



Monday 23rd september 2024, Vienna, Austria

Roots and Wings for PV Solar Energy
*« Des Racines et des Ailes pour l'énergie solaire photovoltaïque »**

DANIEL LINCOT



Emeritus Research Director at CNRS
Institut Photovoltaïque d'Île de France
French Academy of Technology



* Title adapted from that of a popular french TV show

“Looking at the past to shed light on the present and provide pointers for the future, with the aim of highlighting personalities and *groups** who are taking action in the field”.

« Regarder le passé pour éclairer le présent et donner des pistes pour le futur, avec la volonté de mettre en lumière des personnalités *et des groupes** qui agissent sur le terrain »

Source : explanation by a creator (from wikipedia)

* Added by myself

1820-1891

Edmond Becquerel

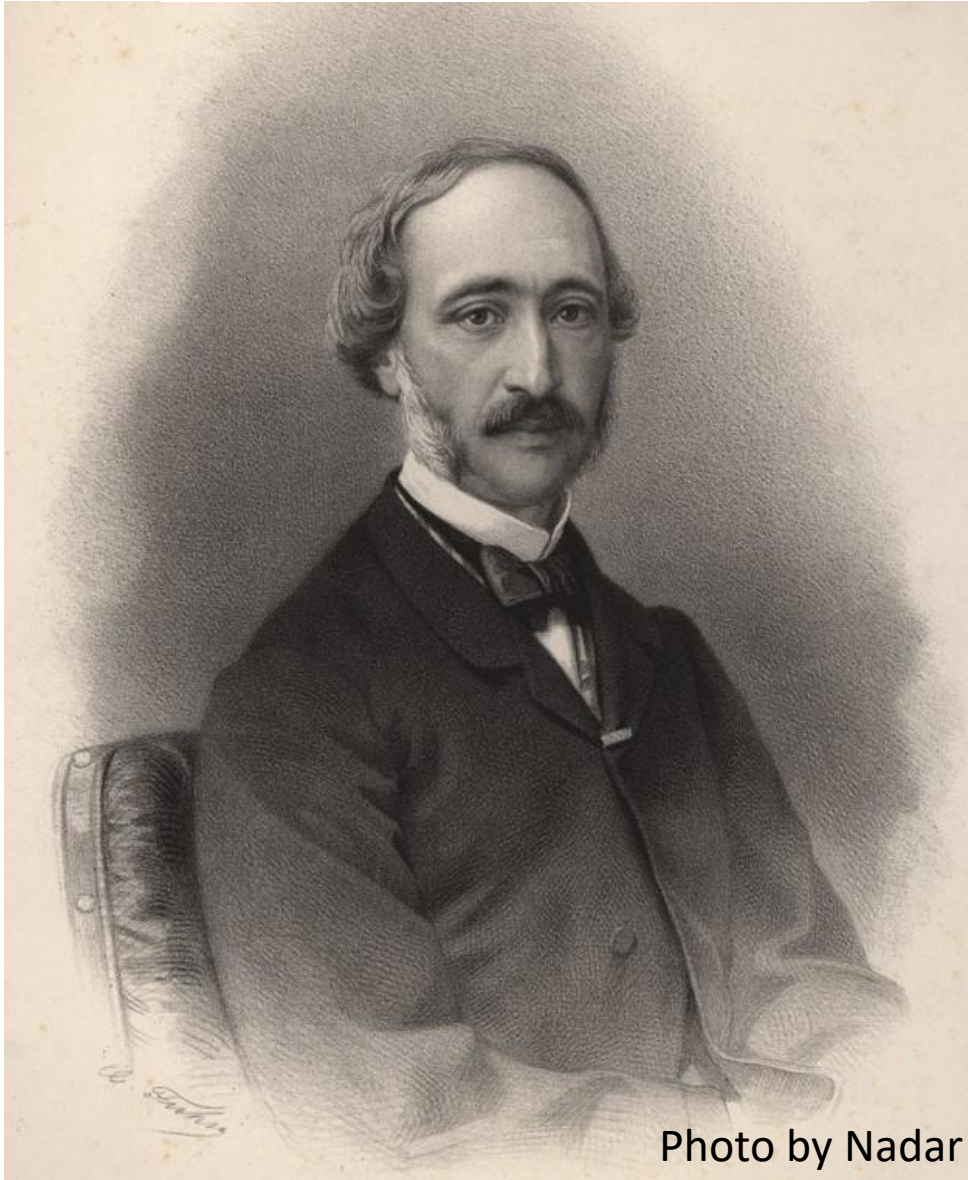


Photo by Nadar

1989



EDMOND BECQUEREL

The Discoverer of Photovoltaics



Daniel Lincot, Becquerel Prize, EUPVSEC, 23/092024

Paris : Muséum National d'Histoire naturelle –Jardin des plantes



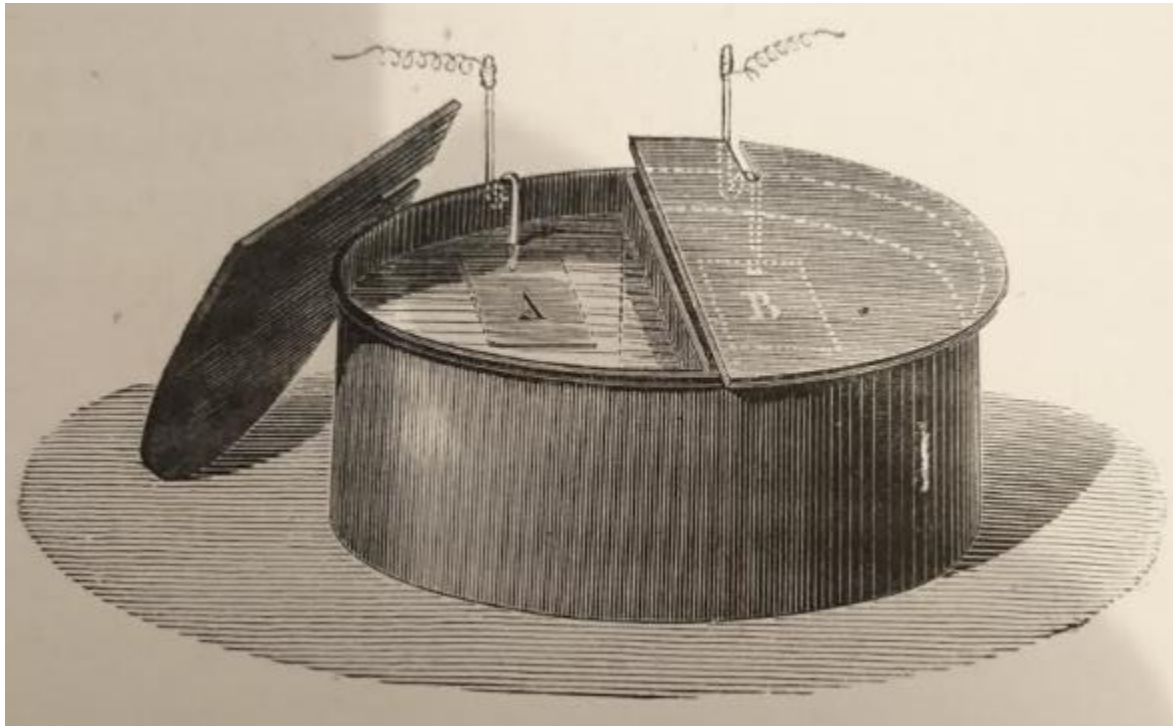
Antoine :1837
Electrochemistry
Medal Copley
Royal Society
London

Edmond (Alexabdre-Edmond)
Light and electricity
Photography
Phosphorescence
Discovery of photovoltaics

Henri
1903 Nobel Prize1903
with Pierre and Marie Curie
Radioactivity

Fast track From Discovery to Application to industry 1941 : The electrochemical actinometer

1839 : the discovery of photovoltaics



Rayons du spectre:	Intensité du courant:
Rouges	0
Orangés	
Jaunes	
Verts.....	trace
Bleus.....	0°,75
Indigo.....	1°
Violet.....	3°
Rayons au-delà du violet...	3°

