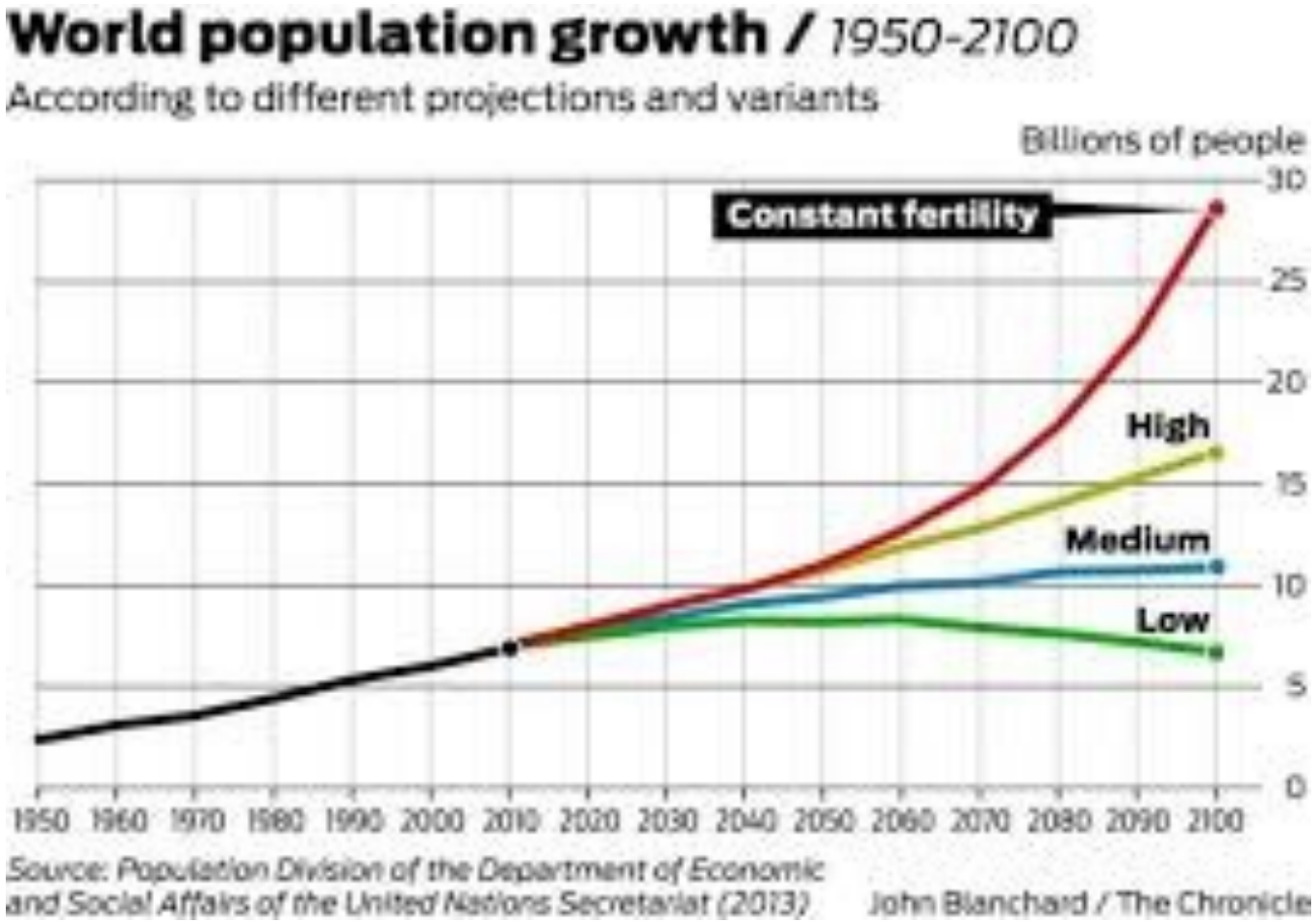
GreEnergy Summer School 2022
Cutting-edge electronics for eco-friendly energy

Dr. Avi Ginzburg

GreEnergy – its concepts and scientific/engineering challenges

GreEnergy

What is GreEnergy project and why it was born?

