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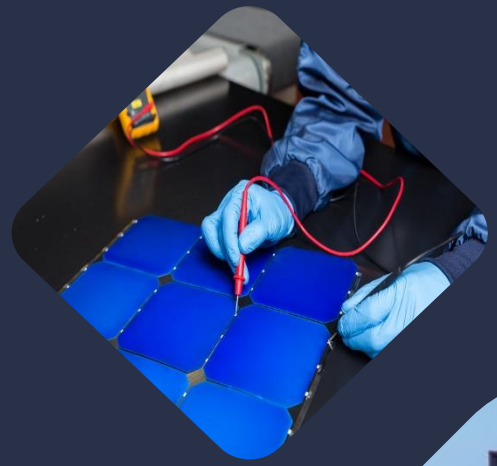
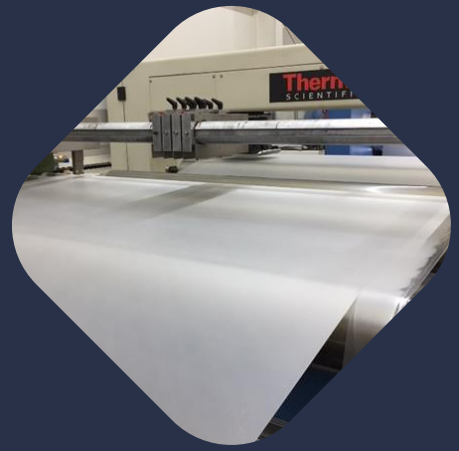


Activities at CSEM PV & Energy Center

Solar Swiss Connect PV Forum

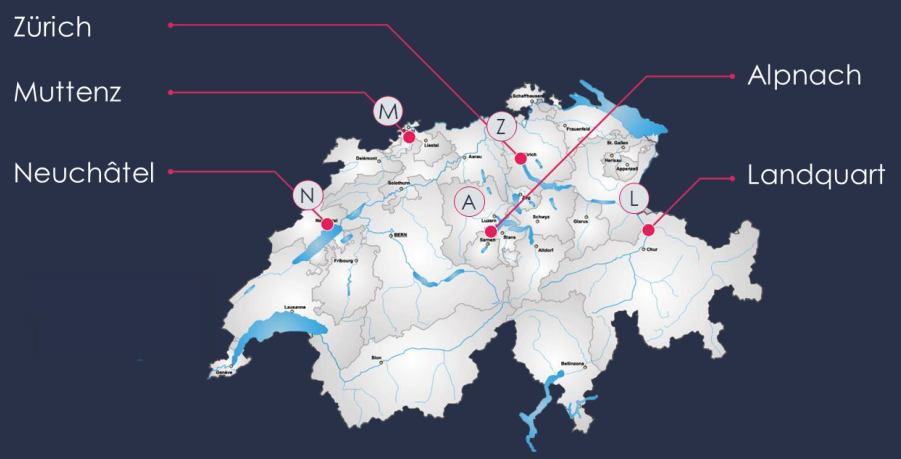
4th November 2021

Yverdon-les-Bain



antonin.faes@csem.ch

CSEM: **Innovation engine** for the industry



Swiss private non-profit **Research & Technology Organization (RTO)**

Development and transfer of world-class technologies **to the industrial sector**