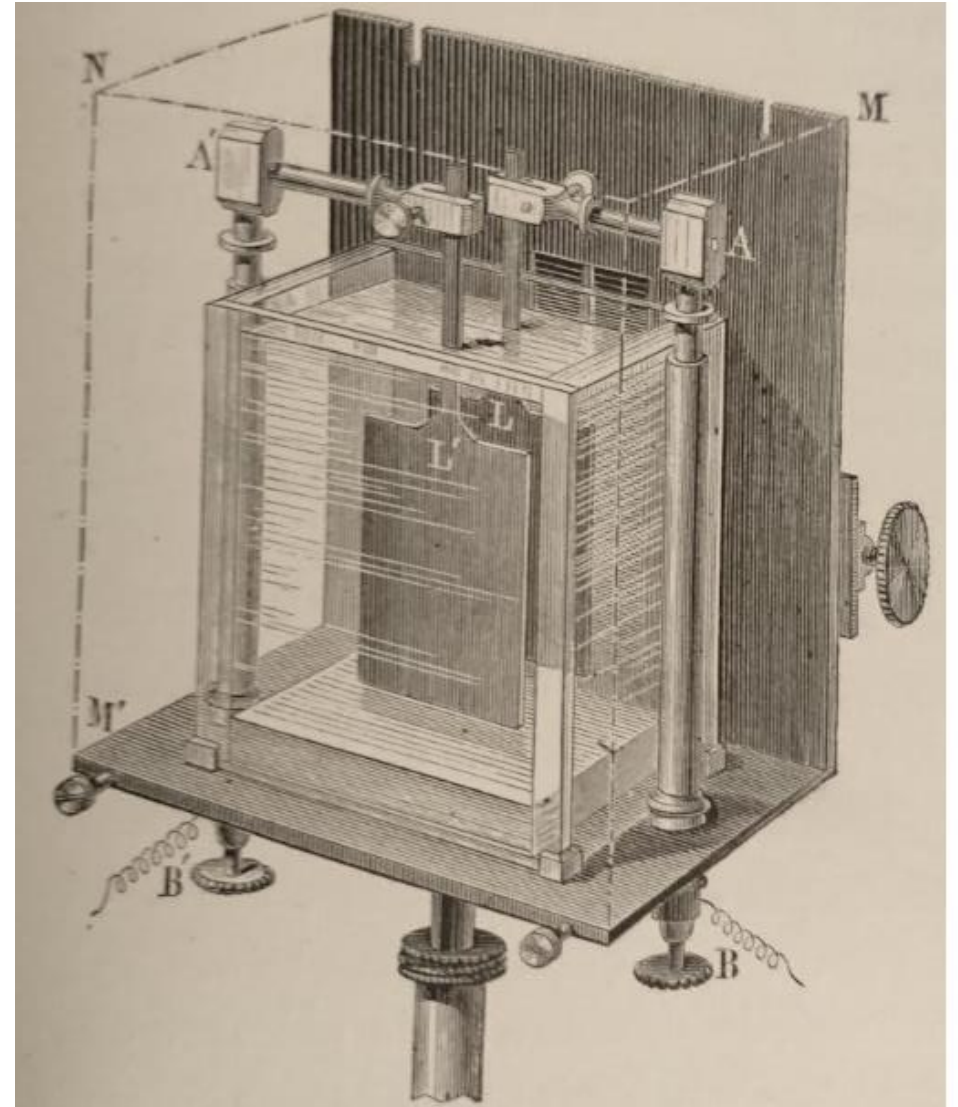


AgCl
Wide gap
Semiconductor



Halide perovskites PV

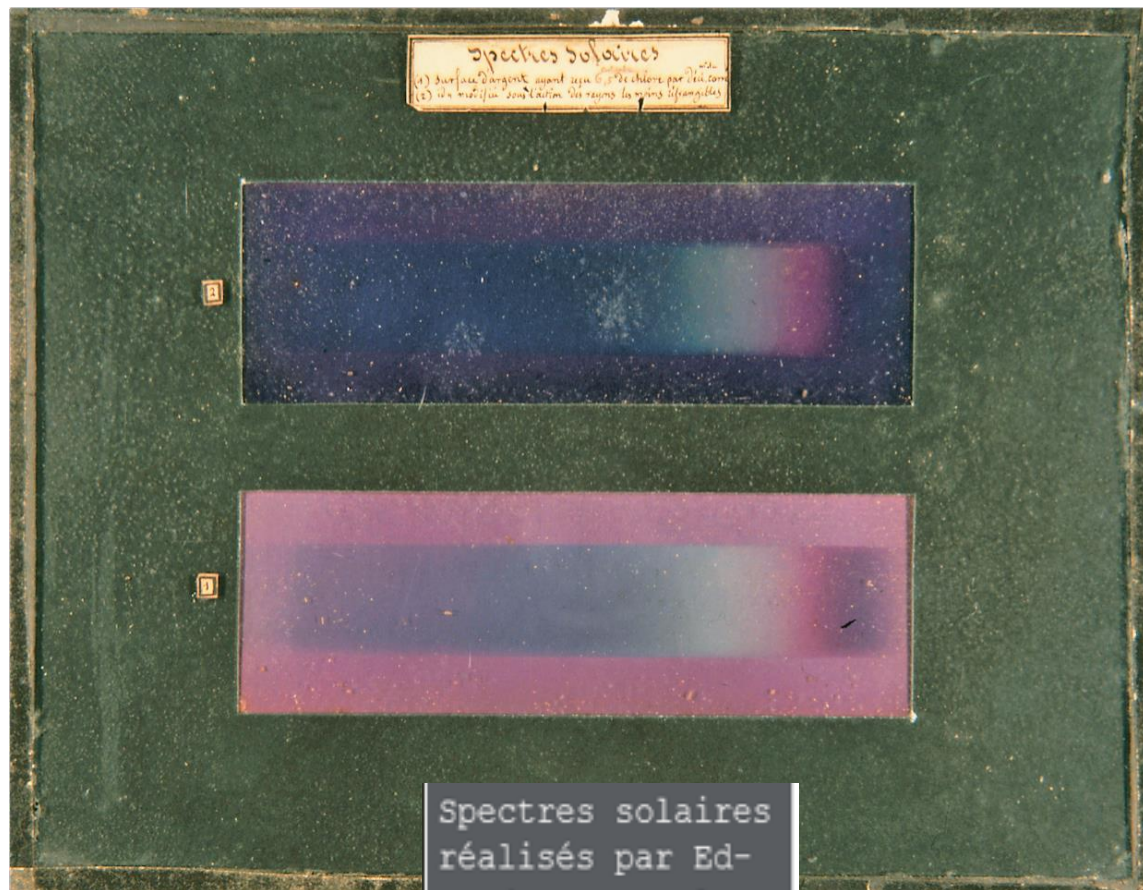
1941 : The electrochemical actinometer
The ancestor of photoelectrochemical cells



1948

Pluridisciplinarity

Convergence with photography (also with AgCl)
first colored photography by Becquerel (quantum size effects)



Spectres solaires
réalisés par Ed-
mond Becquerel en
1848.
Photo© Musée Ni-
céphore Niépce,
Chalon-sur-Saône.

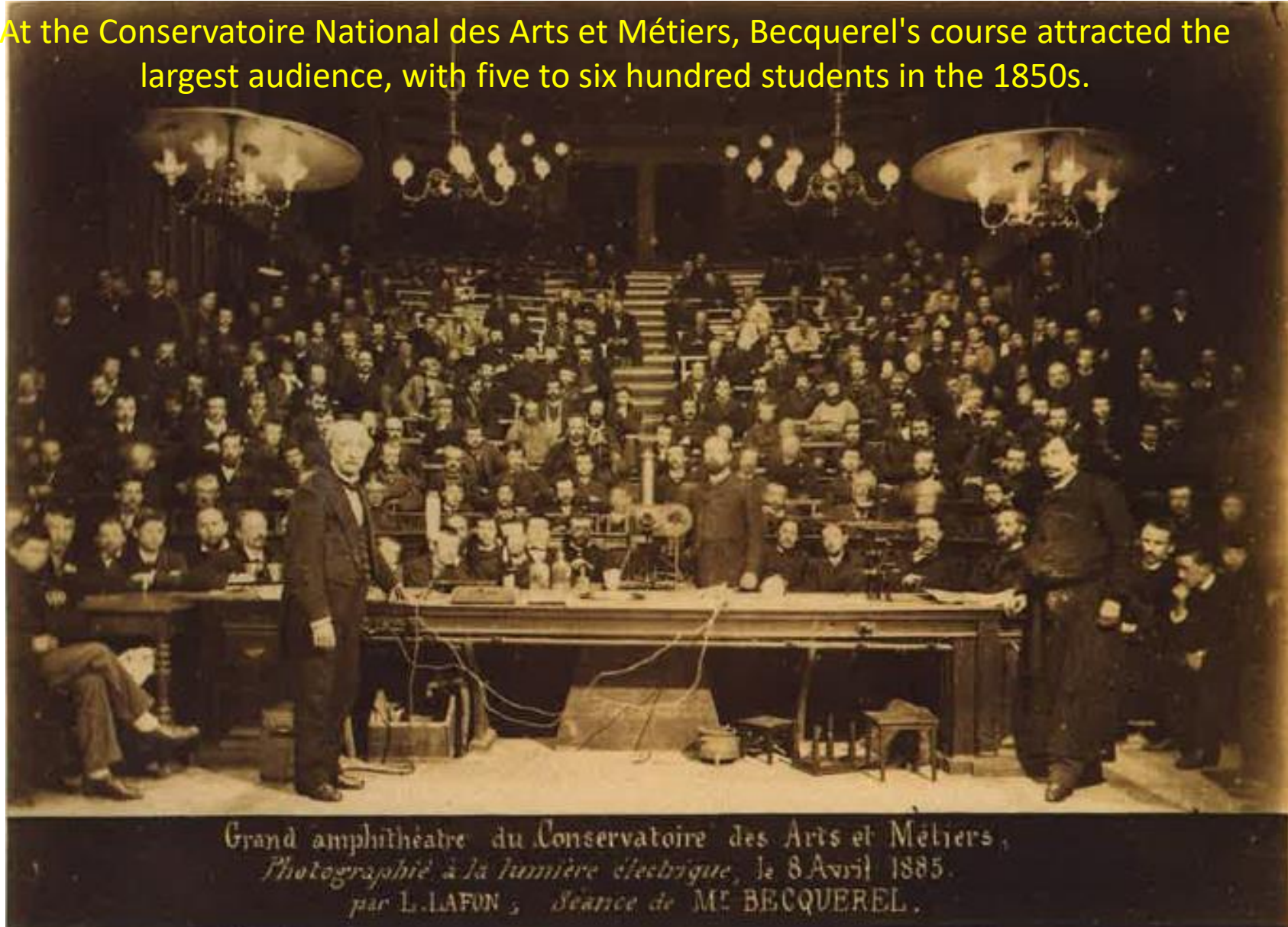
Fundamental study of phosphorescence
The phosphoroscope



Daniel Lincot, Becquerel Prize, EUPVSEC, 23/092024

A passion for teaching and experiments

At the Conservatoire National des Arts et Métiers, Becquerel's course attracted the largest audience, with five to six hundred students in the 1850s.



A passion for light : A fantastic Book

1867

LA LUMIÈRE SES CAUSES ET SES EFFETS

PAR

M. EDMOND BECQUEREL

DE L'ACADÉMIE DES SCIENCES
DE L'INSTITUT DE FRANCE
PROFESSEUR AU CONSERVATOIRE IMPÉRIAL DES ARTS ET MÉTIERS, ETC., ETC.