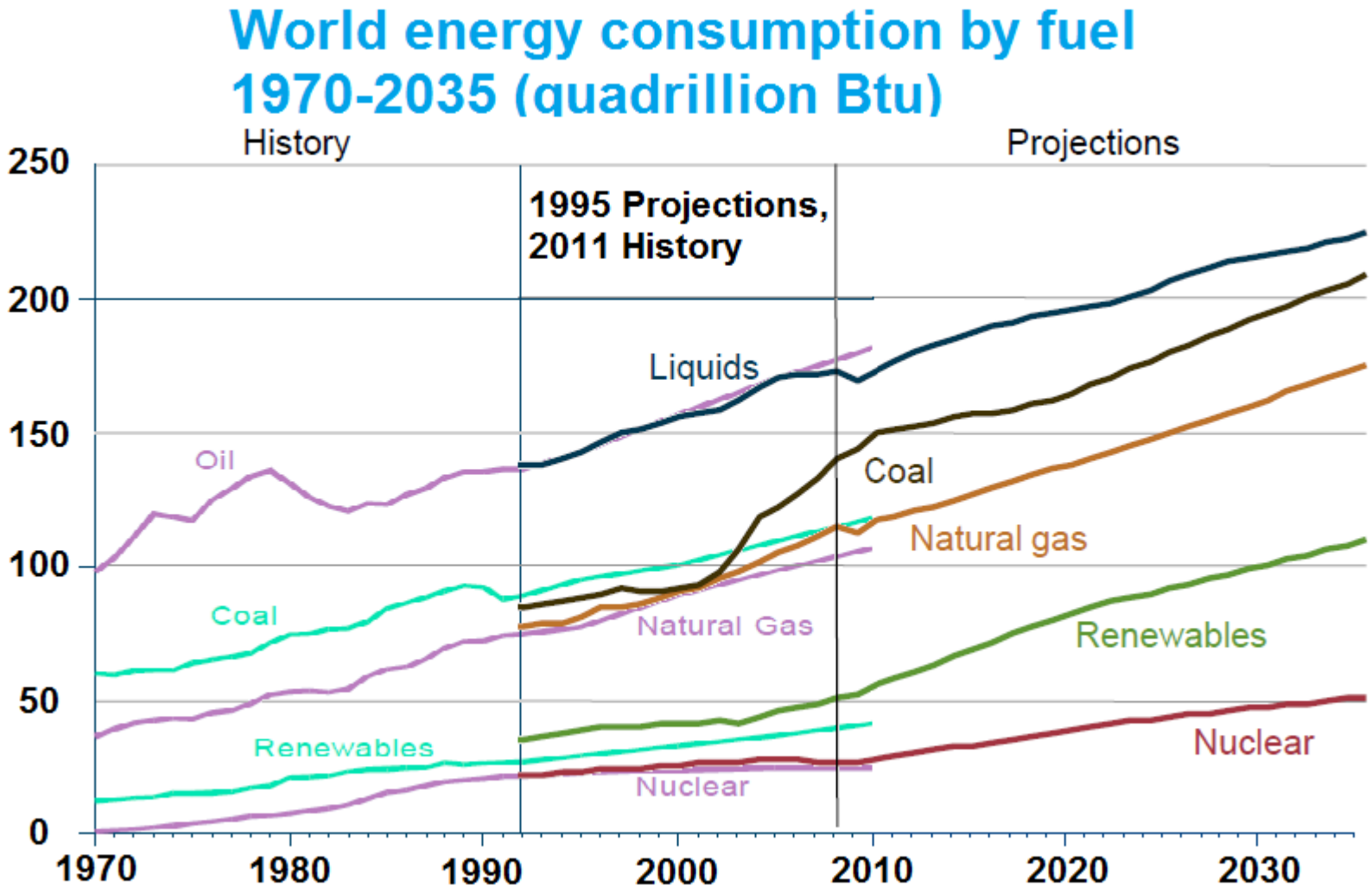


What is GreEnergy project and why it was born?