83.0
Annual turnover (Mio CHF)

500
Employees

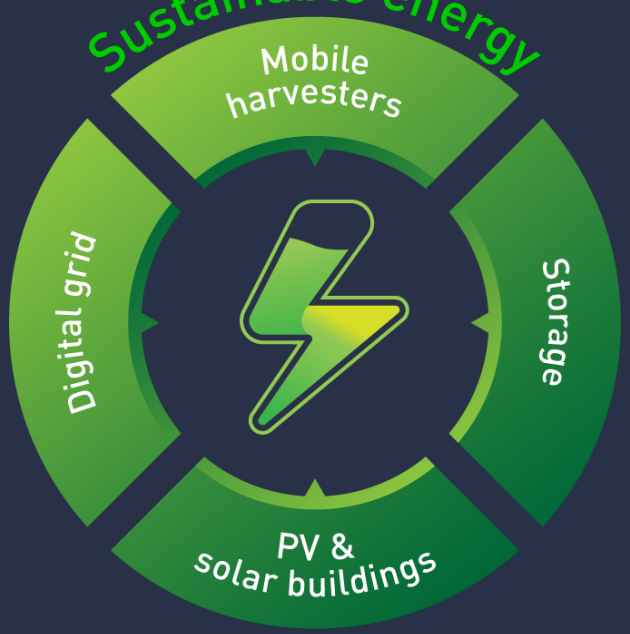
175
Industrial clients / year

210
Patent families

:: csem

CSEM Technology platforms – sustainable energy

Digital grid as enabler
for upcoming electrification



Mobility need fully integrated, robust and lightweight PV solutions

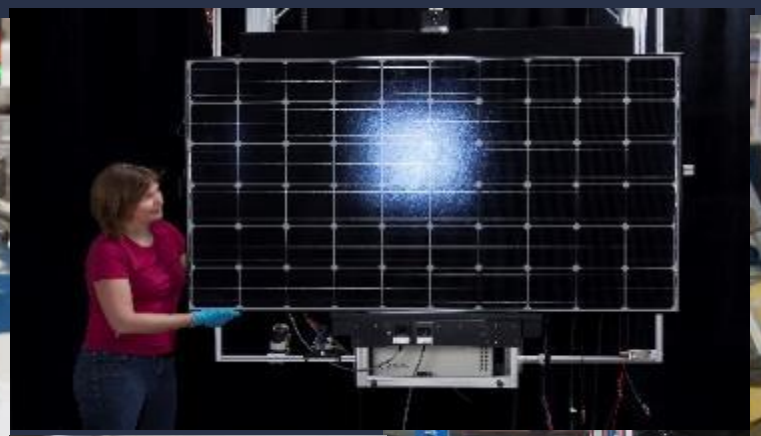
Storage as facilitator to include renewables years

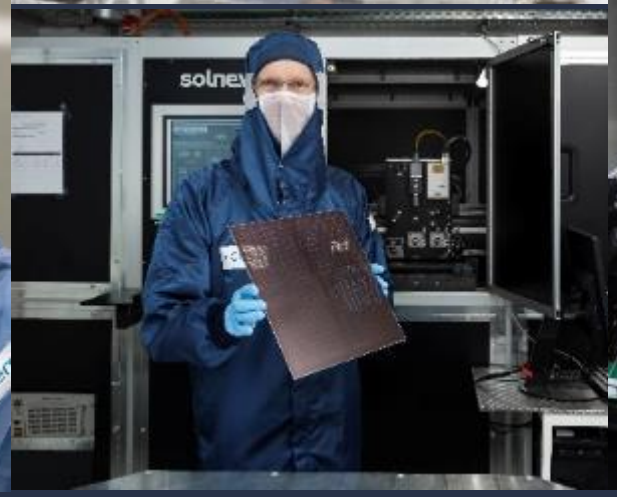
Cells & Buildings integrated
PV solutions including colors

csem

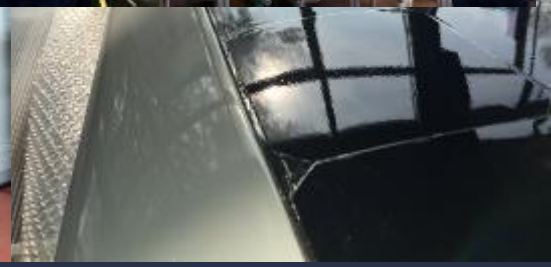
PV technology platform @ CSEM

- ✓ 2000 m^2 R&D platform, from cells and modules manufacturing to reliability testing of modules and batteries.
- ✓ Continuously upgraded to keep CSEM's technological leadership