TOME PREMIER

SOURCES DE LUMIÈRE



PARIS

LIBRAIRIE DE FIRMIN DIDOT FRÈRES, FILS ET C^{ie}

IMPRIMEURS DE L'INSTITUT, RUE JACOB, 36

1867

Light Sources

1868

LA LUMIÈRE SES CAUSES ET SES EFFETS

PAR

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PROFESSEUR AU CONSERVATOIRE IMPÉRIAL DES ARTS ET MÉTIERS, ETC., ETC.

TOME SECOND

EFFETS DE LA LUMIÈRE



PARIS

LIBRAIRIE DE FIRMIN DIDOT FRÈRES, FILS ET C^{ie}

IMPRIMEURS DE L'INSTITUT, RUE JACOB, 36

1868

Effects of Light

7th december 2020 : <https://www.ipvf.fr/symposium-edmond-becquerel/>

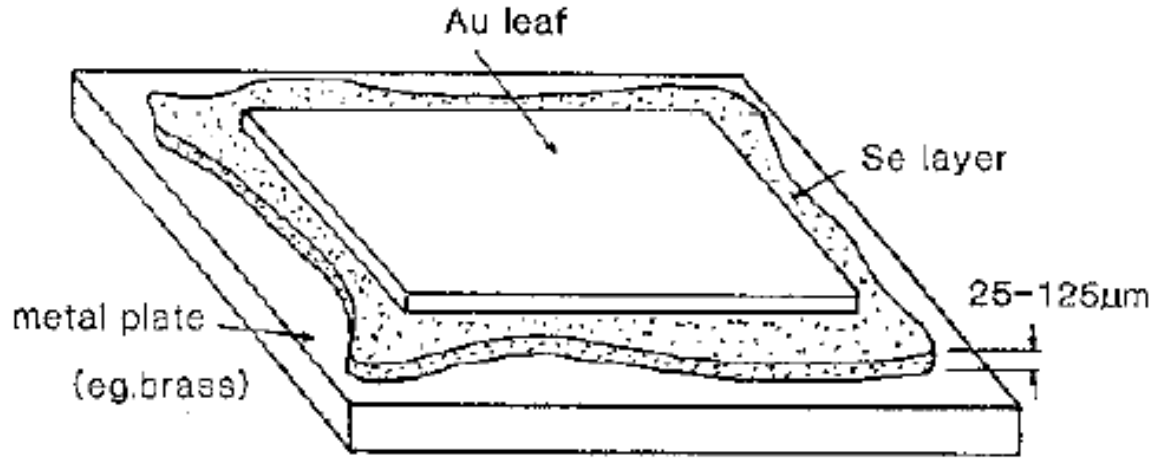


Figure 3: Thin film selenium cell demonstrated by Fritts in 1883.

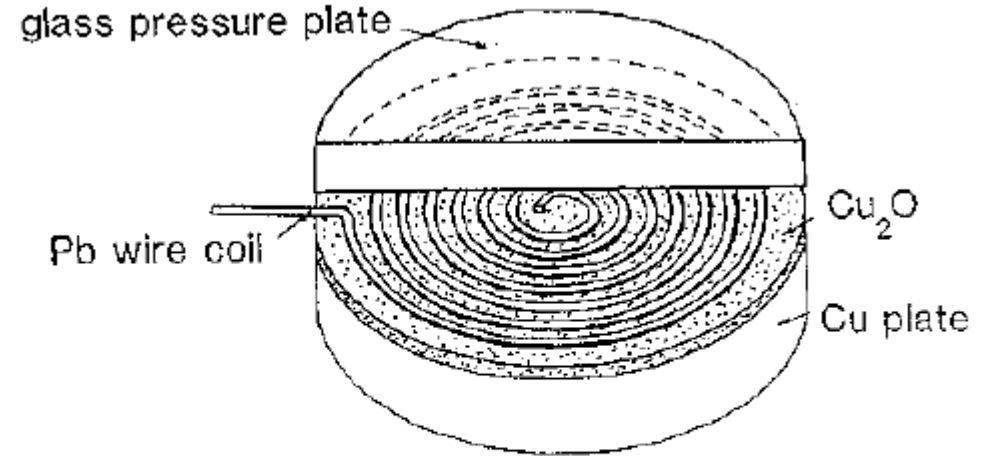
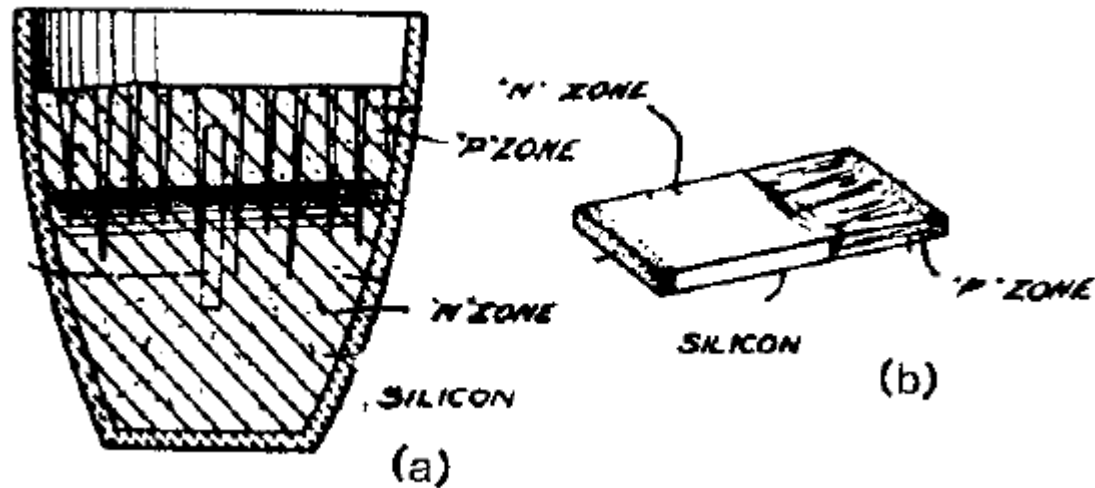


Figure 4: Early Grondahl-Geiger copper-cuprous oxide photovoltaic cell (circa 1927).

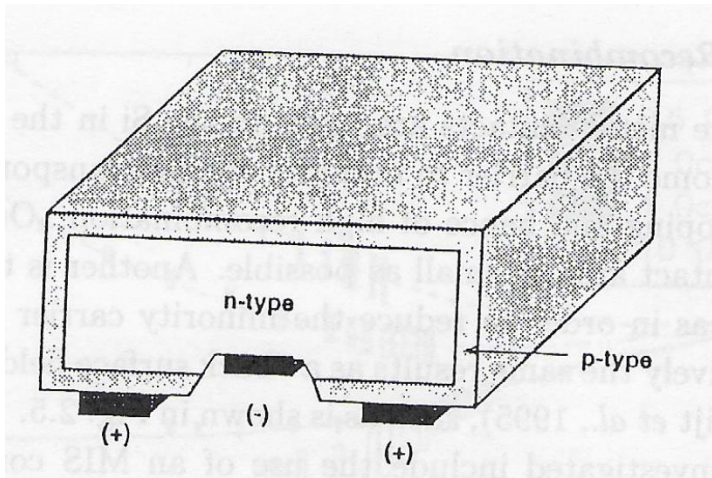


Early Crystalline silicon solar cell (R. Ohl 1941)

Four Years to Change the World

1954 – Bell telephone 6% de rendement → 1958 First satellite powered by PV (Vanguard)

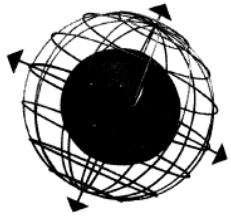
2024
70th anniversary
of the First Modern Solar Cell



Pearson, Fuller, Chapin



1955- Solar Energy for the World



Proceedings of the
**WORLD SYMPOSIUM
 ON APPLIED SOLAR ENERGY**

PHOENIX, ARIZONA
 NOVEMBER 1-5, 1955

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 Directeur du Laboratoire de
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Electricity from the Sun

G. L. PEARSON
 Bell Telephone Laboratories, Inc.
 Murray Hill, N. J.



High Temperature Furnaces

FELIX TROMBE
 Research Director
 National Center of Scientific Research
 and
 Director
 Solar Energy Laboratory at Montlouis
 France

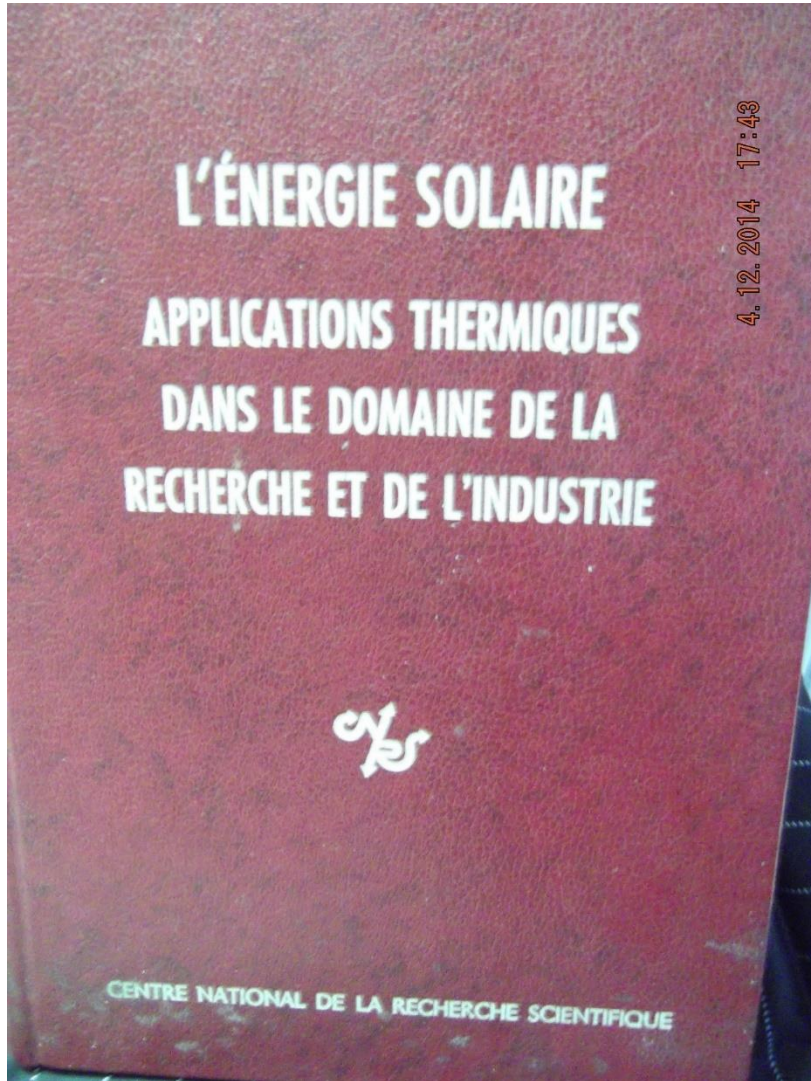
Odeillo, 1969
 « The Solar Temple »