Btu = British Thermal Unit

A BTU was originally defined as the amount of heat required to raise the temperature of 1 avoirdupois pound of liquid water by 1 degree Fahrenheit at a constant pressure of one atmospheric unit.

One Btu is approximately:
- 1.0551 kJ (kilojoules)
- 0.2931 W·h (watt hours)
- 252.2 cal (calories)
- 0.2522 kcal (kilocalories)



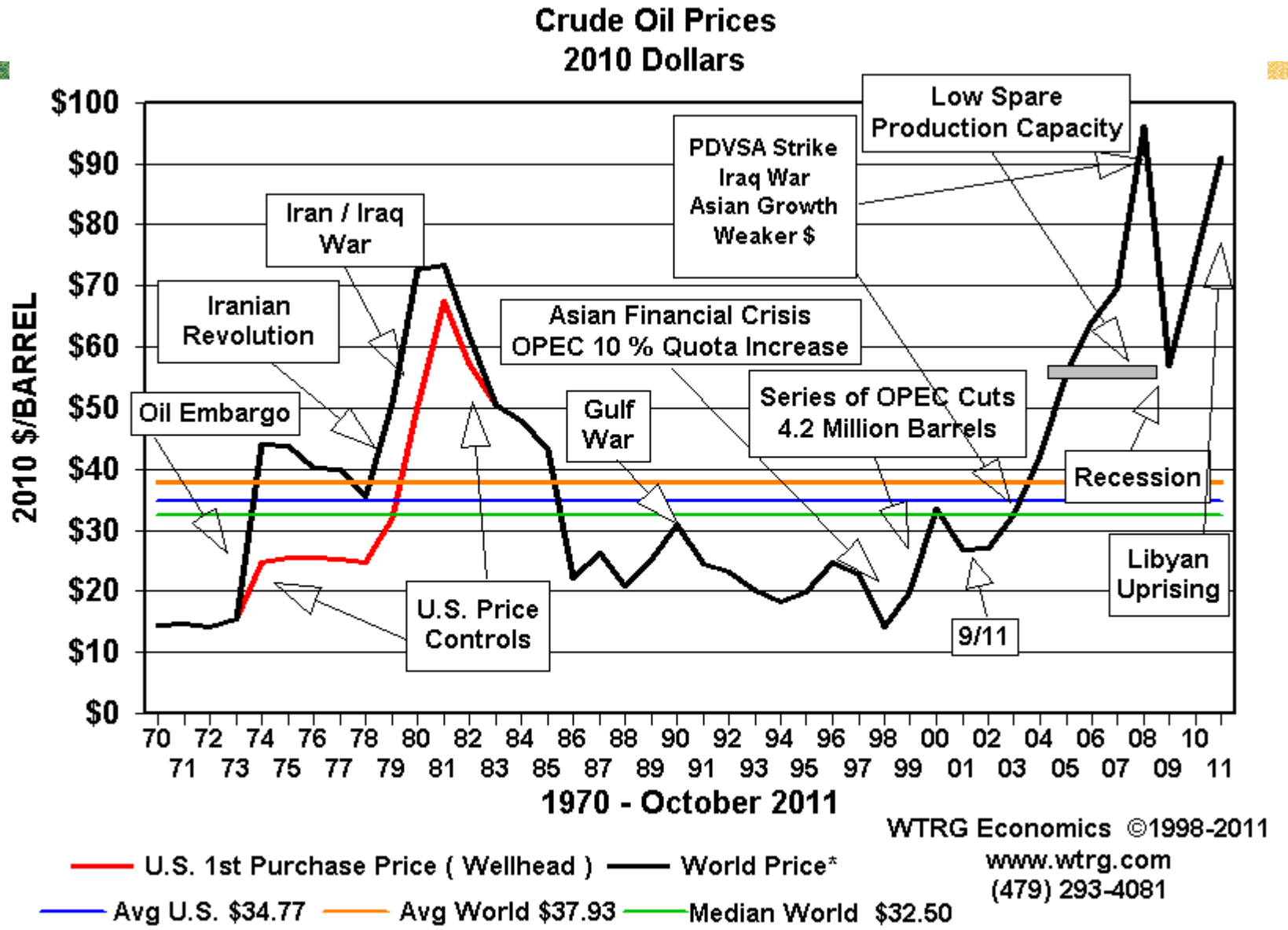
….and your problem is…..

