

Technologie, Digitalisierung, Dezentralisierung: Die grossen Trends für die nächsten 10 Jahre

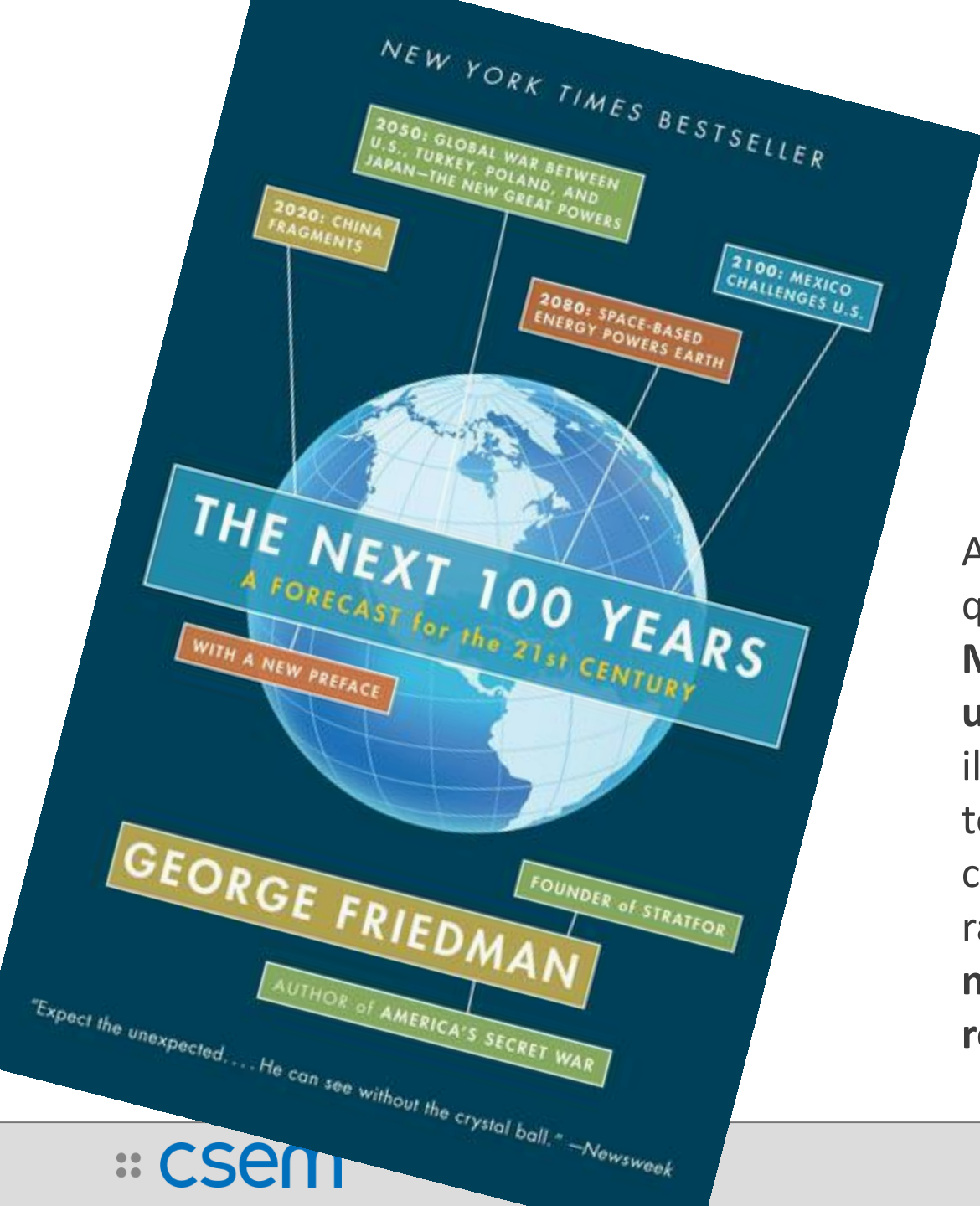


Closing session
Swiss PV conference March.
2019, Bern

Prof. Christophe Ballif
EPFL&CSEM, Neuchâtel
Switzerland

The Next 10 years (and beyond)





„Die von den Medien und Mitte-Links-Parteien vielgelobten neuen erneuerbaren Energien wie z.B. Wind und Sonne können diesen Ausfall bei weitem nicht wettmachen. Im Gegenteil, ihr Anteil am Strommix ist trotz Milliarden an Subventionen erschreckend gering.

Vision officielle du plus grand parti de Suisse

FAKE NEWS

Albert Rösti critique ainsi vertement la SSR. «C'est comme si qu'une foule de gymnasiens s'engagent politiquement. Mais notre télévision d'Etat a fait de la grève du climat une bataille de propagande sans précédent», proteste-t-il. Ces deux dernières semaines, il y avait pratiquement tous les jours des émissions sur ce sujet, affirme-t-il. Du coup, le président de l'UDC s'en prend à la redevance radio-TV. «Il semble qu'une initiative visant à réduire de moitié les redevances soit désormais nécessaire pour remettre la SSR sur les rails», menace-t-il.

Interview 20 minute, 26 mars 2019



If mankind is serious
about global warming,
PV will be a major way to
decarbonise



~~Rich Coal/Oil/Gas
Lobbies
and related media/
politicians~~

Annual world PV module production → **1 TW** by 2030 (x10)
→ 25 TW installed by 2050 → 30'000 TWh
(2017 world electricity consumption of 22'000 TWh)



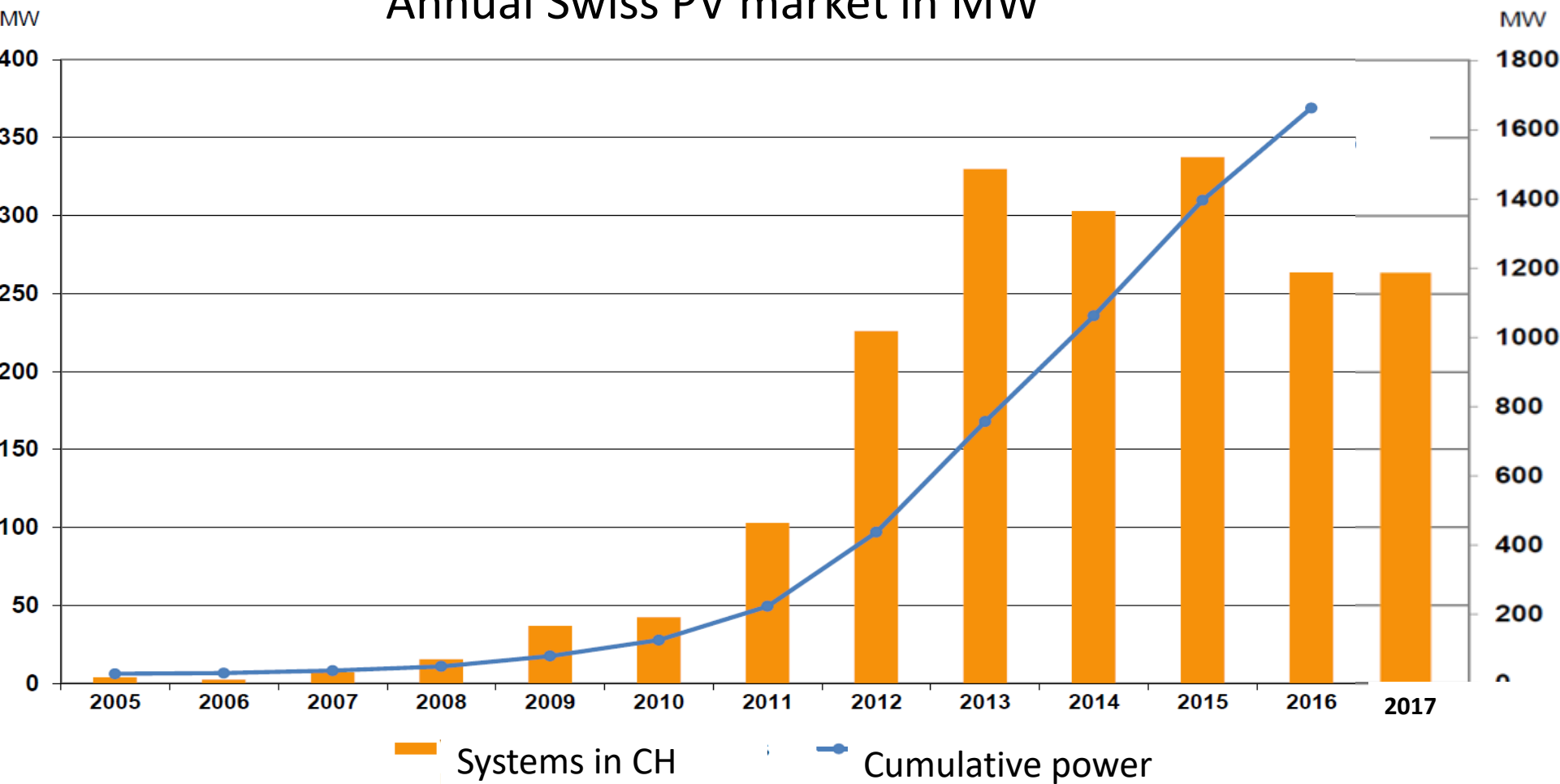
M. Topic

We are only at the beginning of Solar Area !