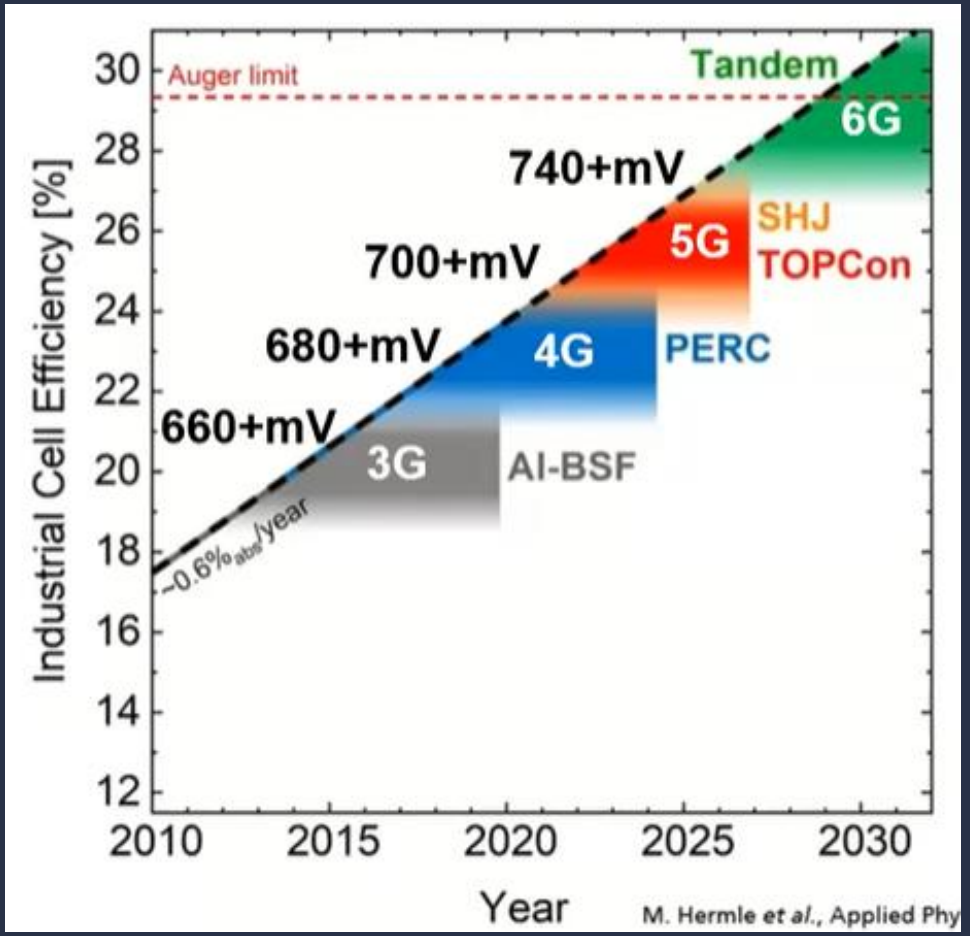





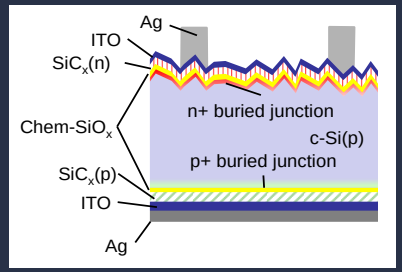


High(er) efficiency solar cells @ CSEM

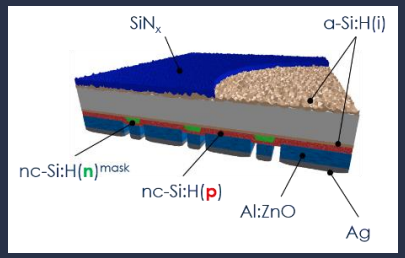


[R. Kopecek, ETIP-PV Conf. 2021]

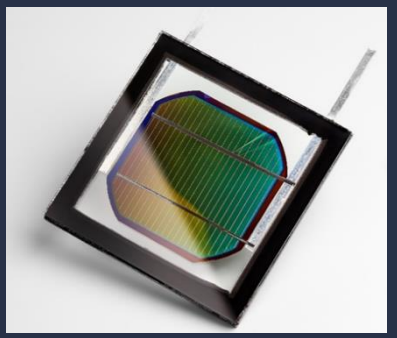
TOPCon



SHJ



Tandems



« industrial process » / proven, upside potential for efficiency

With the fewest step manufacturing process for IBC

Technology	CSEM's best	WR (owner, year)
SHJ (BSC)	**24.4 %** (2019)	26.3 % (Longi, 2021)
IBC-SHJ	**25.4 %** (2019)	26.7 % (Kaneka, 2017)
TOPCon-like	**22.8 %** (2021)	26.0 % (ISE, 2021)
Si/PK tandems	**27.6 %** (4 cm²)(2021)	29.5 % (1 cm²)(OxPV, 2020) 28.3 % (4 cm²)(OxPV, 2020)

With the highest productivity tools

Record RTO large scale devices + mastering of texture

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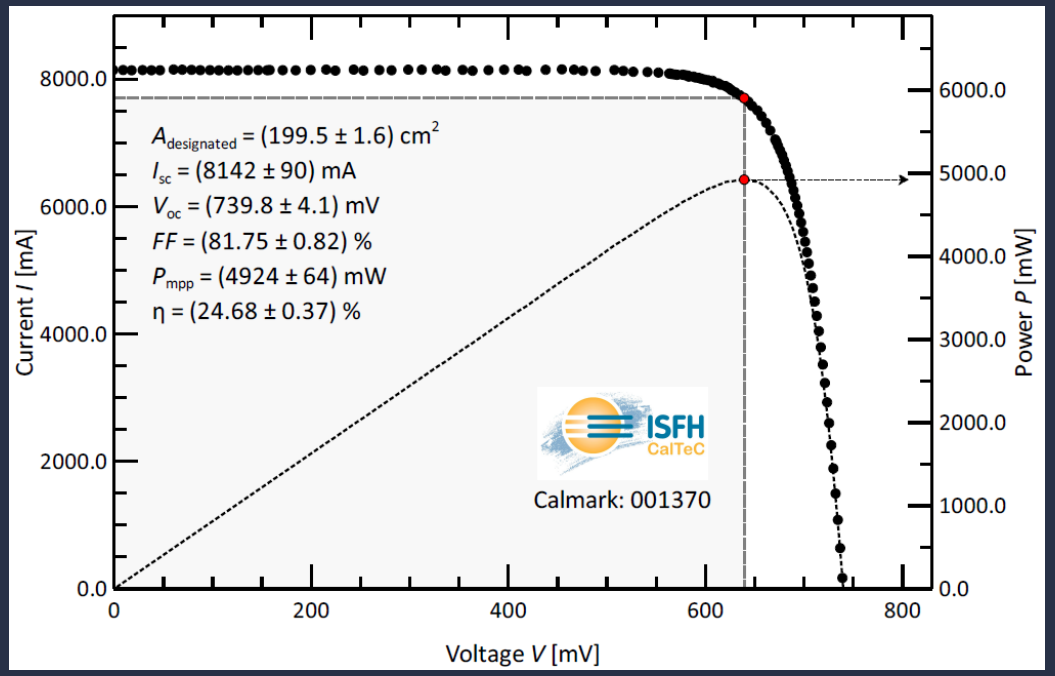
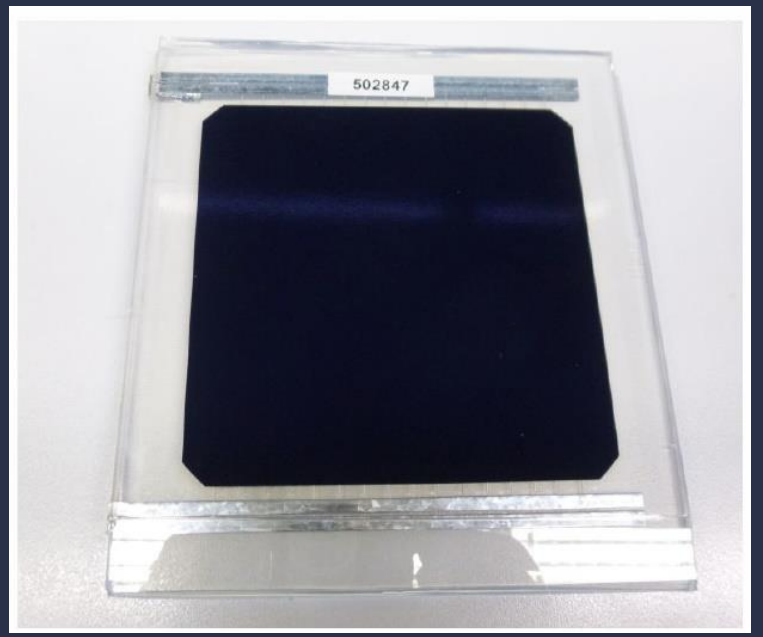
The tunnel-IBC: ongoing R&D activities at module level

