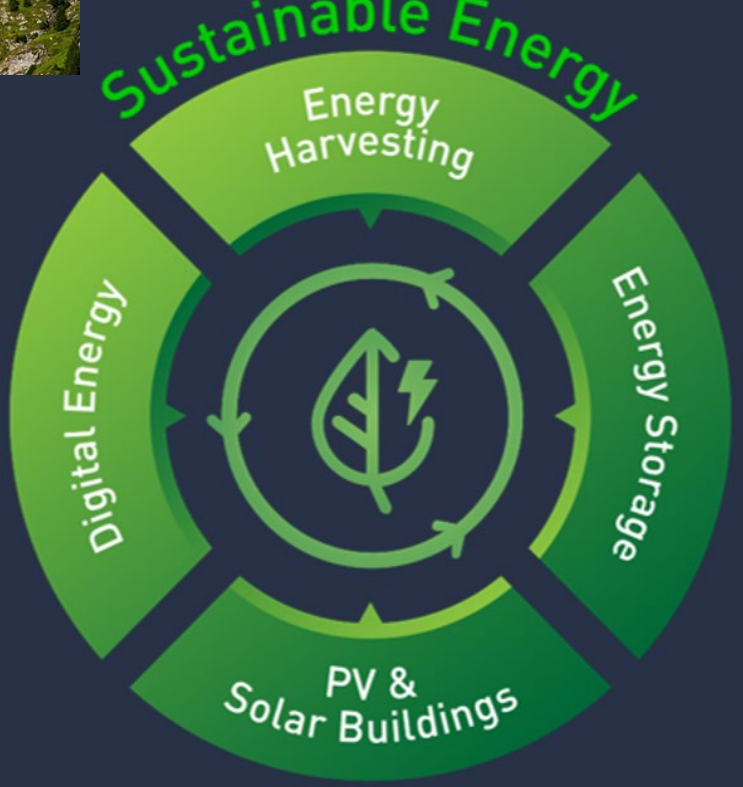
Large ecosystems of large companies, SME start-up, electric utilities which develop/need solutions around/requiring solar technology, energy management and flexibility



2019-2021:
Contracts/collaboration with ~45 companies, 70% in Switzerland

Expected 2021 (MCHF)

5.5 base funding

5.2 Industrial

2.0 Innosuisse

1.3 FNS/SFOE

2.6 EU

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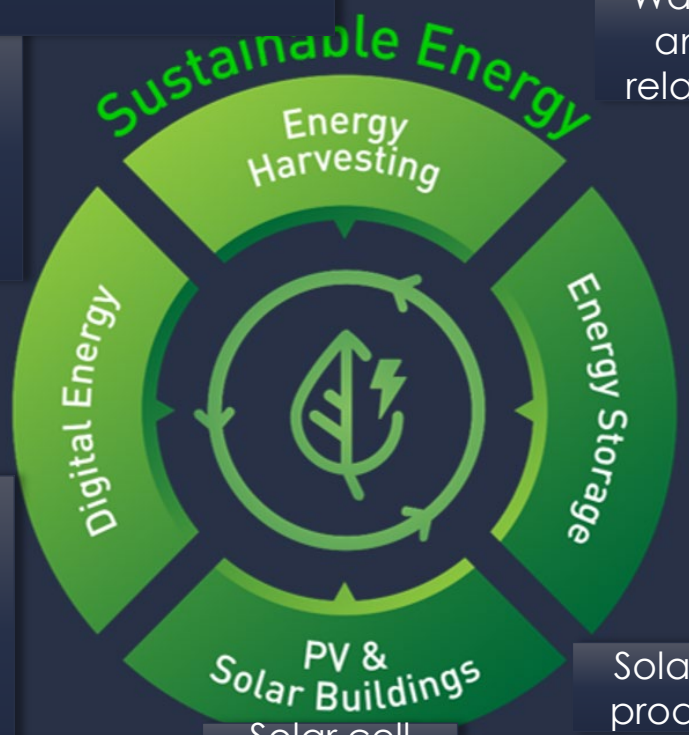
Customers of SE 2019-2021 (~75% in CH)



Watch maker

Lightweight for automotive

Lightweight for stratosphere

Lightweight for stratosphere

Coatings for energy

Watch components

Watch related

Watch and related

Watch and related

Public collectivities

Electric utility

Small

Coatings

Coatings

Custom PV elements

Energy management

Small

Electric utility

Public collectivities

e- software

e- software

Custom PV elements

Custom PV elements

Technology for RTO

Electric utility

Small

Equipment supllier/cell maker

Small

Solar cell producer

Solar module producer

Technology for RTO

Technology for RTO

automotive

Solar cell producer

Solar cell producer

PV metroloy

Thin film technology devlopper

Solar module producer

Custom PV elements

C-Si PV techn

Solar components

Polymer company

semiconductors

PV technology developper

Equipment supllier

Equipment supllier

dectors

foils company

Small

Small

Small

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