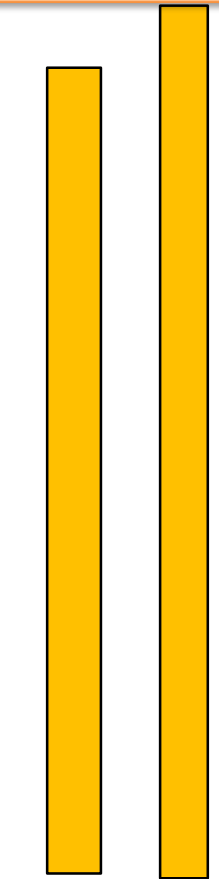
(And not at the end of technology development)

Jan. 2019: 2.1 GW installed, 3.1 % of annual CH electricity consumption

Annual Swiss PV market in MW



Min 400-500 MW/year



?

2020 2030
-2030-2045*

Source: Swissolar/internal data

* Including renewal

Change Swiss parlement
orientation ?

Let's decarbonise CH!
The R. Nordmann PV climb
(or 45 GW scenario)



Scénario «RN»**

Simple macroeconomics 45 GW solar vs business as usual

Cost of import of components for 45 GW of PV = 22 billions CHF.

Will last 35 years or more (talk by SUPSI)

+ ~ 600 millions per year electricity import or gas import

Business as usual: Import of fossil fuel over 20 years = 200 billions CHF

Over 20 years

34 billions 14% CO2

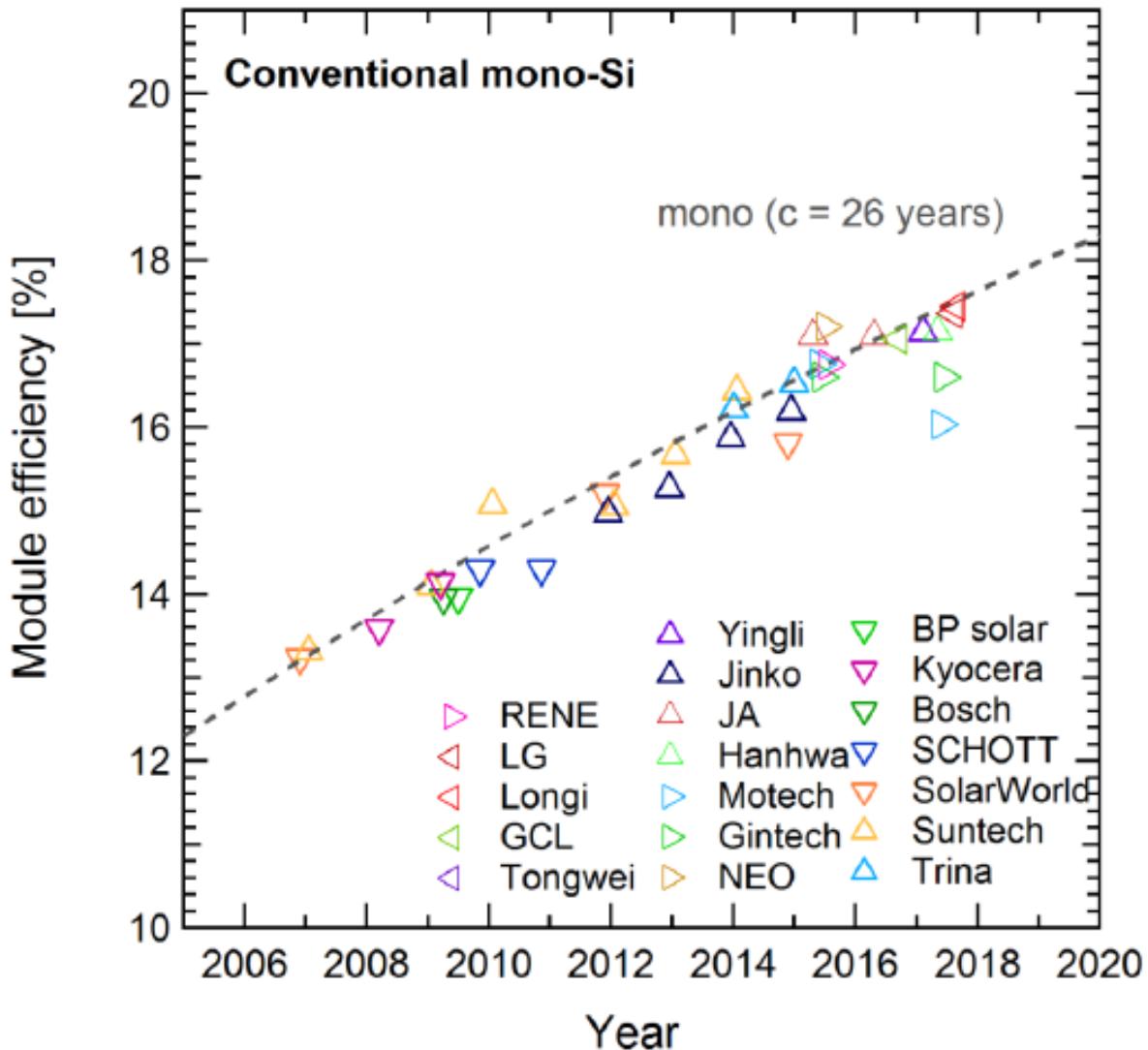
220 billions 100% CO2

** estimation does not include one-time extra import costs For insulation materials and heat pumps,
As well as extra-costs for car components