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

- World record single-cell **laminate** with tunnel-IBC + SmartWires® (with Meyer Burger):

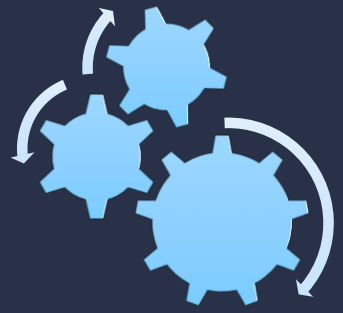




✓**24.7 % efficiency**
world record for a laminate !

csem

Facilities for **Advanced Polymers**



Cast film extrusion line, compounder, dryer, pelletizing, storage

Underwater pelletizing line, most advanced pelletizing equipment

Characterization lab for polymers (rheology, DSC, UV-Vis spectroscopy, FTIR…)

- Base materials: **EVA, PP, PE**
- **Polymer formulation** development
- Specific **Additive package** development
- Specific **mechanical properties** of the compounds

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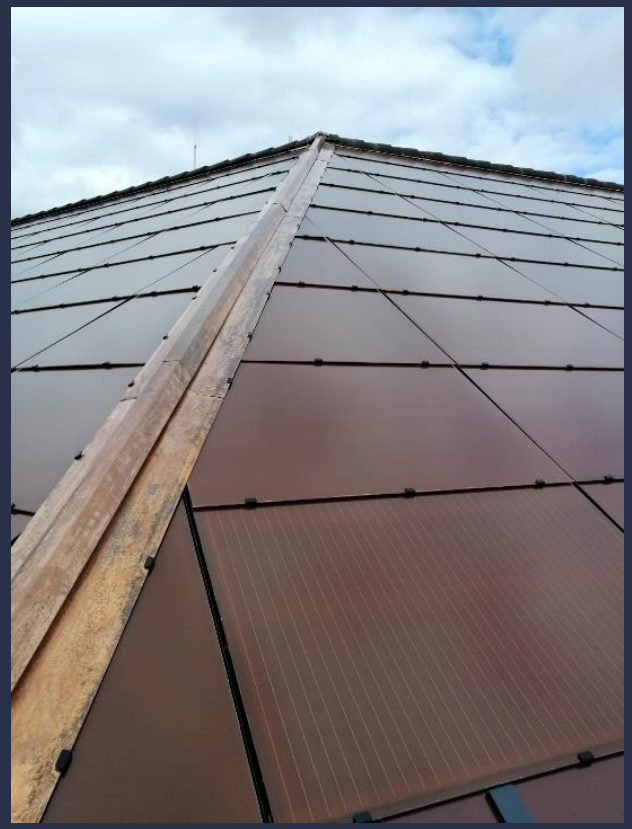
BIPV solutions @ CSEM – Recent achievements

- 800 m^2 terracotta modules installed in Zürich (3S+ with Solaxess foils):



- New colours developments @ CSEM: coloured 60-cell module manufactured

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Integrated PV to reaches the Stratosphere

Solarstratos aims to reach the stratosphere with an electric plane powered only by solar energy