- Not enough energy
- Too much “dirty” energy

….back to the 70's ….80's…..

Fears and hopes

- Oil prices went up dramatically….
- Oil reserves forecasts showed sever shortage until 2020

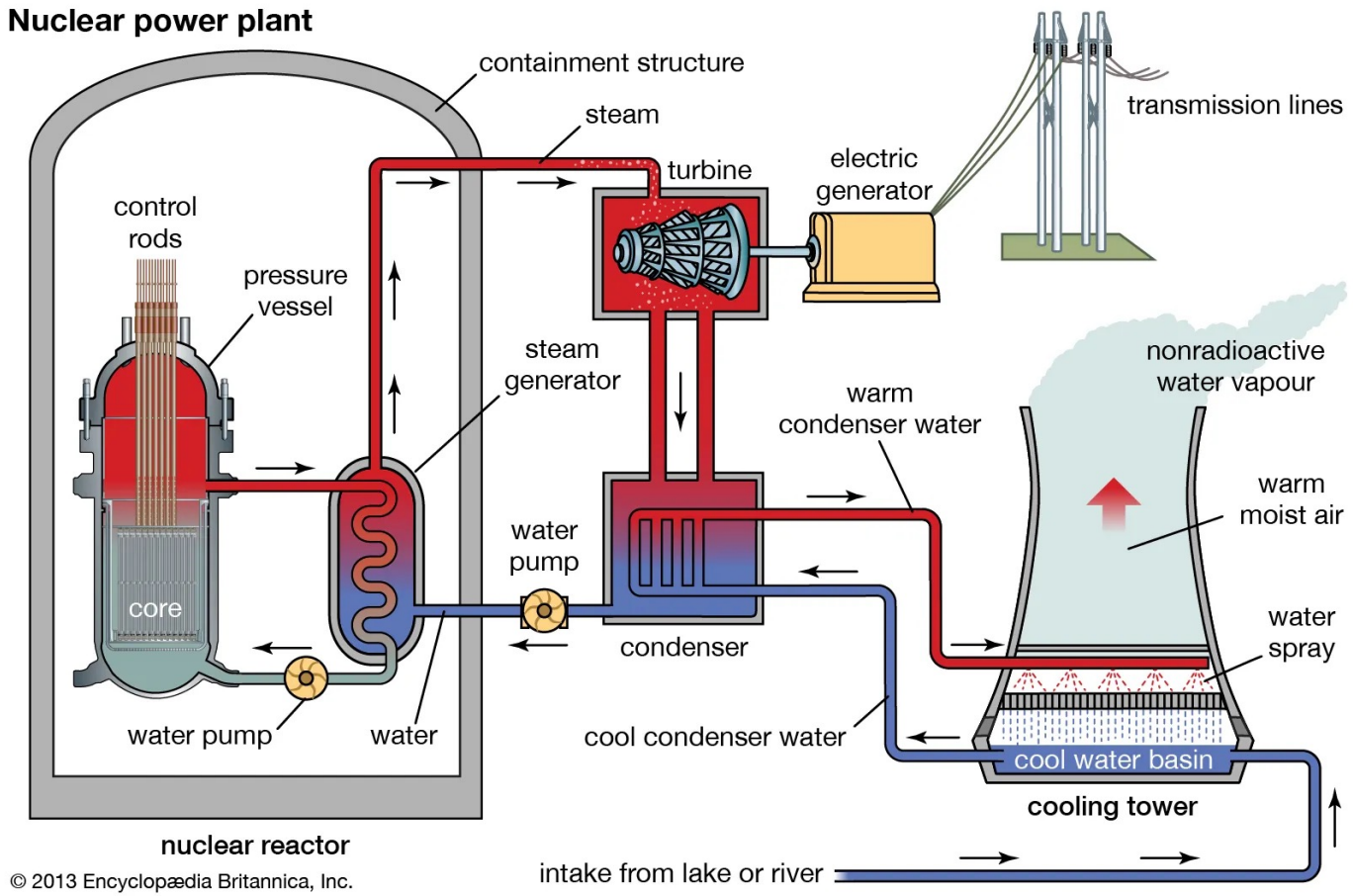


….back to the 70's ….80's…..

Fears and hopes

- Emerging technologies