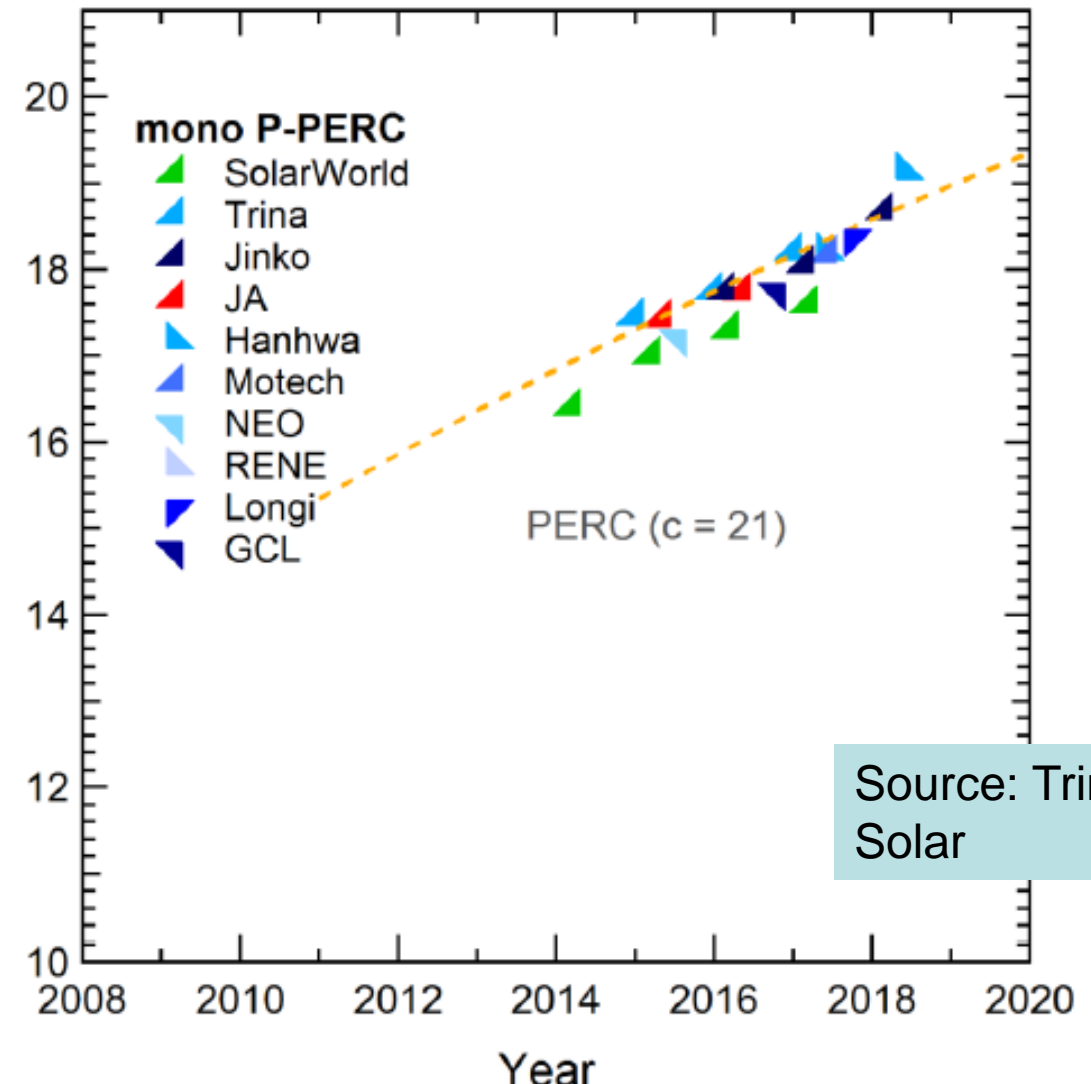
**Scénario préféré
droite «dure»**

Mainstream market: efficiency increase of 0.3-0.4%/year

Conventional mono Si modules



PERC mono Si modules



Source: Trina Solar

Global installed PV capacity at over 500 GW (end 2018)

PV module efficiency improvement:
a necessary trend !

2018 ~ 18.2% average monocrystalline
«modules»



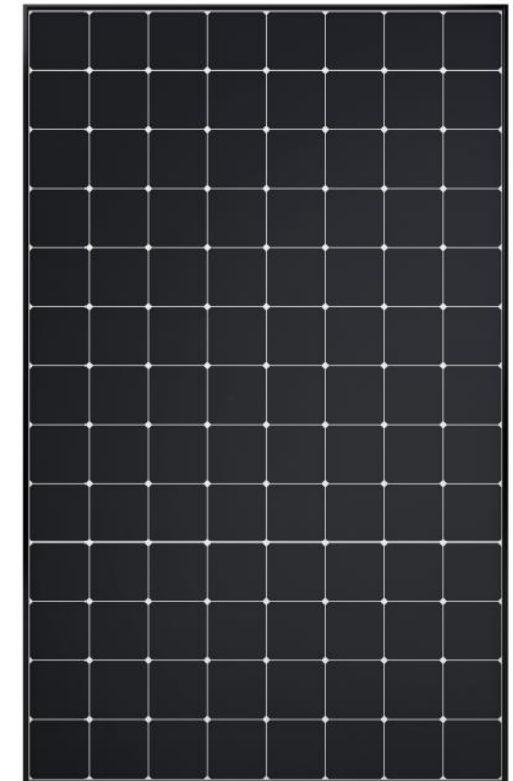
Average modules at 22-23 % in 2029 (at < 0.2\$/W)
→ 26-27% (?) in 2039

- Much lower cost of solar electricity
- Better in space constrained systems (Switzerland)

→ **Best in class at 22.5%**
(Sunpower)
(at 0.8 CHF/W in CH)

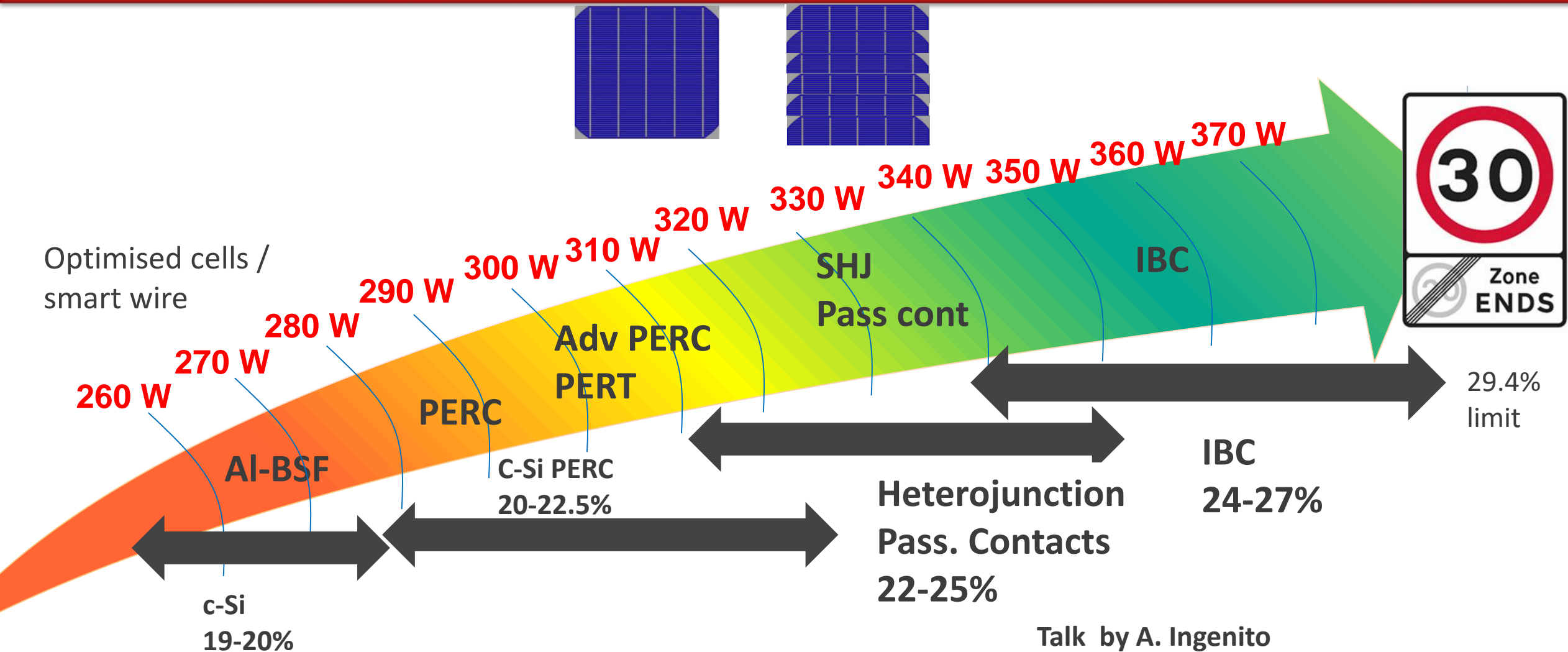
MAXEON® 3 | 400 W

DC Residential Solar Panel



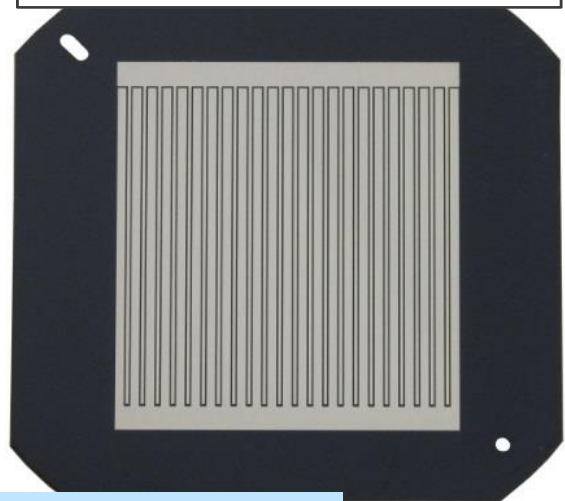
Powerpure

Recent exemples market application



HETEROJUNCTION: UPGRADE SCENARIO to IBC-HJT

25-cm² tunnel-IBC



Tomasi et al.
Nature energy
2017

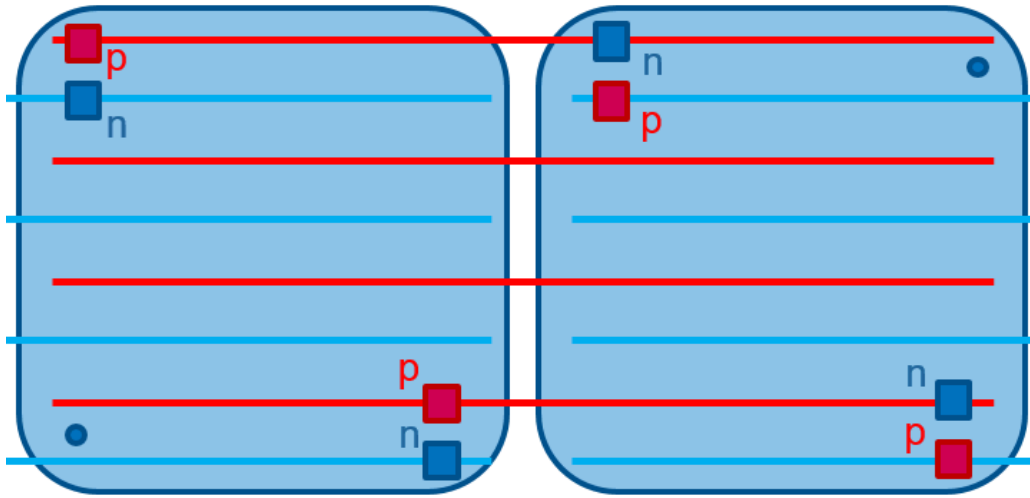
**25.0% certified cell efficiency by CSEM
(measurement at Fraunhofer Calab)**

**World most simple process for 25%
efficiency (8-10 process steps)**

Goal: Sunpower at the price of PERC !