SOLARSTRATOS
TO THE EDGE OF SPACE

The PV CHALLENGE

Only 700 g/m²

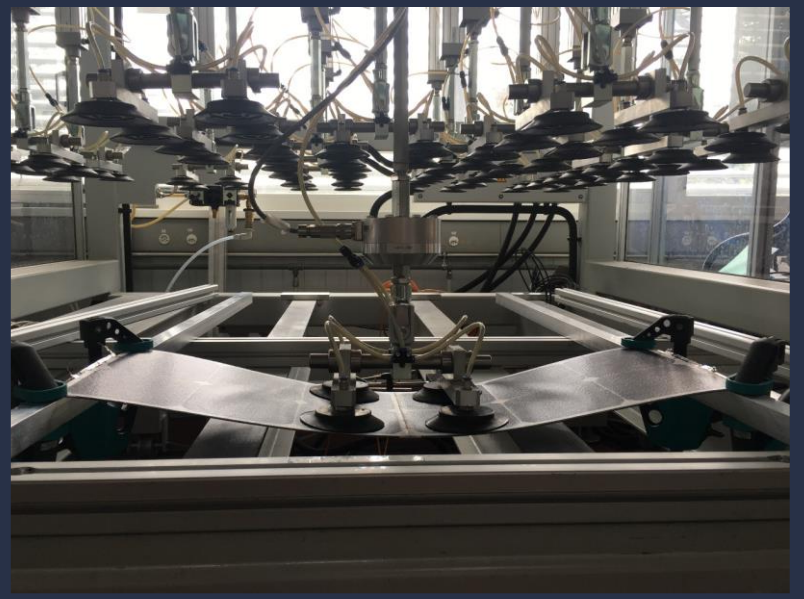
> 210 W/m²

< 0.2 mm roughness on wing.

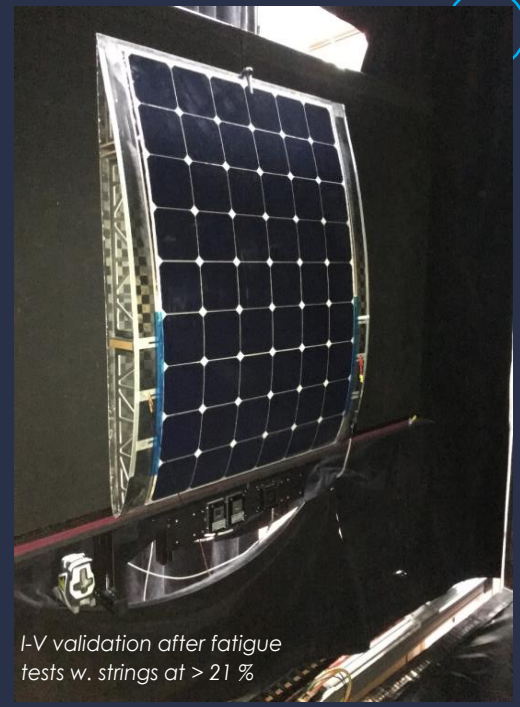
Thermal-cycling > 200 cycles – 40°C to + 80°C

Adhesion/fatigue 10’000 cycles 25 N/cell peel force

Load test with bending (3 m curve of wing)



Adhesion demonstrated on wing element: 10’000 cycles realized successfully



I-V validation after fatigue tests w. strings at > 21 %

csem SOLARSTRATOS TO THE EDGE OF SPACE

First jump from an electrical aircraft

First skydive only powered by solar energy

SOLARSTRATOS
TO THE EDGE OF SPACE

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Swiss Solar Boat

Other example of CSEM solar solution for **Mobility**

- 2nd place and price of eco-conception at the Monaco Solar & Energy Boat Challenge 2021
- Powered by CSEM PV solutions
- EPFL student team (60 members)

https://swisssolarboat.ch

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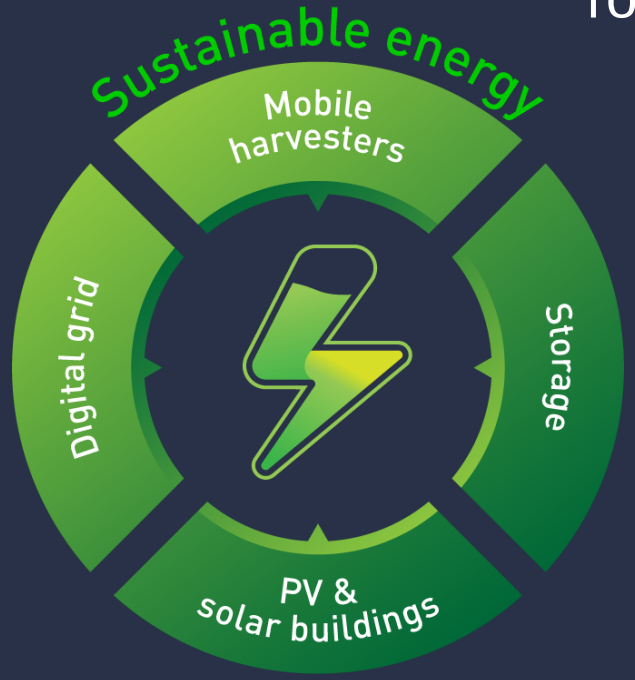
CSEM Technology platforms – sustainable energy