Lain Stark

1958 Start of the French Solar Golden Age

Solar Energy :Thermal applications in the area of research and Industry organized by CNRS in Montlouis 23-28 juin



Only one paper on PV

LA CONVERSION DE L'ÉNERGIE SOLAIRE EN ÉNERGIE ÉLECTRIQUE PAR LES SEMI-CONDUCTEURS : THERMOPILES ET PHOTOPILES

par M. MICHEL RODOT,
*Laboratoire de Magnétisme et de Physique du Solide,
C.N.R.S., Bellevue (France)*

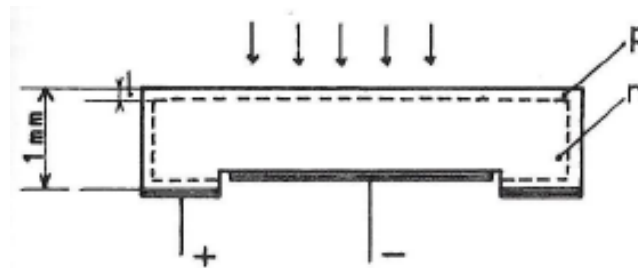


FIG. 1. — Schéma d'une photopile solaire en silicium.

Cellules commerciales 2,5%

Michel Rodot
(1928-2002)



Notes added to proofs (1960) "At present, silicon solar cells manufactured in our in our laboratory reach an efficiency of 14%".

French Solar Golden Age

Michel Rodot



2024

Polytechnic school
Solid state physicist
1954 joined CNRS

1956: silicon cells

1960: Si patent, first industrial space applications

1966-1976: Director of the Physics Laboratory Physics Laboratory in Meudon

1976-1981

Director of the interdisciplinary program on solar energy of CNRS (PIRDES)

COMES : Scientific director of Commissariat of Solar Energy

European Action (EUPVSEC), Advocating for Solar Energy for the world

Team building : Colleagues, students, post-docs

Also : Wolfgang Palz, Jean Eric Bourée, Quan Nam, Daniel Lincot, Jean François Guillemoles...and many others





1973

International Congress
« The Sun at the Service of Mankind »
UNESCO, Paris



LE SOLEIL au service de l'homme

Palais de l'Unesco - Paris - 2-6 Juillet

Source d'énergie non polluante permanente et inépuisable, ultime ressource de l'homme, le Soleil est notre avenir.

C'est pourquoi AMENAGEMENT ET NATURE s'est associé aux organismes spécialisés :

- l'International Solar Energy Society (I.S.E.S.)
- la coopération Méditerranéenne pour l'Energie Solaire (C.O.M.P.L.E.S.)
- l'Association Française pour l'Etude et le Développement des Applications de l'Energie Solaire (A.F.E.D.E.S.)

pour l'organisation d'un congrès international qui se tiendra sous les auspices de l'UNESCO du 2 au 6 juillet 1973, à Paris, sur le thème :

Sous le patronage d'un Comité exécutif présidé par le Professeur AUGER, ancien Directeur du département des Sciences à l'UNESCO, des Comités scientifiques et techniques spécialisés ont été constitués pour chaque section, dont les thèmes sont les suivants :

SECTION A : LE SOLEIL ET LA VIE

SUN AND LIFE

SECTION B : LE SOLEIL ET L'ENERGIE

SUN AND ENERGY

SECTION C : LE SOLEIL ET L'HABITAT

SUN AND HABITAT

Modern Global and Universal vision: Scientific, Technological, Social and Environmental

Photo BROSELIN Lis Martagon



Science, Experiments, Fun and Vision

PALAIS DE L'UNESCO DU 2 AU 6 JUILLET: CONGRÈS SOLAIRE

INAUGURATION
DU CONGRÈS:
LE SOLEIL AU
SERVICE DE L'HOMME,
ENTRE AUTRES, ALLOCUTION
DU PROFESSEUR AUGER.

NOUS ALLONS ECOUTER
"L'HYMNE AU SOLEIL" DES INDES
GALANTES DE RAMEAU.

Professor Auger
« The Auger recombination »
Opening the Congress
Singing the « Hymn to the sun »