B. Paviet- Salomon et al. To be
presented soon

Interconnection for IBC



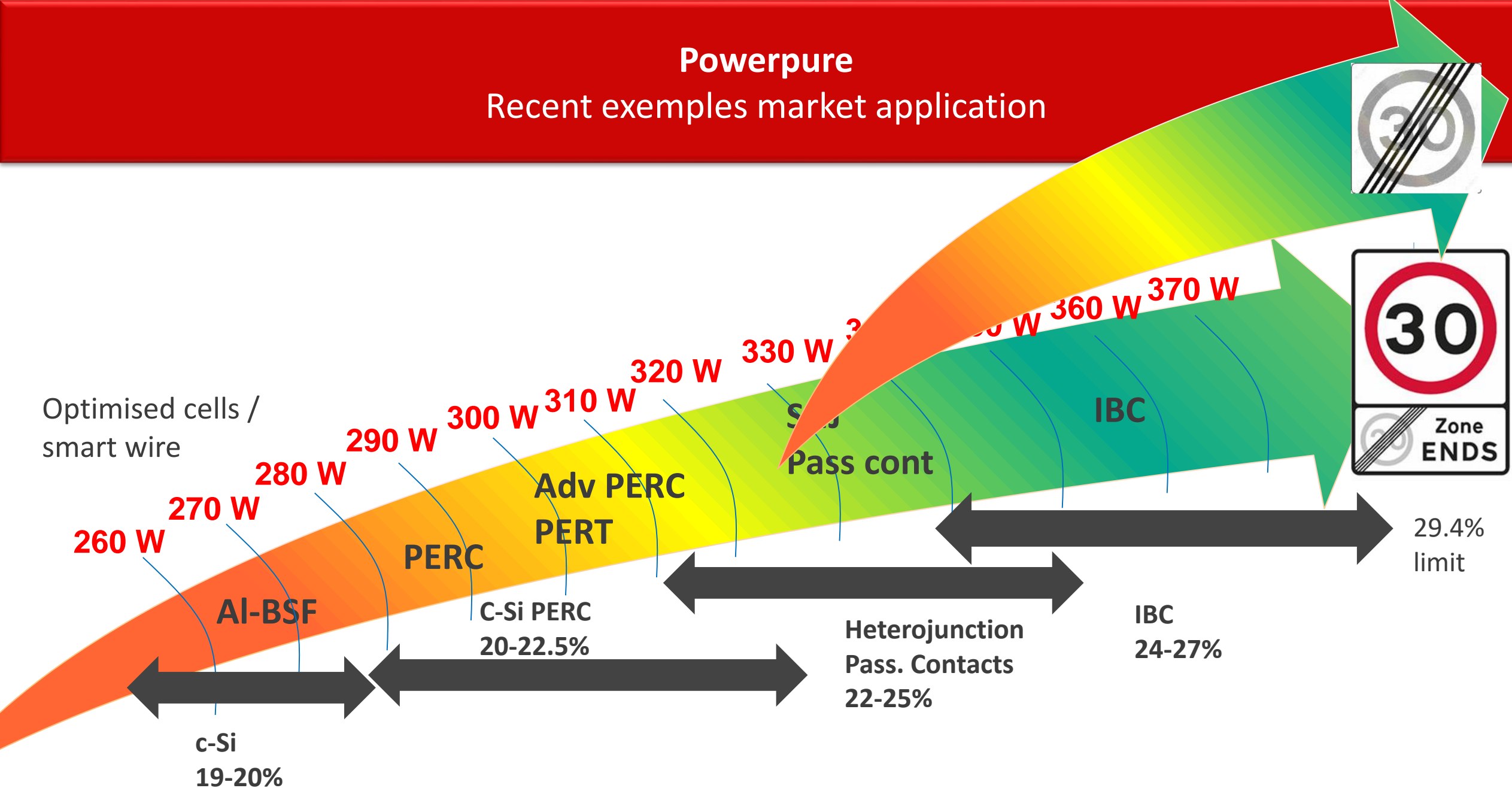
First “23.2%” mini modules with Smart-wire interconnect



A. Faes^{1*}, B. Paviet-Salomon¹, J. Champlaud¹, N. Badel¹, E. Muliqi¹, D. Lachenal², P. Papet², B. Strahm², N. Voicu³, M. Despeisse¹, C. Ballif¹. ¹ CSEM, ² Meyer Burger Research, Switzerland, ³ DSM, Netherlands, 8th Metalisation workshop 2019

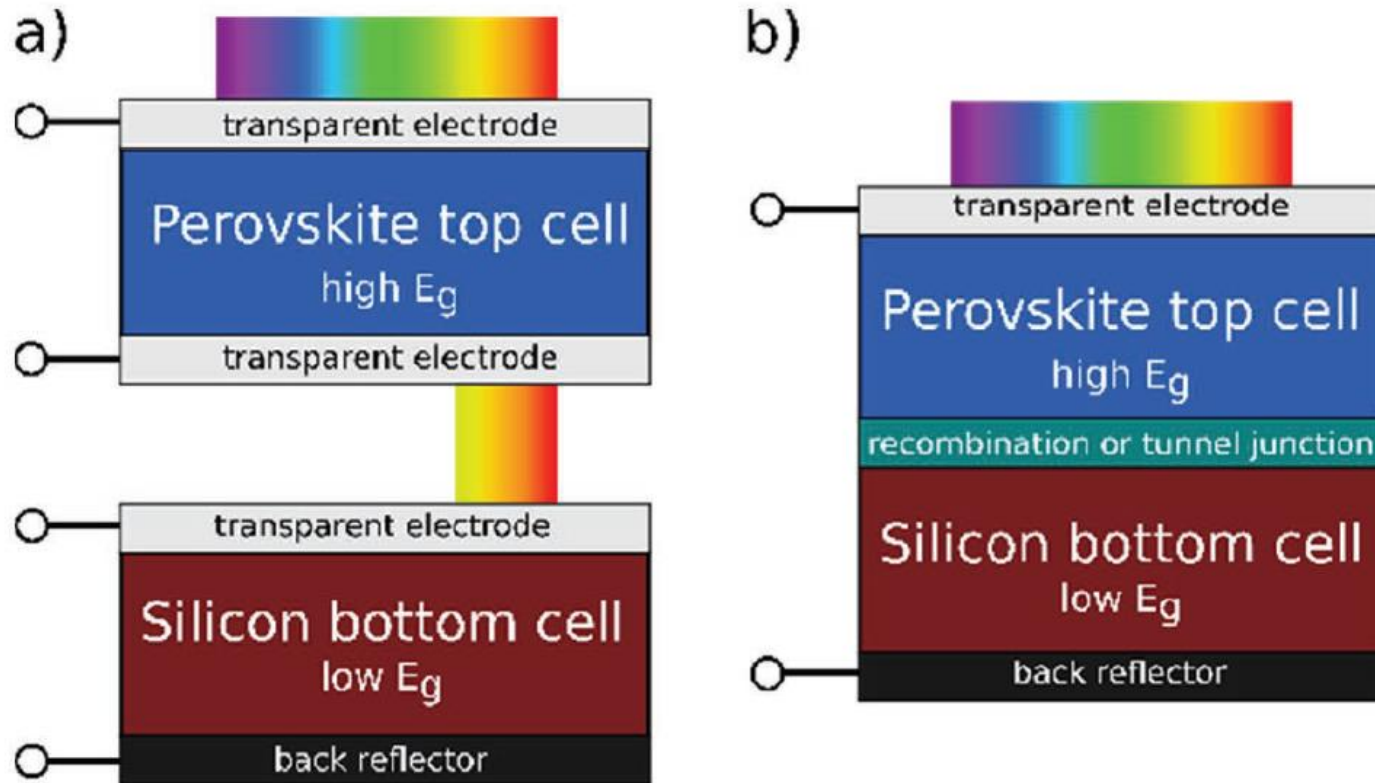
Powerpure

Recent exemples market application



Powerpure : tomorrow

Examples of cutting edge research on multi-junctions/Si based



Is perovskite on Silicon the future ?