  - Nuclear energy

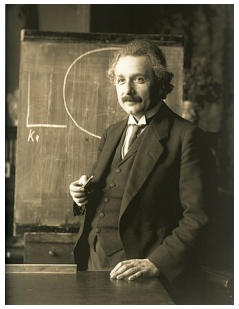
Prof. Franz Heinrich Ollendorff 1900-1981



….back to the 70's ….80's…..

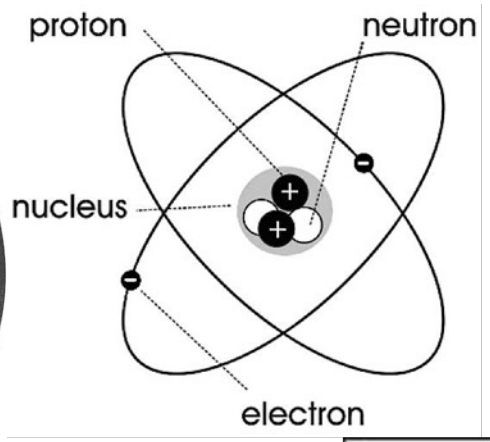
Fears and hopes

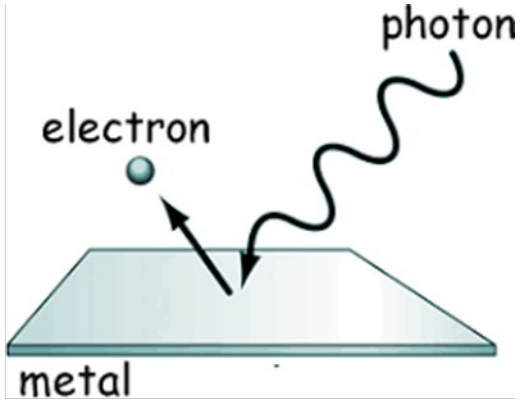
- Emerging technologies
  - Photovoltaic (PV) cells