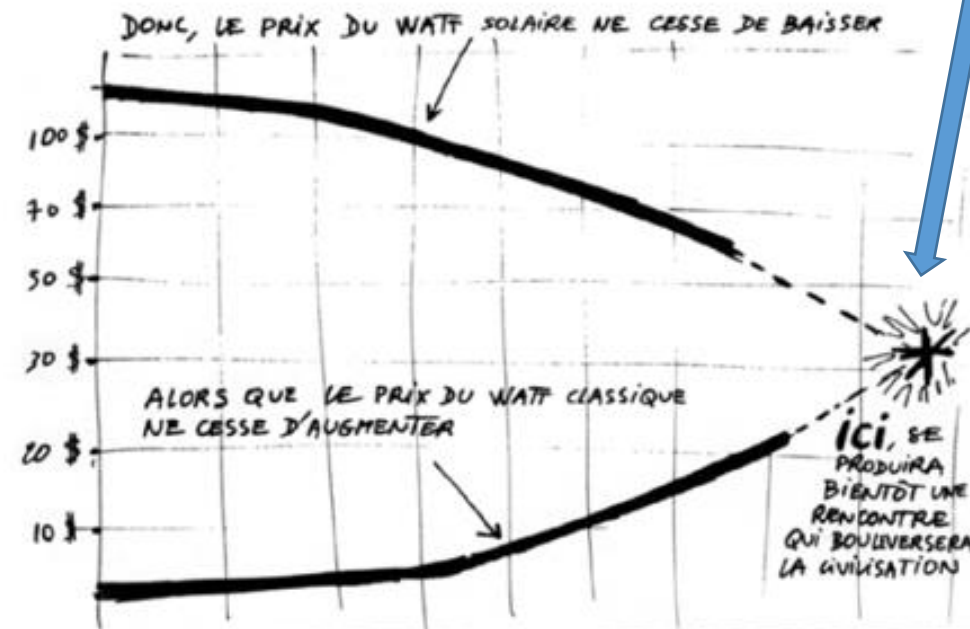


Jean Marc Reiser
(1940-1983)
Cartoonist and
Passionated with PV

Correct
prediction

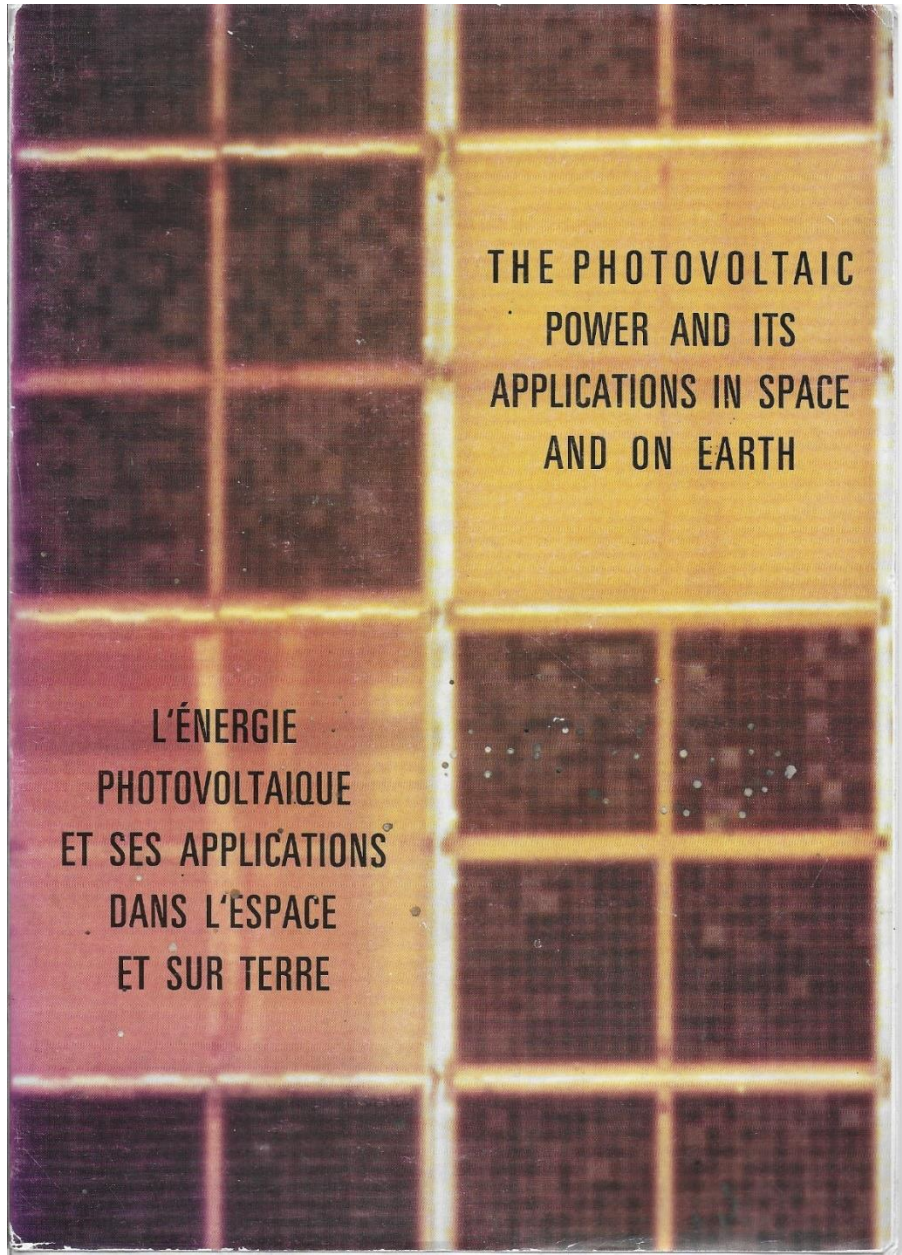


A congress
with
Experimental
Practice



Daniel Lincot, Becquerel Prize, EUPVSEC, 23/092024

Full Symposium with proceedings : The PV Power and its applications in Space and on Earth



THE PHOTOVOLTAIC
POWER AND ITS
APPLICATIONS IN SPACE
AND ON EARTH

L'ÉNERGIE
PHOTOVOLTAÏQUE
ET SES APPLICATIONS
DANS L'ESPACE
ET SUR TERRE



Wolfgang Palz

1965 Doctorate in semiconductor physics from the University of Karlsruhe

1970-1976 : Responsible of the solar PV program at the French National Space Agency (CNES)

1977-1997 : Responsible of Renewable Energy Program at the European Commission

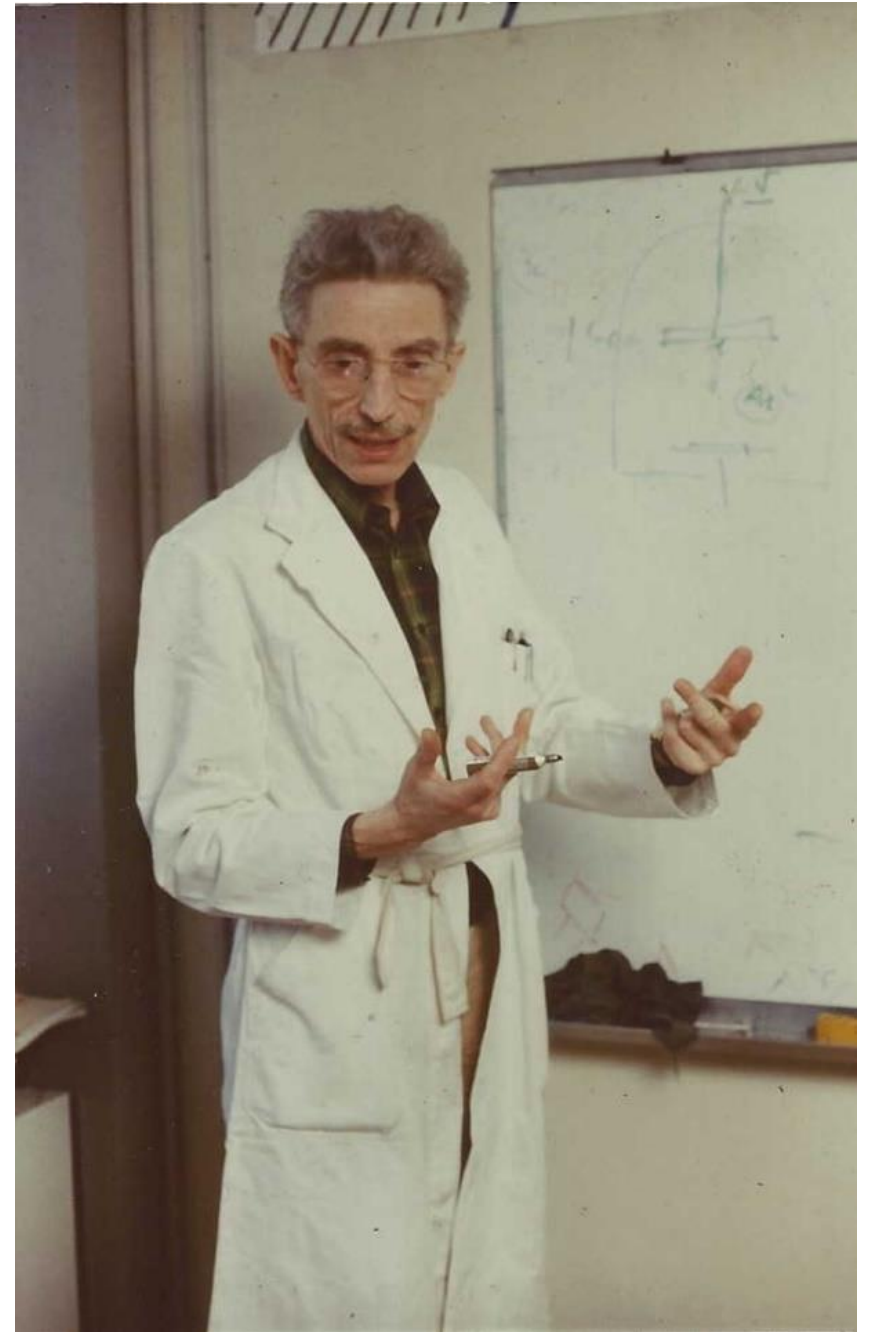
1977 *Launching of European PV conferences*

→ *Up to now : Book writer (Power from the Sun, Solar Euphoria...)*

Ionel Solomon 1929-2015

Ionel Solomon, Director of Research Emeritus and CNRS Silver Medalist, member of the French Academy of Sciences, founder of the French Academy of Technologies, former professor at Ecole Polytechnique and founder of the Condensed Matter Physics Laboratory (1962), former President of the French Physical Society, is first and foremost recognized for his fundamental work in solid state and semiconductor physics. He laid the theoretical foundations for the spin-spin dipolar interaction and the interpretation of the Overhauser effect, with equations bearing his name in the field of Nuclear Magnetic Resonance. Translated with DeepL.com (free version)

But **his other passion was solar energy**, and in particular **photovoltaic conversion**, which he took up following the discovery of **hydrogenated amorphous silicon in thin-film technology** in 1976. He was president of the European PV Conference in 1988. Rather than staying in his ivory tower, he also set up a company dedicated to industrial transfer, **SOLEMS**, in 1981, of which he was scientific director. He was at the heart of the creation of the **CNRS photovoltaic cluster at Polytechnique: PMC, LPICM (Bernard Equer, Père Roca i Cabarrocas)**.

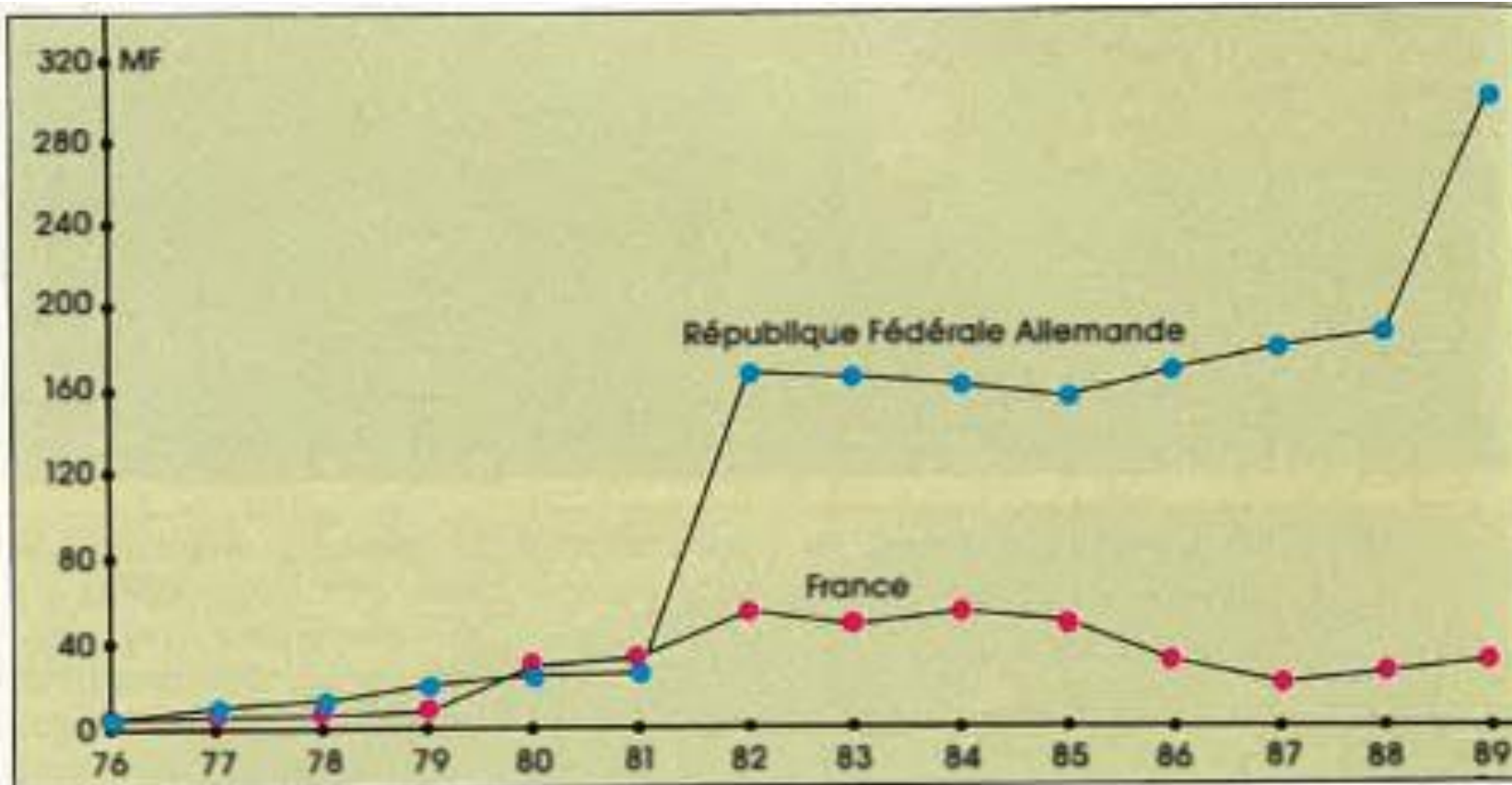


Daniel Lincot, Becquerel Prize, EUPVSEC, 23/092024

Up and Down of Solar Research in France

The raise of Germany

Budget for research



Year

Review paper on solar research and perspectives in France
 La Recherche, 224, September 1990