With perovskites, things go much faster than you think !



First 2 MW solar park with 27% modules Perovskite/Silicon
(installed in Pays de Cocagne)

**Perovskite on Silicon: a high efficiency potential but
still a lot of challenges ahead !**




DSC_0246.jpg

Make your roof solar: From simple to complicated



Make your roof solar: From simple to complicated





Ecuvillens
27 kWp
28'000 kWh during
1st year of operation

*One of the Terra-cotta
Tones, with ISSOL, Solstis
Userhuus, SFOE*



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra





With support of

Everybody wants a solar roof / even nature

//// active
interfaces

• Most home owner wants PV !

*c. Ballif et al.
Nature Energy
2018*



nature
energy

Photovoltaics
blends in

Everybody wants a solar roof: the new BIPV roof of Albert Rösti

Everybody wants a solar roof: the new BIPV roof of Albert Rösti



So many good companies providing PV roof solutions in CH !!

BIPVBOOST



- Let's make PV appealing
- Let's make people love it ...
- Let's have people ready to pay the right price (even when high)

A lot of new «improved approaches coming»



Including Digitalisation in manufacturing



Proposed new «climatic emergency law» (starting Dec 2019) to reach 45 GW

Roof kick
(or T.
Nordmann
law)

Any new roof or renovated roof **needs a construction permit** if less than 70% of its surface is covered by PV (not including openings).

* Areas which would generate less than 80 kWh/m² when covered with 20% modules are not counted into calculation

Winter
kick

Any new façade or renovated façade needs a special construction permits if less than 60% of its surface is covered by PV (not including windows).

* Areas which would generating less than 50 kWh/m² when covered with 20% modules are exempted of obligation



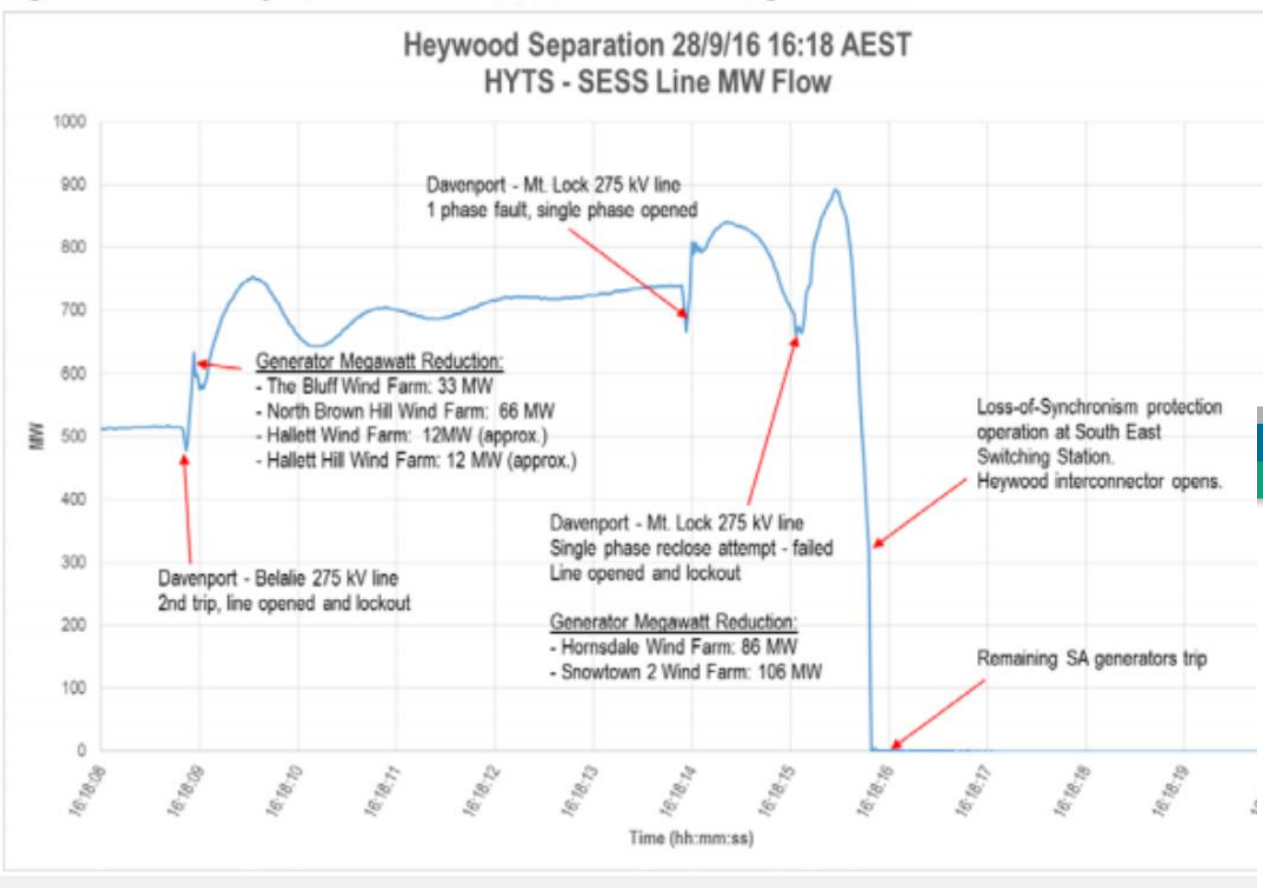
Decarbonisation
Decentralisation
Digitalisation

**WORLD
ENERGY
COUNCIL**

PV and Wind: “low inertia power system” →

PV and Wind can lead to catastrophic failures. They are the grid enemies

Figure 3 Flow on Heywood – South East interconnector during the event



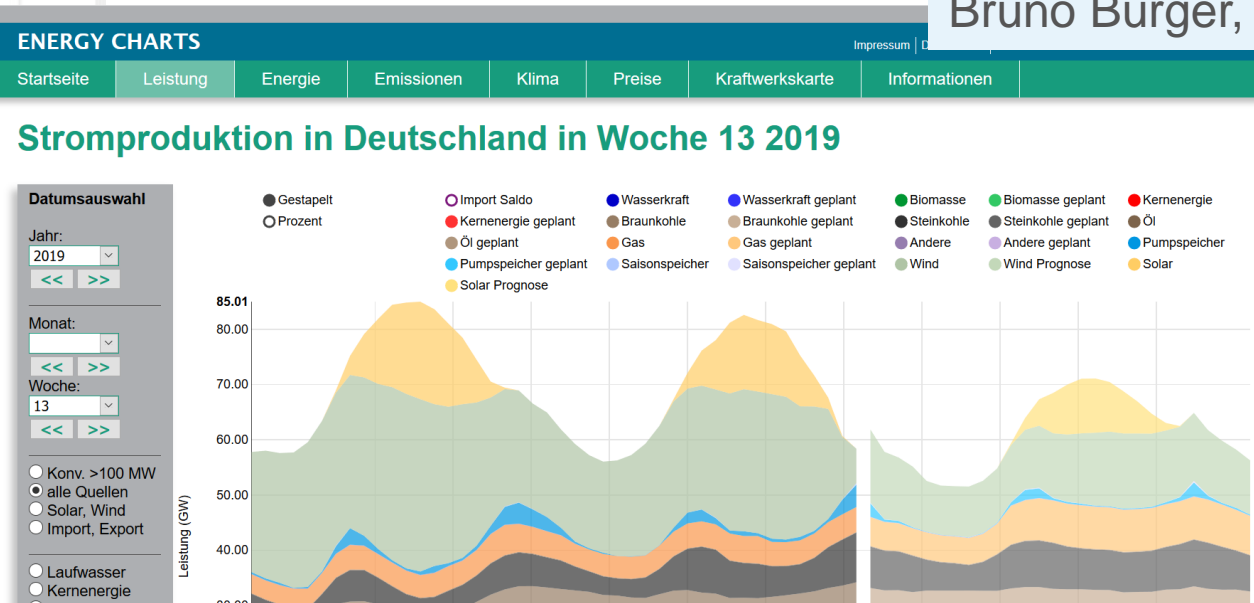
📖 Australian black-out 2016: in a few seconds black-out.