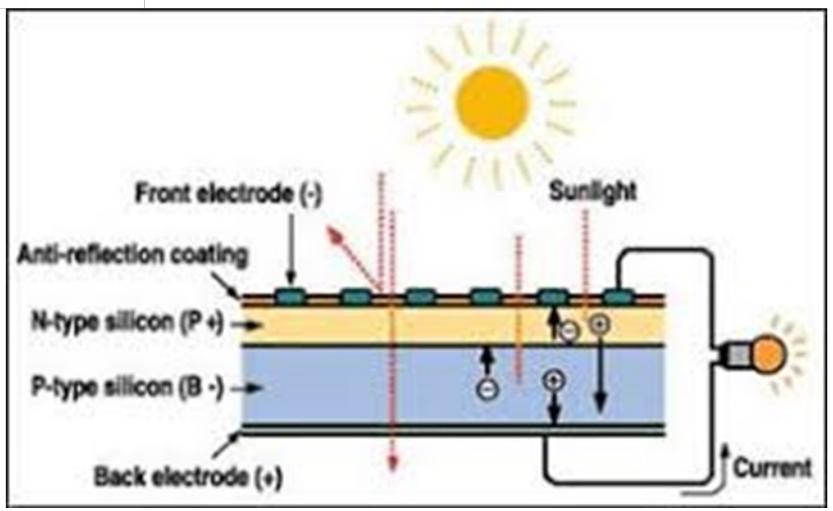


Prof. Albert Einstein 1879-1955

Prof. Max Karl Ernst Ludwig Planck 1858-1947





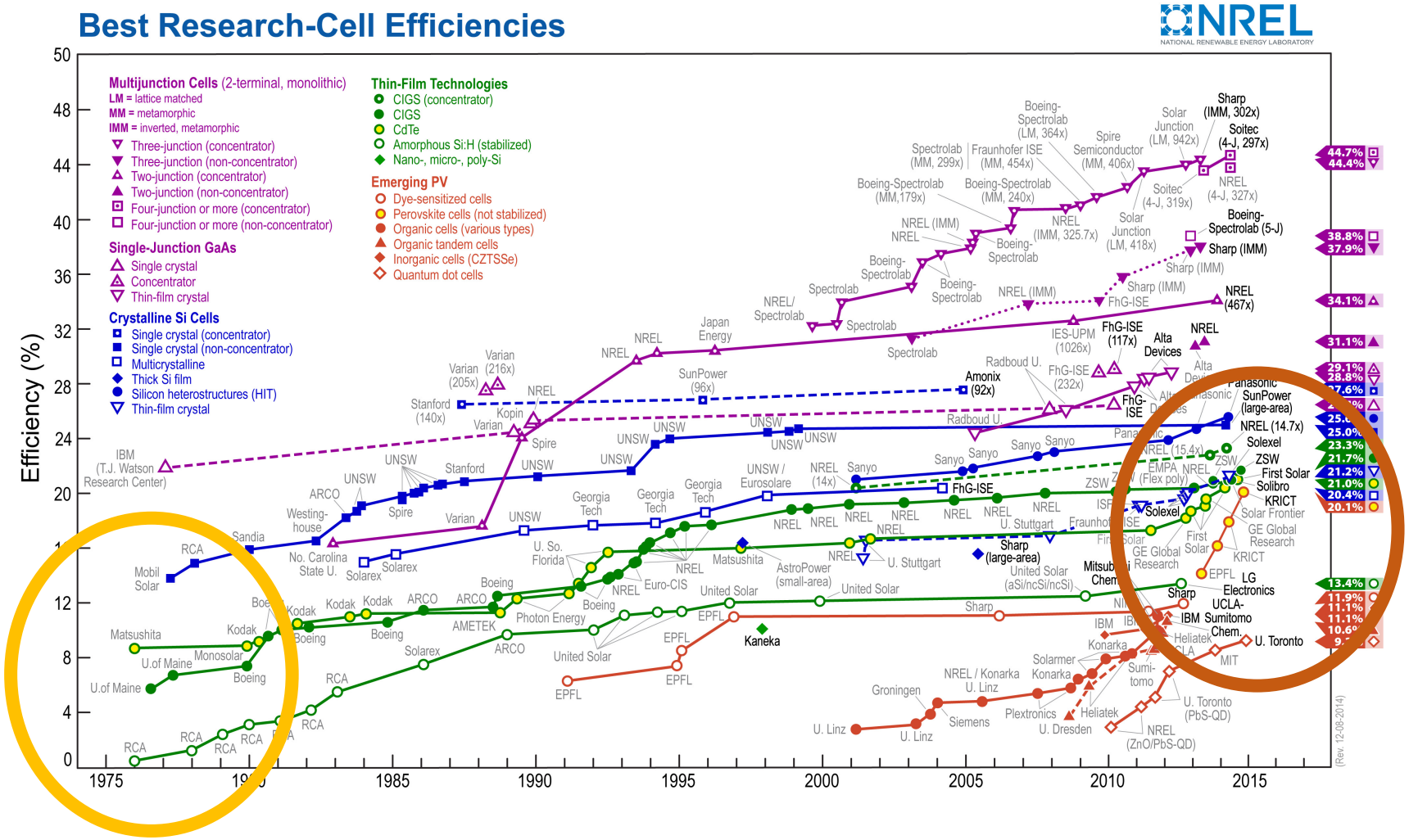


….back to the 70's ….80's…..