Digital grid as enabler
for upcoming electrification



Mobility need fully integrated, robust and lightweight PV solutions

Storage as facilitator to include renewables years

Cells & Buildings integrated
PV solutions including colors

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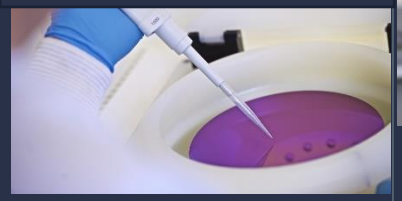
Battery research activities @ CSEM: from materials to systems

Coatings and Interfaces



- Thin-film coatings
- Wet coatings
- Interface functionalization

Solid-state electrolytes

- Polymer solid state
- Ceramic solid state
- Integration and stabilization in cell

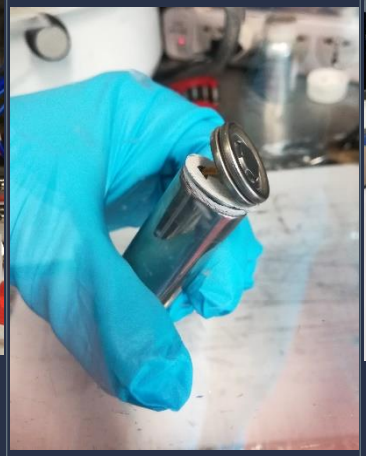
Cell modelling

- SoX estimators based on EIS
- Validation vs. measurements
- Simulations

Cell/module testing

- Technological screening
- Ad-hoc testing protocols
- Second-life testing procedures

Post mortem analyses



- Opening
- Imaging
- Modelling

BMS prototyping

- CMS concept
- Active balancing
- EIS integration

System-level analyses

- Frequency regulation
- Power trading optimization
- V2G analysis

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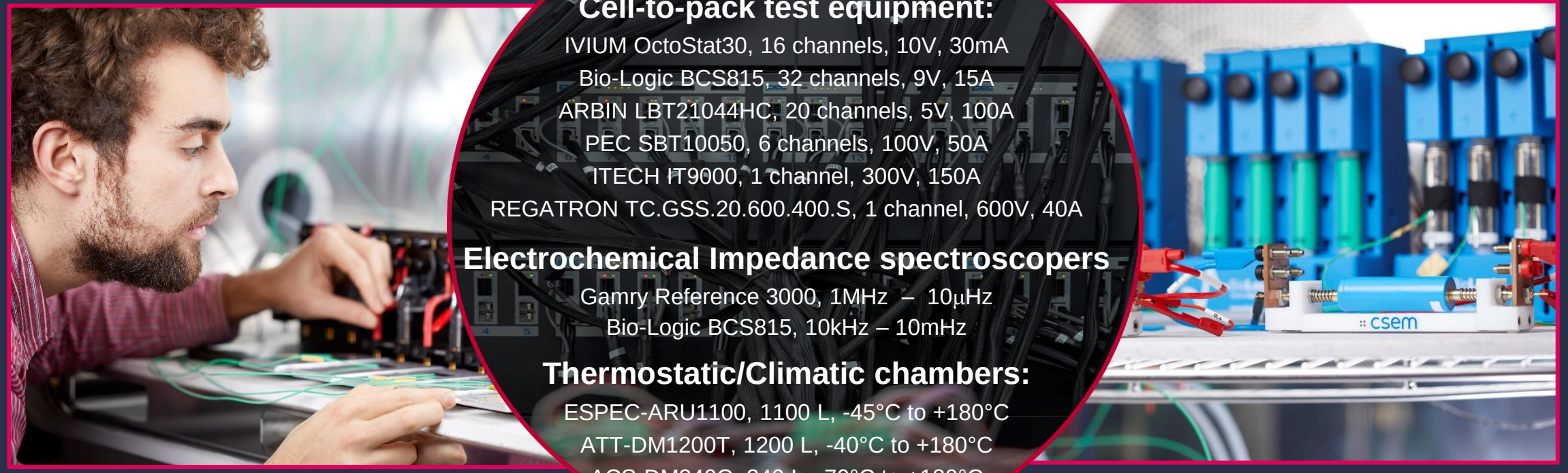
Our battery testing infrastructure in Neuchâtel

Focused on battery research «from cell to system»



Laboratory equipment

Cell-to-pack test equipment:

IVIUM OctoStat30, 16 channels, 10V, 30mA

Bio-Logic BCS815, 32 channels, 9V, 15A

ARBIN LBT21044HC, 20 channels, 5V, 100A

PEC SBT10050, 6 channels, 100V, 50A

ITECH IT9000, 1 channel, 300V, 150A

REGATRON TC.GSS.20.600.400.S, 1 channel, 600V, 40A

Electrochemical Impedance spectroscopers

Gamry Reference 3000, 1MHz – 10μHz

Bio-Logic BCS815, 10kHz – 10mHz

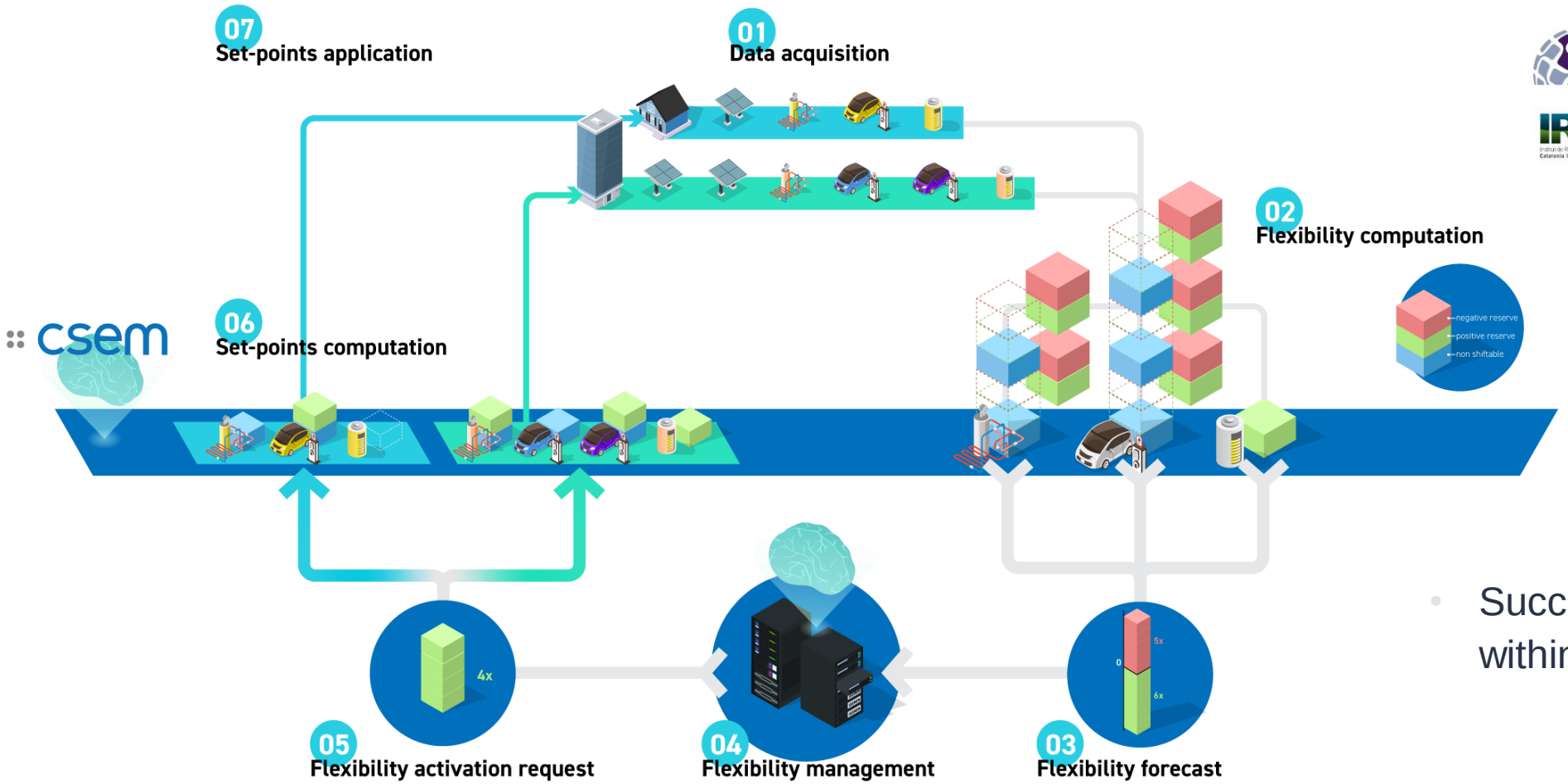
Thermostatic/Climatic chambers:

ESPEC-ARU1100, 1100 L, -45°C to +180°C

ATT-DM1200T, 1200 L, -40°C to +180°C

ACS-DM340C, 340 L, -70°C to +180°C

Digital Grid – Energy Data Management



Schneider Electric

INSERO

IREC

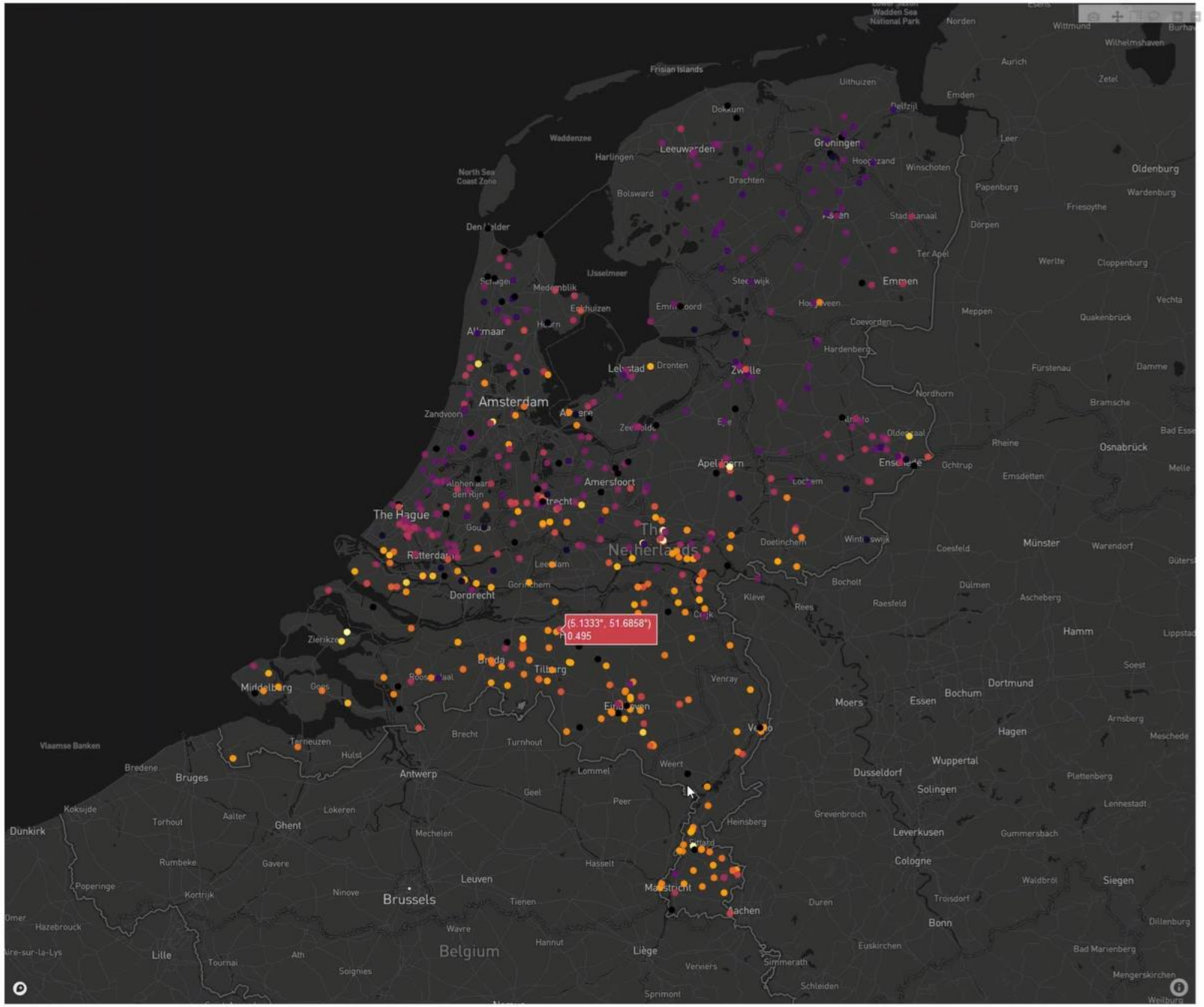
smsplc

- Successful **demonstration** within project on electrical grid

SABINA

B. Schubnel *et al.*, 'State-space models for building control: how deep should you go?', *Journal of Building Performance Simulation*, vol. 13, no. 6, pp. 707–719, Nov. 2020, doi: 10.1080/19401493.2020.1817149.

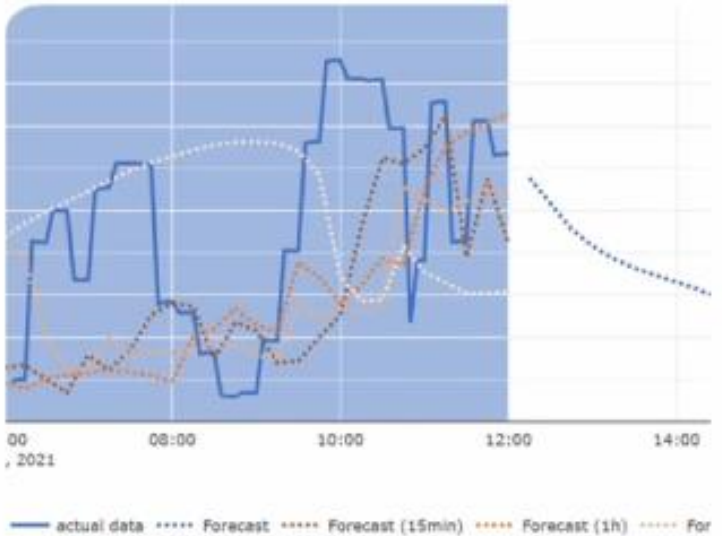
PVLIVE Home Live map Animated forecast Node view



Selected node

Lat: Lon:

View node



Conclusion

If you have a need in sustainable energy just come to CSEM!

Thank you for your attention!

antonin.faes@csem.ch

www.csem.ch