See talk by

To be worked on

Florian Doerfler et al.
http://people.ee.ethz.ch/~floriand/docs/Articles/PSC_C_2018_Survey.pdf

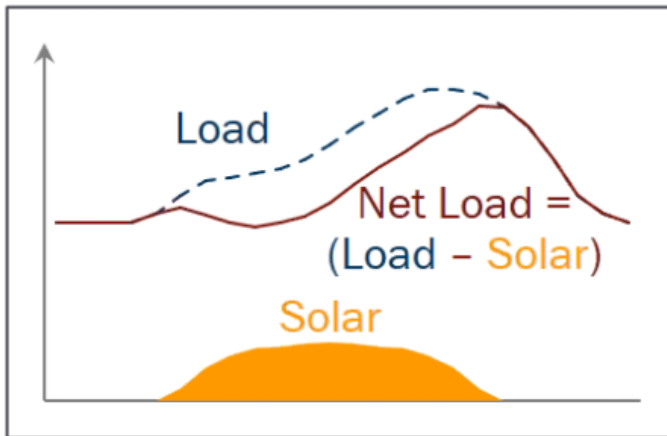
Bruno Burger,



Three stages of grid-connected PV

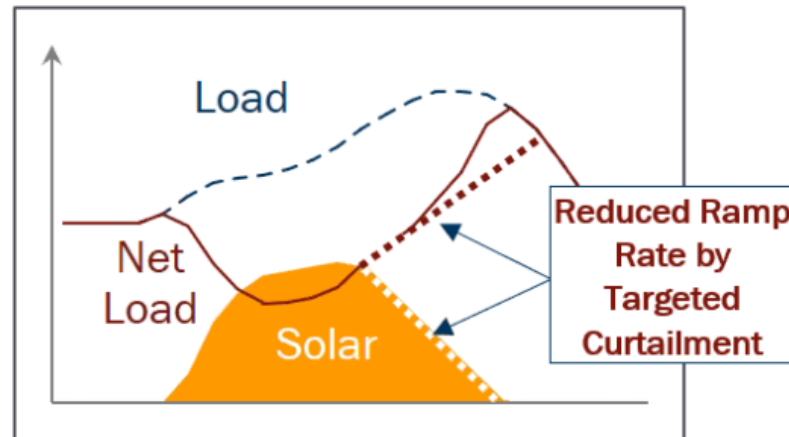
Solar 1.0: Traditional

- Solar is part of day-time load offsetting peak or near-peak loads



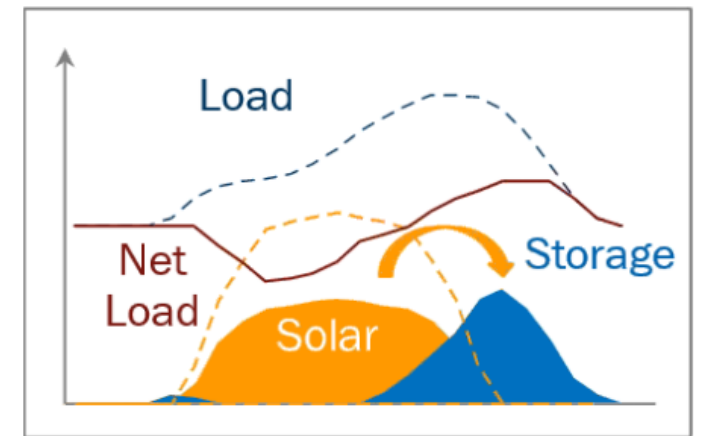
Solar 2.0: Controllable

- Controlling solar makes it more flexible & increases its value



Solar 3.0: Fully Dispatchable

- Storage time-shifts solar to make it fully dispatchable



📖 M. Morjaria, 'Fact vs. myth: PV solar and grid stability', presented at the SolarPower Europe Webinar, 26-Oct-2017.

Source: First Solar

DCSMART: added-value DC microgrids

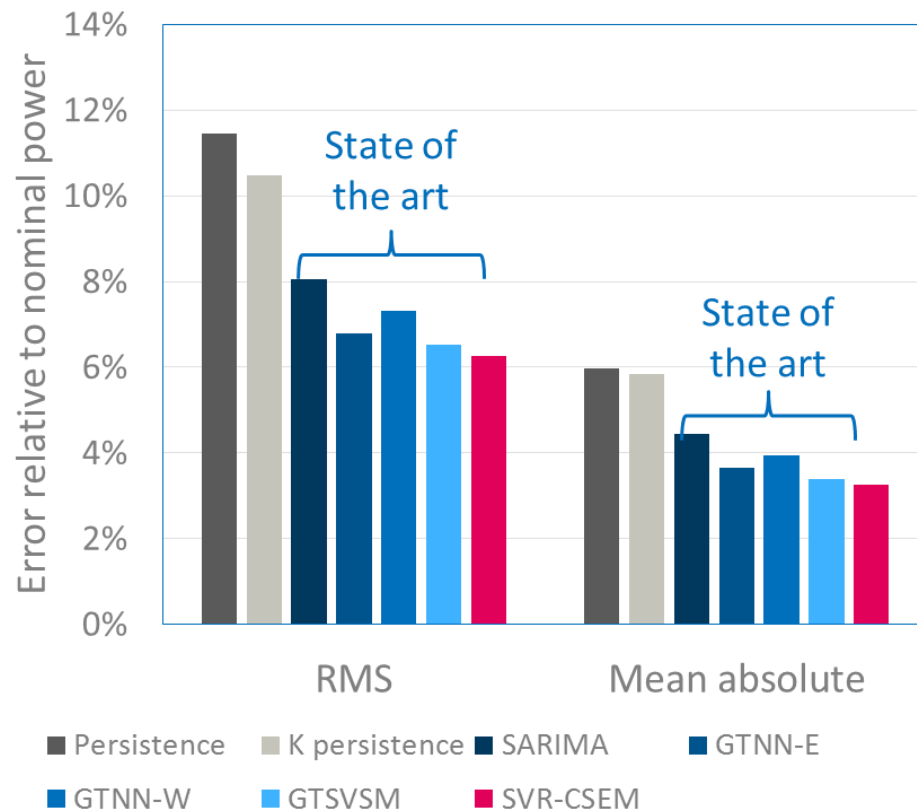
- Multiple services
 - Self-consumption, peak shaving, ramp-rate control
- Proven economic benefits
 - 4x faster return on investment for batteries
- Scalable and adaptable
 - For applications in residential, commercial and industrial buildings
- Patent pending
 - Innovative control architecture
- Demonstrator running at Neuchâtel's wastewater treatment plant