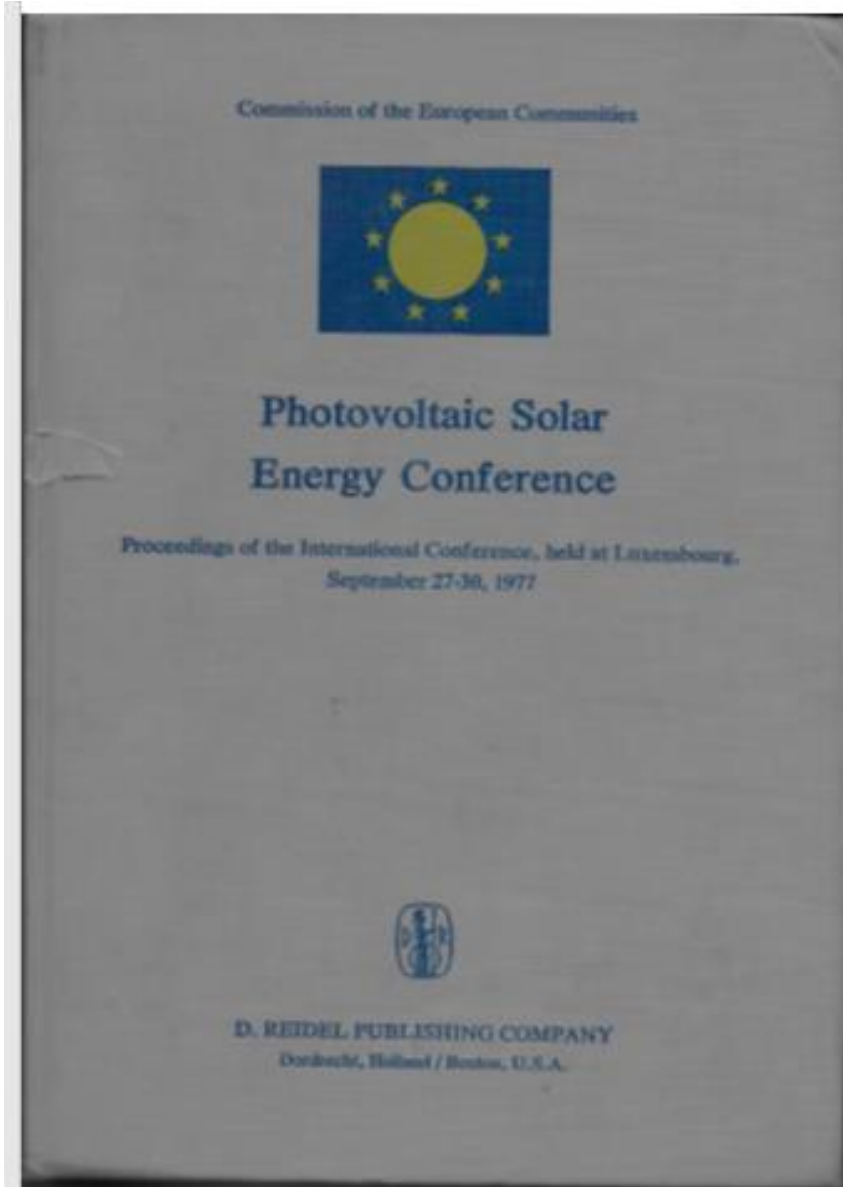


par Maurice Claverie et Benjamin Dessus

Maurice Claverie est directeur du PIRSEM/CNRS (Programme interdisciplinaire de recherche sur les sciences de l'énergie et des matières premières). Benjamin Dessus est chargé de mission au PIRSEM/CNRS.

The Endeavor of Europe

1977 – First EUPVSEC in Luxembourg



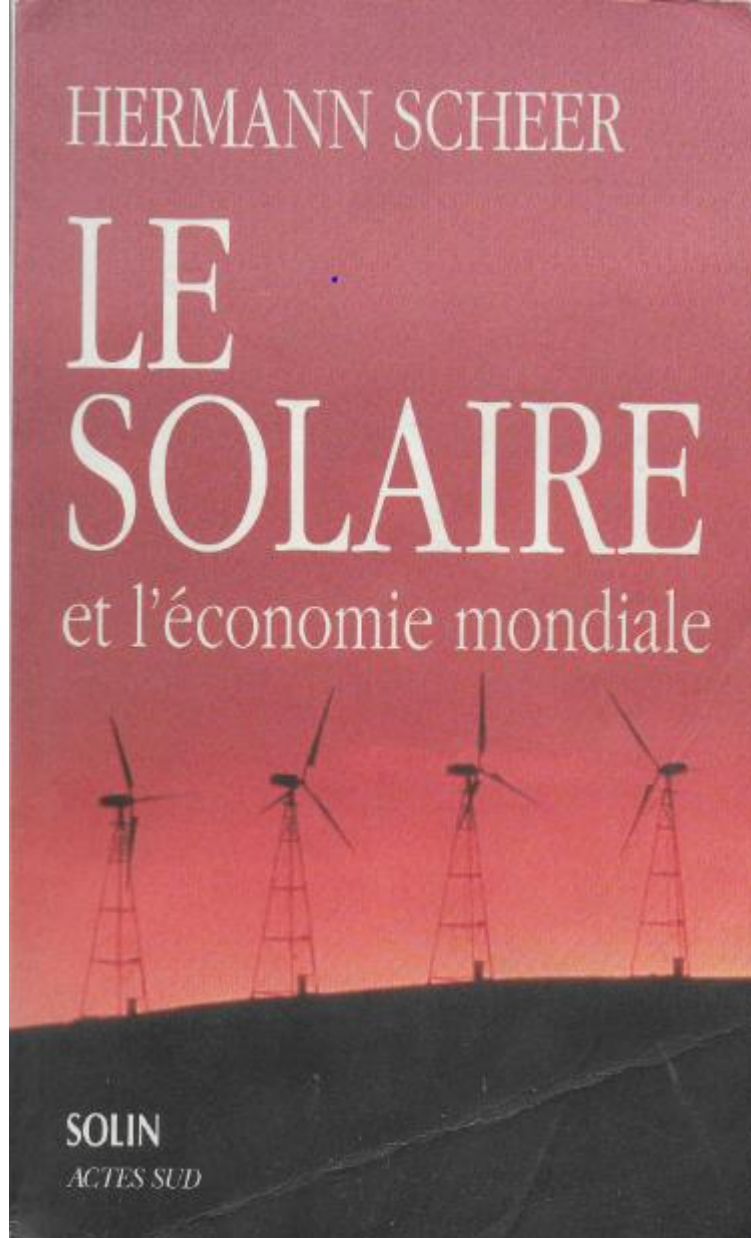
Follow up proceedings books



1977 : Première conférence photovoltaïque européenne
Luxembourg



Participants of the Committee meeting at Luxembourg (from left to right).
Sitting: Karl-Heinz KREBS, Rolf BUHS, John GOLDSMITH, Albert STRUB,
Len MAGID, **Henry DURAND**, Horst FISCHER, **Wolfgang PALZ**, Klaus
REINHARTZ. Standing: Bryan WILSON, **Michel RODOT**, Roger VAN OVER-
STRAETEN, Fred TREBLE, Antoon KIPPERMAN, Giovanni SONCINI,
Henry BRANDHORST, Moe FORESTIERI, Michel BRUNET, Sergio PIZZI-
NI, Boris BOIKO, Denis NICOLAY.



Acceptance Speech of Hermann Scheer

Awardee World PV Conference Award for Outstanding Contributions and Dedication

“...in 100 years people will say: the work is done, we are living in the Solar Age.”