PV cells efficiently

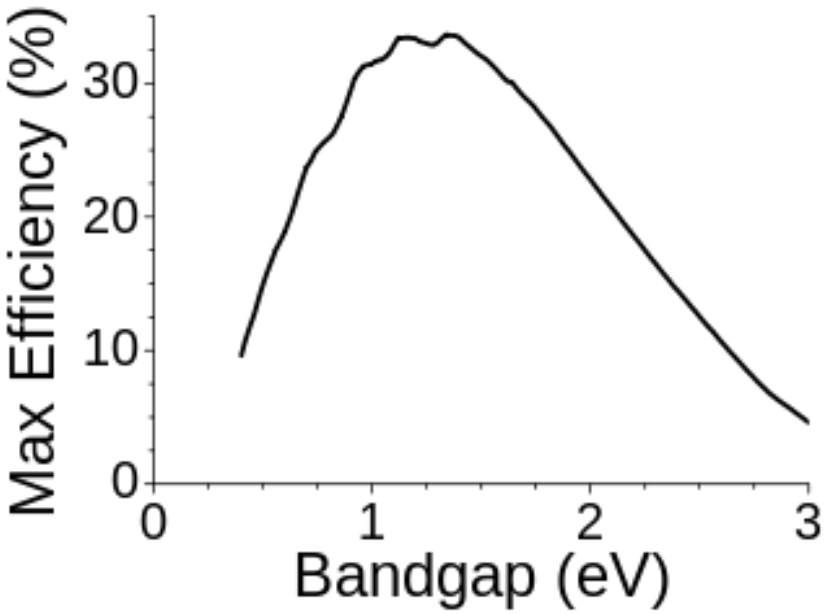
1887 – Electrodes illuminated with ultraviolet light create electric sparks - Heinrich Hertz
1900 - **Energy carried by electromagnetic waves could only be released in "packets" of energy** - **Max Planck**
1905 - Light energy is carried in discrete quantized packets - Albert Einstein
1914 - experiment supported Einstein's model of the photoelectric effect – Robert Milliken
1921 - **Nobel Prize for " discovery of the law of the photoelectric effect**" - **Albert Einstein**
1923 - Nobel Prize in for "work on the elementary charge of electricity and on the photoelectric effect" - Robert Milliken

Today - commercial solar PV cells have approximately 15-20% efficiency, and the **price** of a **1m2 is around €400.**