PV forecasting and analytics

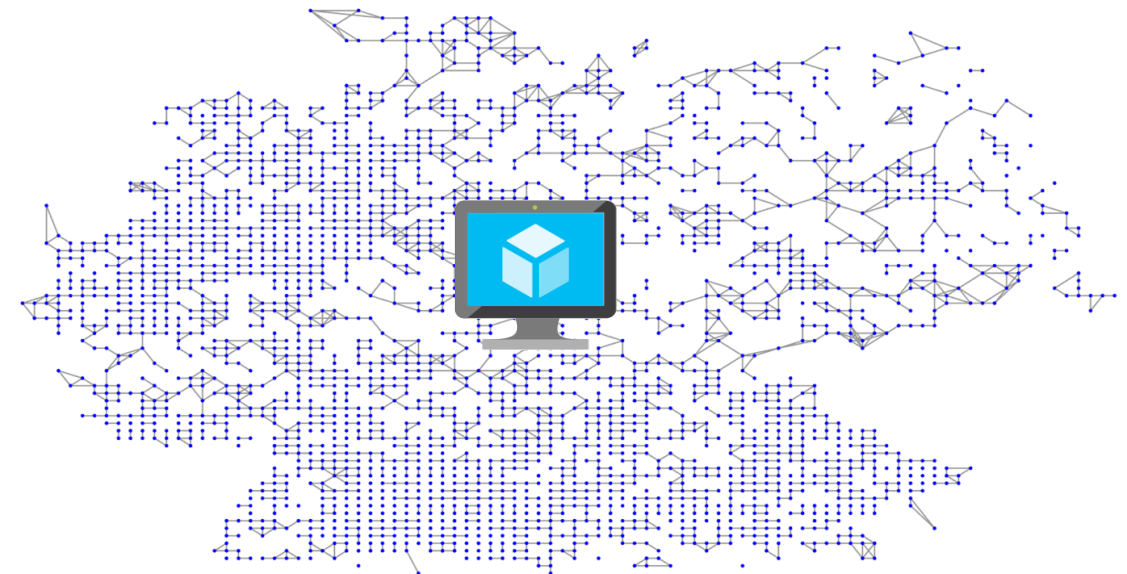
Day-ahead forecasting

CSEM's method **best**
in international benchmark



Digital O&M

big-data analytics for PV systems
on cloud platform: 90'000+ inverters

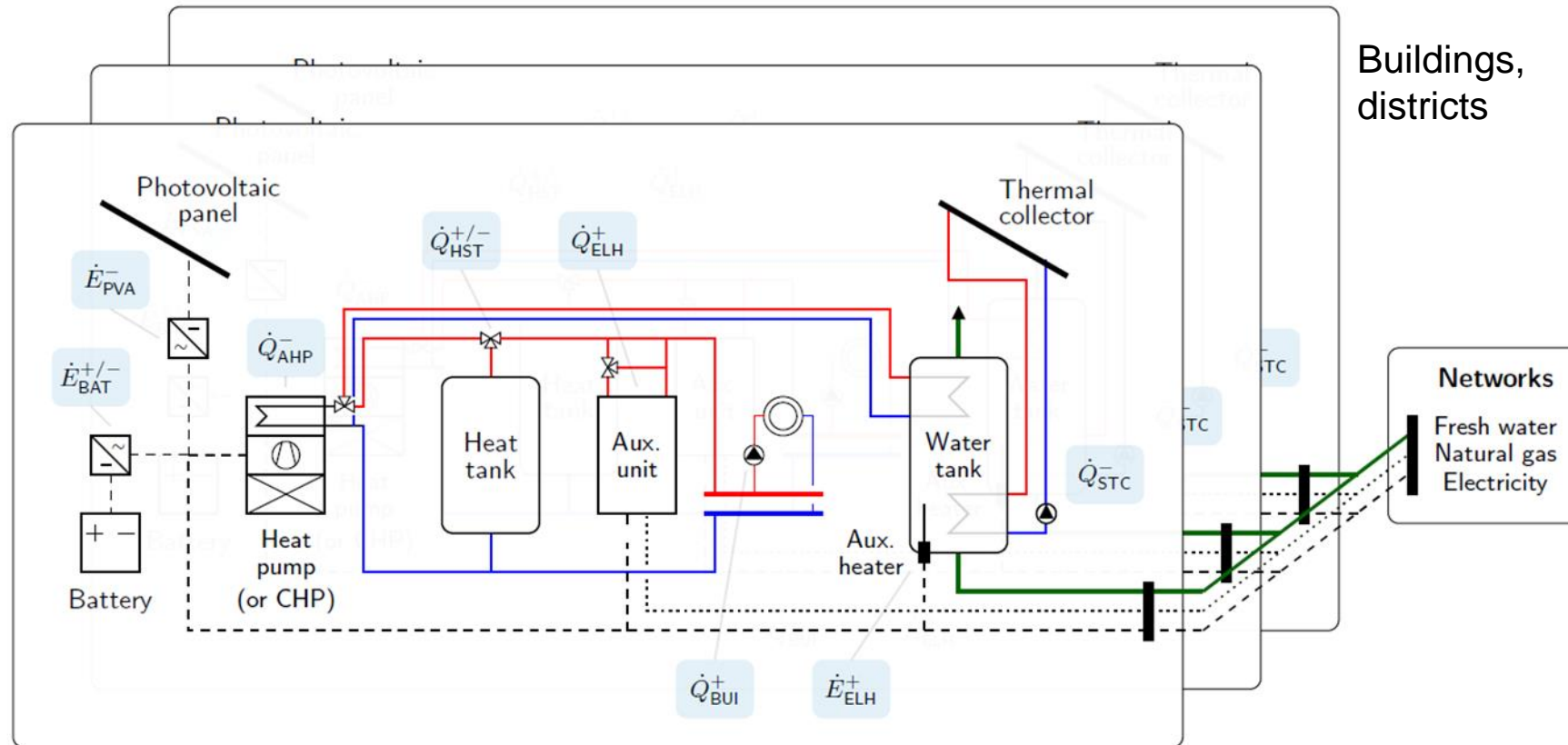


DSOs at the center of the transition

- Drivers:
 - Energy transition happening at the distribution level: PV, ele
 - Regulation e.g., EU's recast electricity directive
- Today:
 - DSO focus on infrastructure design and maintenance
 - Market facilitation role and sourcing of ancillary services limited to TSO
- Tomorrow: enhanced role
 - Procurement by DSO of local ancillary services (e.g., flexibility) to reduce hardware investment costs
 - DSOs providing data management service
 - Facilitating local energy communities, aggregation



Multi-energy grids



- Optimal sizing, optimal operation (peak shavings, demand side management)
- Building energy management, integration of e-mobility
- Micro-grid design and operation (dispatchability)

N. Wyrsh@ csem

Digitalisation is a hot topic but

Huge opportunities for digitalisation

But

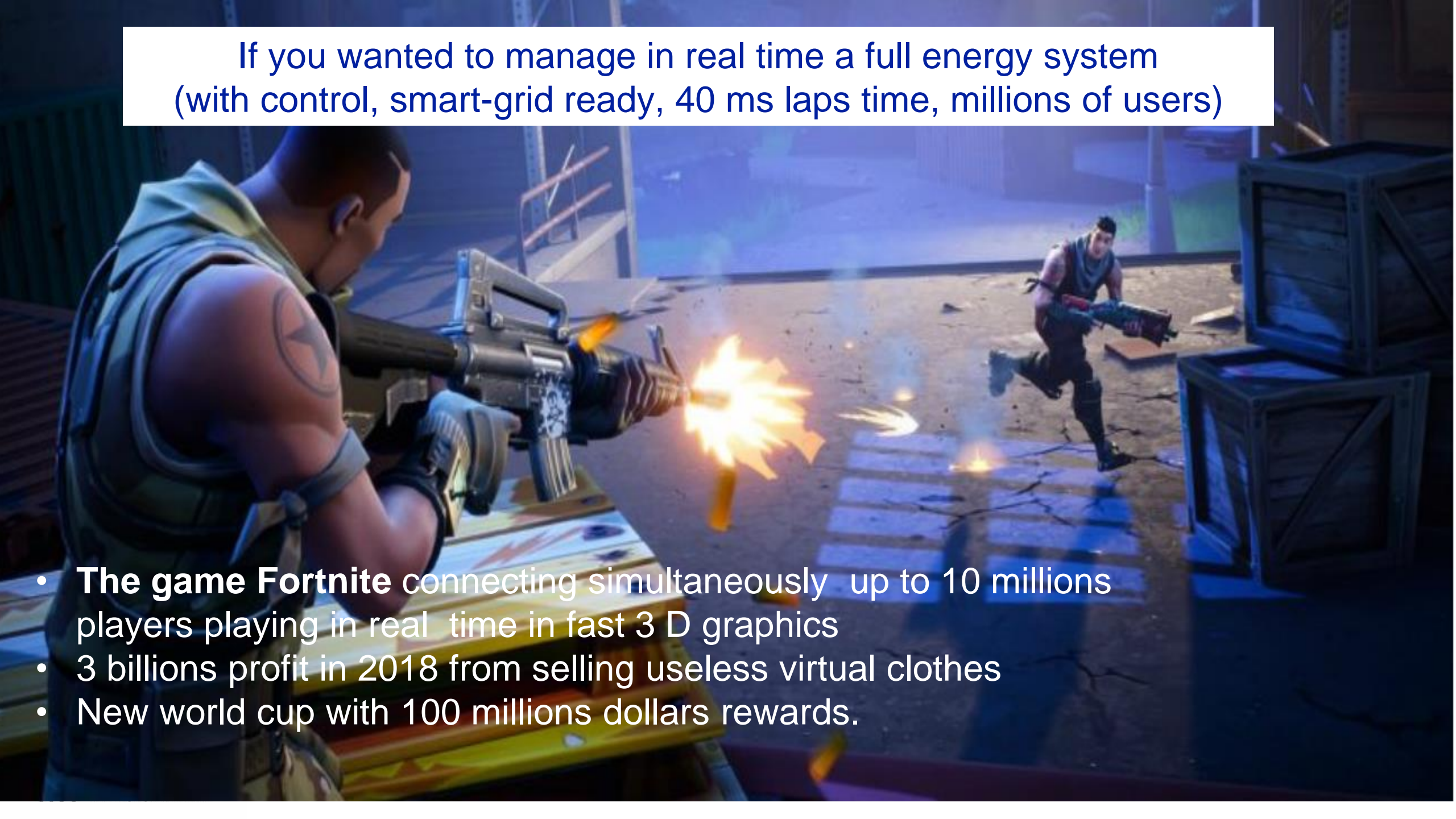
still dependant a lot of «unknown parameters...