« In 100 years people will say: The work is done, we are living in the Solar Age »

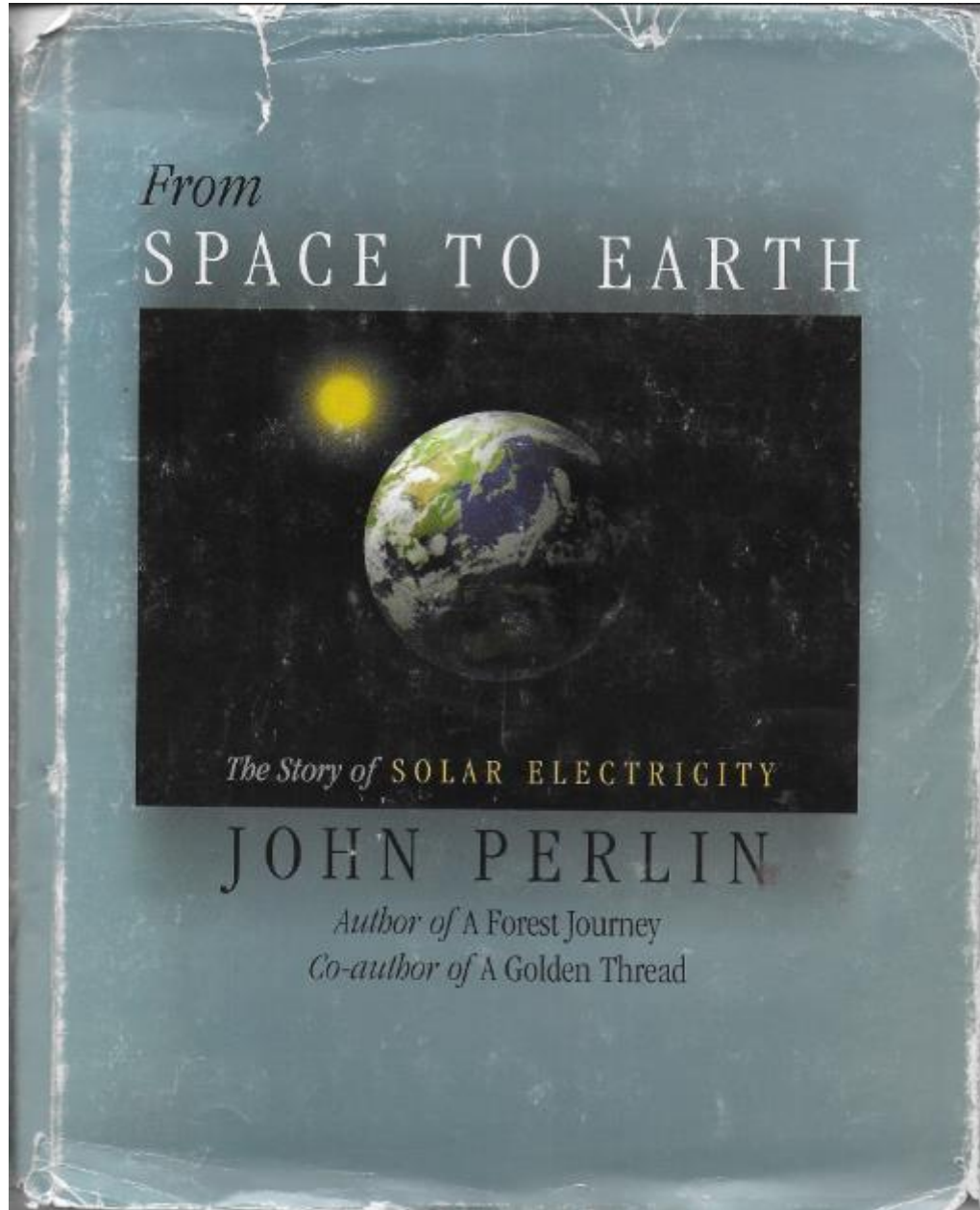
« The remaining question is not how high are the costs for solar introduction, but how big are the social costs for its postponement. In order to avoid these costs, solar energy supporters should be **ASSERTIVE, CREATIVE and TOUGH** for **LEADING OTHERS INTO A MORE PROMISING FUTURE.** »



Hermann Scheer
(1944-2010)

Solar and PV history come on the stage

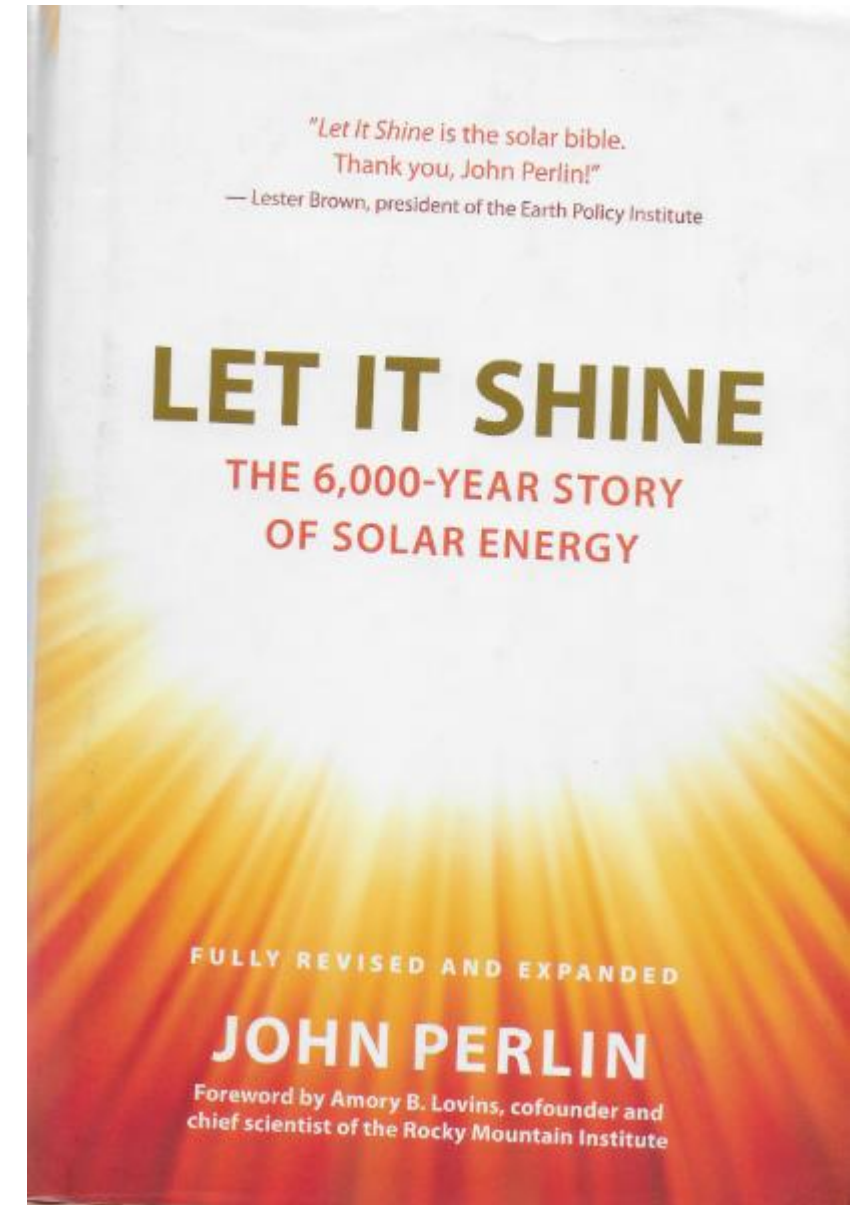
1999



John Perlin

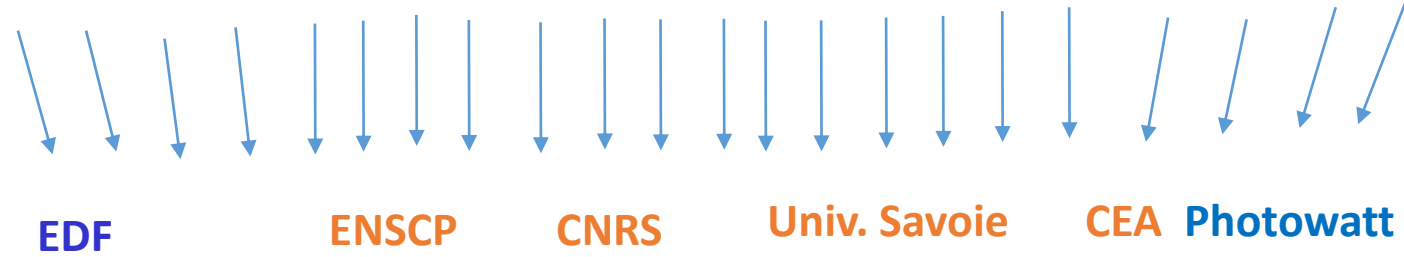


2013



The reconstruction of the PV sector in France (>2000)

1980 – 2000 PV research is dispersed in France at CNRS and Universities
→ No dedicated large institutes like Fraunhofer ISE, ZSW, NREL...



2006
Grenelle
de l'environnement



2003 : CISEL Platform
2005: **IRDEP**(Chatou)

Institute for Research and Development of Photovoltaic Energy
-Thin film PV (CIS) (electrodeposition)
-New Concepts (VHE)

2003 : Si Platform with Photowatt
2005 **INES** (Chambery)

National Institute of Solar Energy
- c-Si
-Organic and Hybrid PV, BIPV, Thermal...
-Training



Scientific day 14 february 2011

2010-
Creation of
French
Solar Networks



2024
FedPV
Tens of laboratories
affiliated

Also

FedeSol
Federation of Solar
Energie
Broader domains



FEDERATION PHOTOVOLTAIQUE



2013 : Creation of the Institut Photovoltaïque Île de France (Institute for the Energy Transition)

2016 Scientific Day
And programs



<https://www.ipvf.fr>

200
RESEARCHERS
ON THE LONG TERM

7800
m² BUILDING

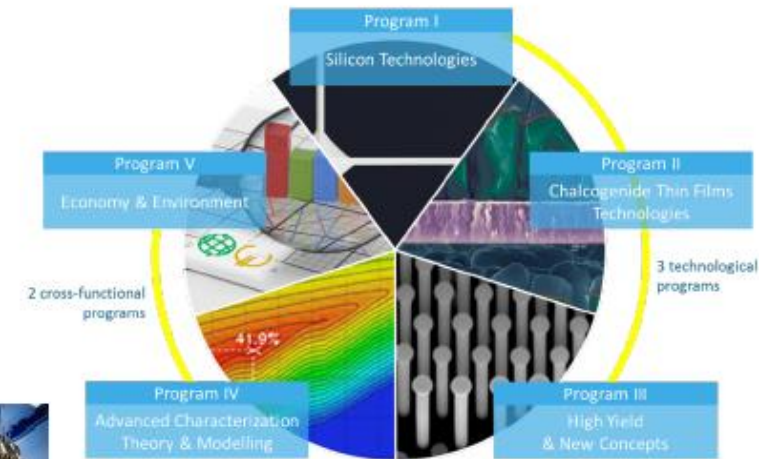
Founding Members



A French Institute for Energy Transition (ITE)