- Evolving regulation
- Who controls ?
- How to control ? (pricing ? centralised ?)
- Who makes money and/or the investment ?

Mechanisms for creating sustainable mainstream business by far not obvious



If you wanted to manage in real time a full energy system
(with control, smart-grid ready, 40 ms laps time, millions of users)

- 
- A screenshot from the game Fortnite showing a player in the foreground aiming a shotgun at another player in the distance. The player in the foreground is wearing a green vest and has a star tattoo on their shoulder. The player in the distance is running towards the right. The scene is set in a dark, industrial environment with wooden crates and a blue-tinted sky.
- **The game Fortnite** connecting simultaneously up to 10 millions players playing in real time in fast 3 D graphics
 - 3 billions profit in 2018 from selling useless virtual clothes
 - New world cup with 100 millions dollars rewards.

African dreams

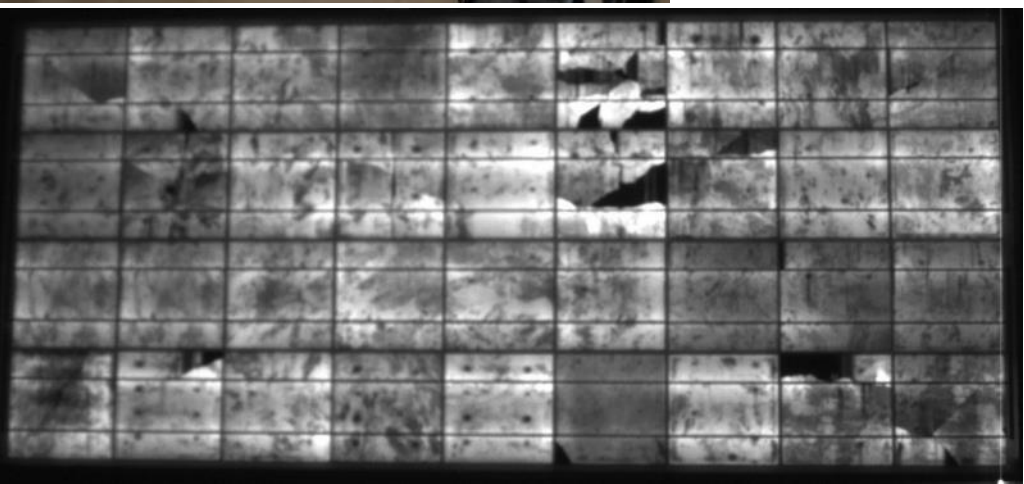


Africa Oil & Power 2019 Senegal to launch renewable energy training and research program

By Thomas Hedley, Field Editor



Technical partners of the program are ESP in Dakar and the Federal Polytechnic Sch
Lausanne through its photovoltaic-laboratory.



EL of modules from PV-lab/ESP Dakar

Manage and store Centralised Or decentralised!



**Batteries
And partly kick
Diesel out...**



Desalinate water (
1m2 for 0.7\$!!!)

Make ice, for cooling at night



GRID COMMERCIAL & INDUSTRIAL NEWS RESIDENTIAL CONTACT U TECHNOLOGY

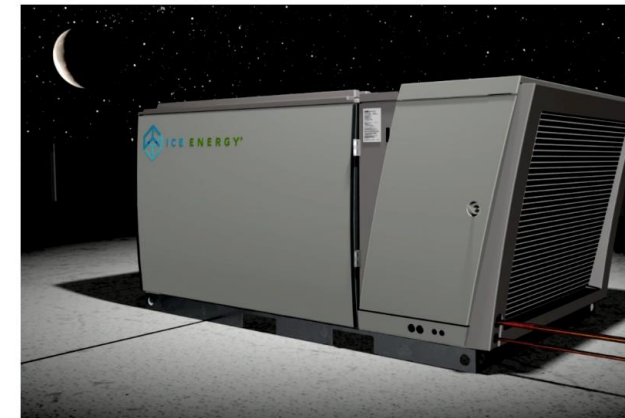
**Irrigation
Pump
(Ennos/ch)**



**Purify/clean
water
(Sorinco/CH)**

Powered by ice

Ice Bear charges by making ice during off-peak hours and discharges by using the stored ice to cool buildings during peak hours. Our smart Ice Bear battery reduces peak cooling electricity by 95% for up to 6 hours a day, every day.



Longer term:

- Electric cars
- H2 storage (interseasonal)



Battery market

- Will be constrained for a couple of years, before an overshooting takes place.....
- Then huge price decline also for residential storage



Power-to-x

Heavy investments in Hydrogen and Power to x

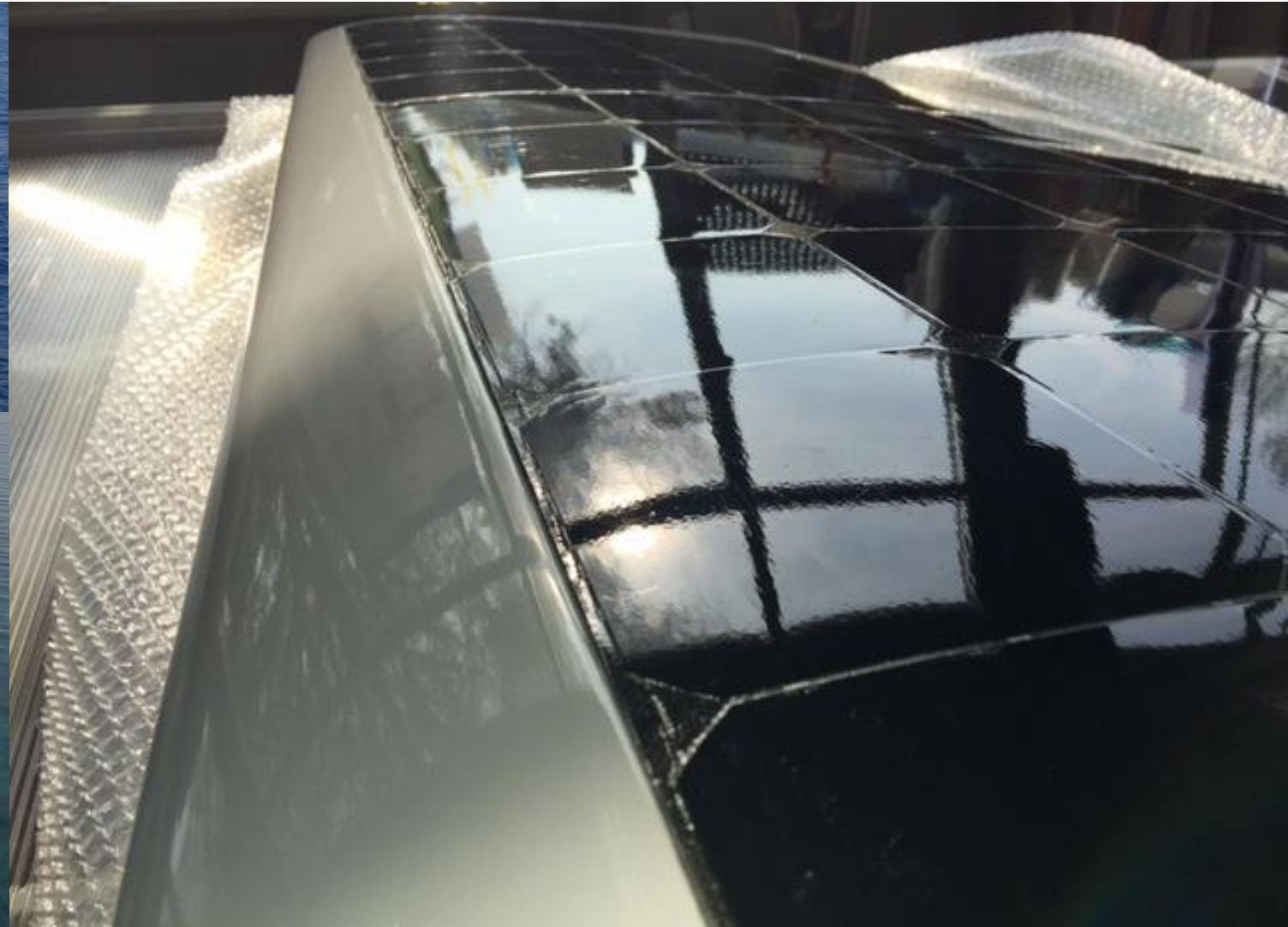


PV everywhere



70 MW Floating PV in China

PV for mobility



The Next 10 years (and more)

will be solar, ...
everywhere,....



Contact: christophe.ballif@epfl.ch

Thanks to EPFL and PV-lab teams, to academic partners
and to industrial sponsors



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra



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