Scientific program



un rendement
> 30%

3³ pour un prix
< 30 c\$/Wc

à l'horizon
2030

Long term vision



Experimental Research Platform



Resources

Researcher community

Solar Energy, the Citizen's Energy

Acceptance Speech for the 1997 Becquerel Prize

14th European Photovoltaic Solar Energy Conference
Barcelona, Spain, 30 June-4 July 1997

« Solar energy was always, as it is today, the people's energy. Solar energy is more popular with the people and to a large extent with the public media than with those who yield economic and political power »

« The opponents, on the other hand, do not understand the market forces driving solar energy and they cannot imagine that solar energy will ever be a viable source of energy. »

« It has to become also the accepted energy for government, business and utilities. »

A. Goetberger

(1928-2023)

Fraunhofer Institute
for Solar Energy Systems,
Freiburg, Germany



mercredi 20 janvier 2010 visit of french students



50th anniversary of the UNESCO congress in 1973 « The Sun at the Service of Mankind »



COLLÈGE
DE FRANCE
— 1530 —

Call launched

Solar energy, climate emergency and collective commitment
Collège de France, Paris 12th December 2023

**Solar Energy and Humanity:
The Time for Worldwide Citizen
Action**

**A call to act together to deploy
renewable energies without
delay for everyone, in every
country**

**Open to worldwide
Signatures
(via the web site)**

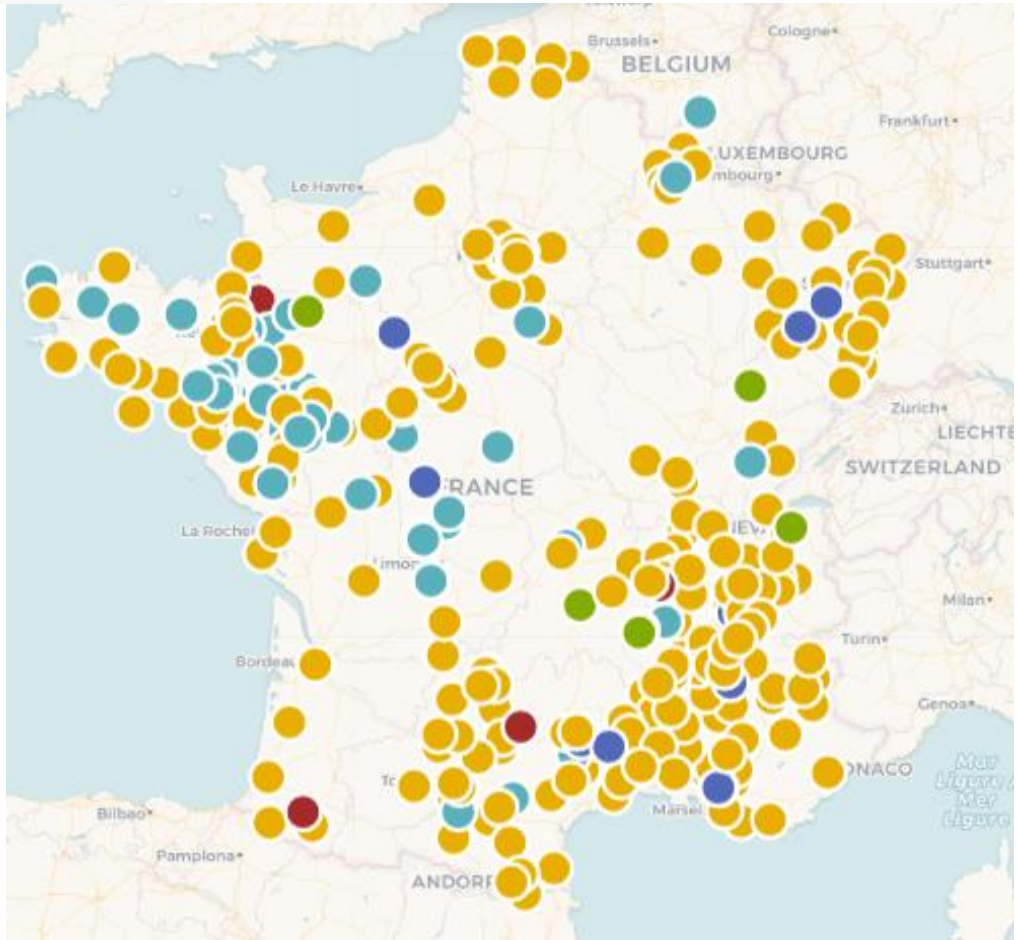
<https://www.soleilethumanite.com/>

Credits @ETA-Florence
Renewable Energies

Renewable Energy Citizen Associations Dynamics in France



<https://energie-partagee.org/>



The Fabulous Story of Scientific Progress : The Olympic games of PV technologies

ROOTS

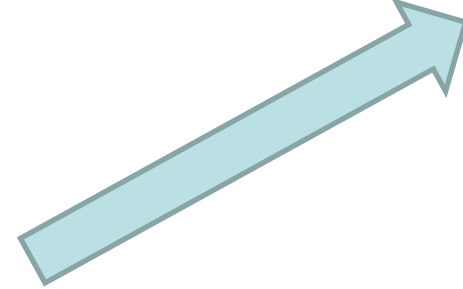
WINGS

What's Next ?

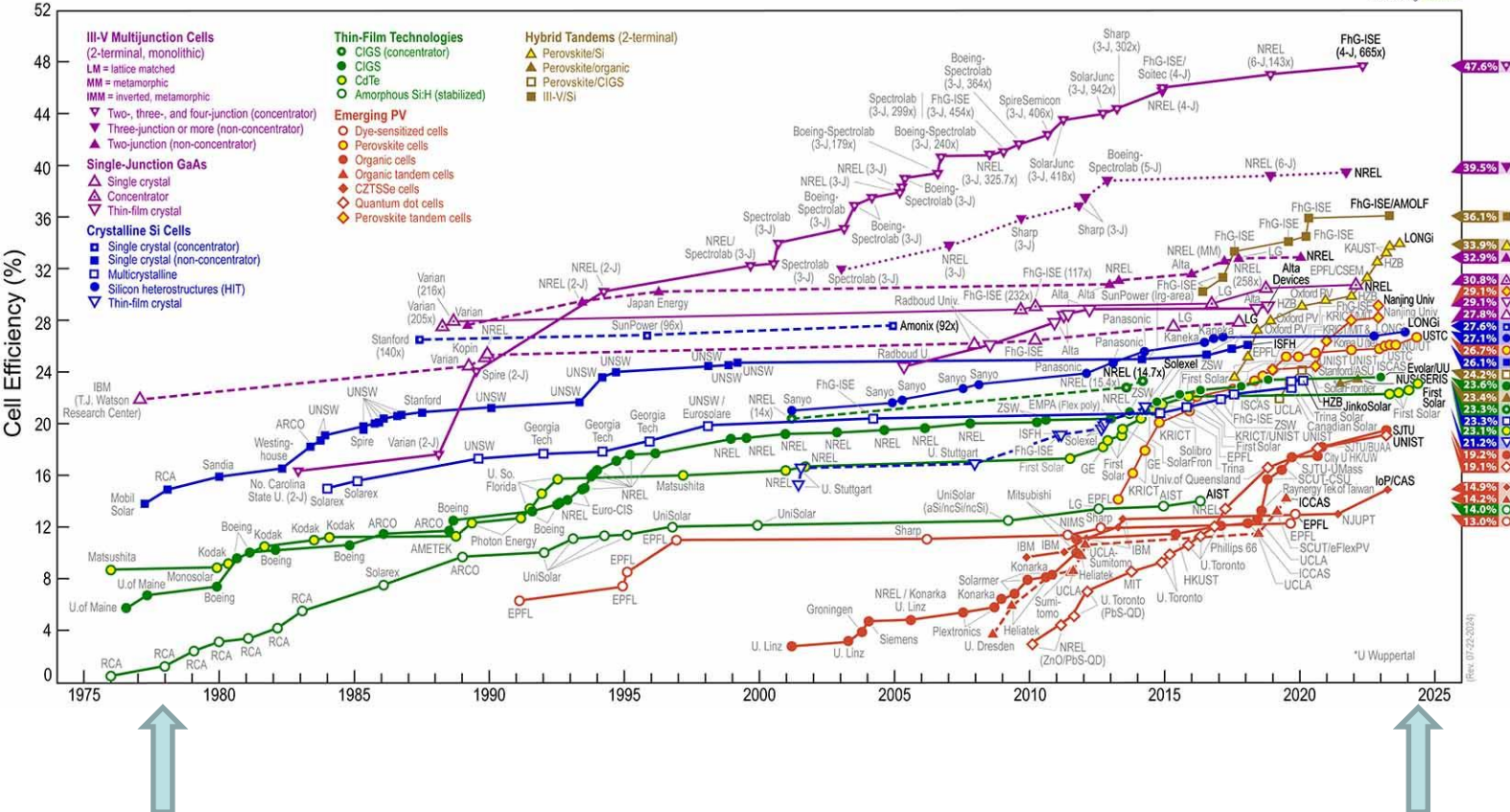
Best Research-Cell Efficiencies



2050 ?



This is in your hands



I Started Here

Almost 50 years after
Who could have imagined?

2000

Thanks to all the Colleagues, friends, organizations who were
My Roots, Wings, Inspiration and... to Chance



Thank you for your attention

2002 (?) EMRS Symposium on Chalcogenide PV