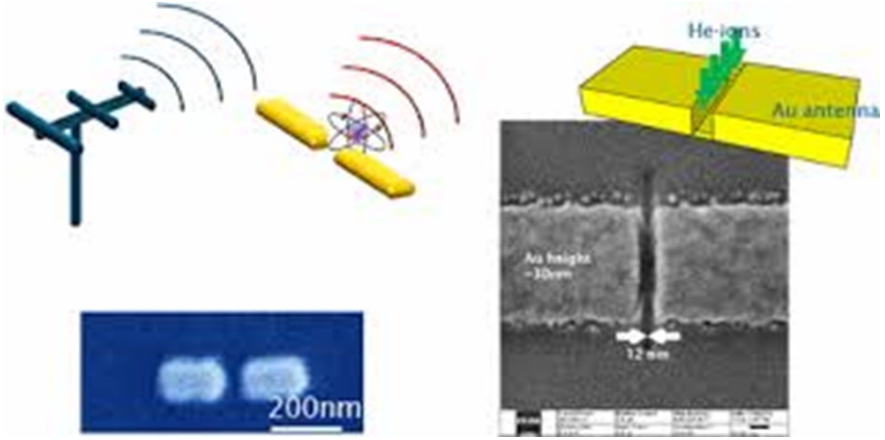


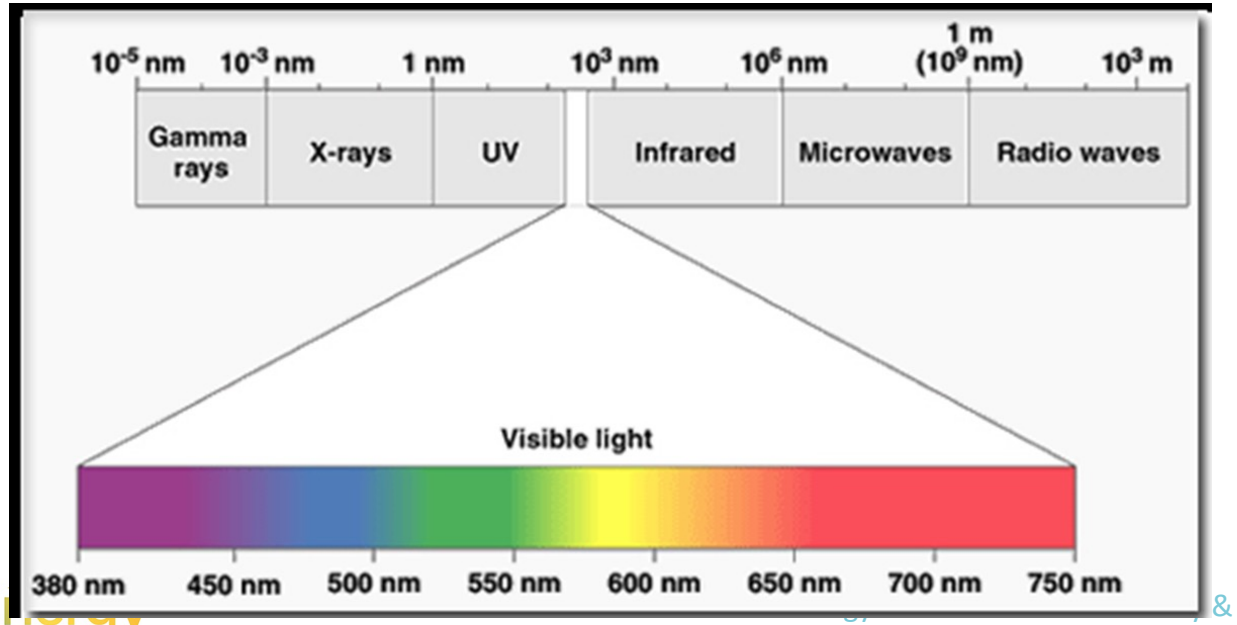
….PV effect efficiency limit!!!

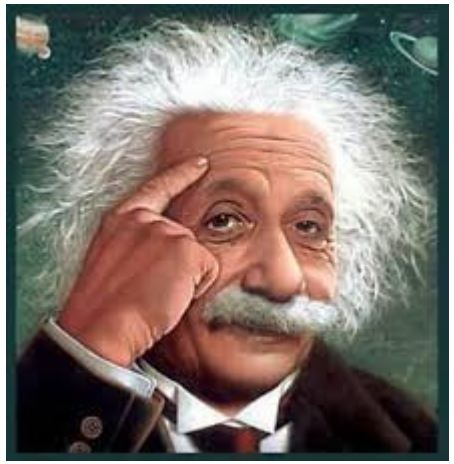
- The Shockley–Queisser limit for the efficiency of a single-junction solar cell under unconcentrated sunlight at 273 K. This calculated curve uses actual solar spectrum data, and therefore the curve is wiggly from IR absorption bands in the atmosphere. This efficiency limit of ~34% can be exceeded by multijunction solar cells.
- William Shockley and Hans-Joachim Queisser presented in 1961 for the first time the calculation of the maximum conversion efficiency of a *p*–*n* junction solar cell illuminated by the sun, where the sun spectrum was approximated by the emission of a black body with a surface temperature of T_S = 6000 K (**Shockley and Queisser, 1961**).



But……quantum theory…







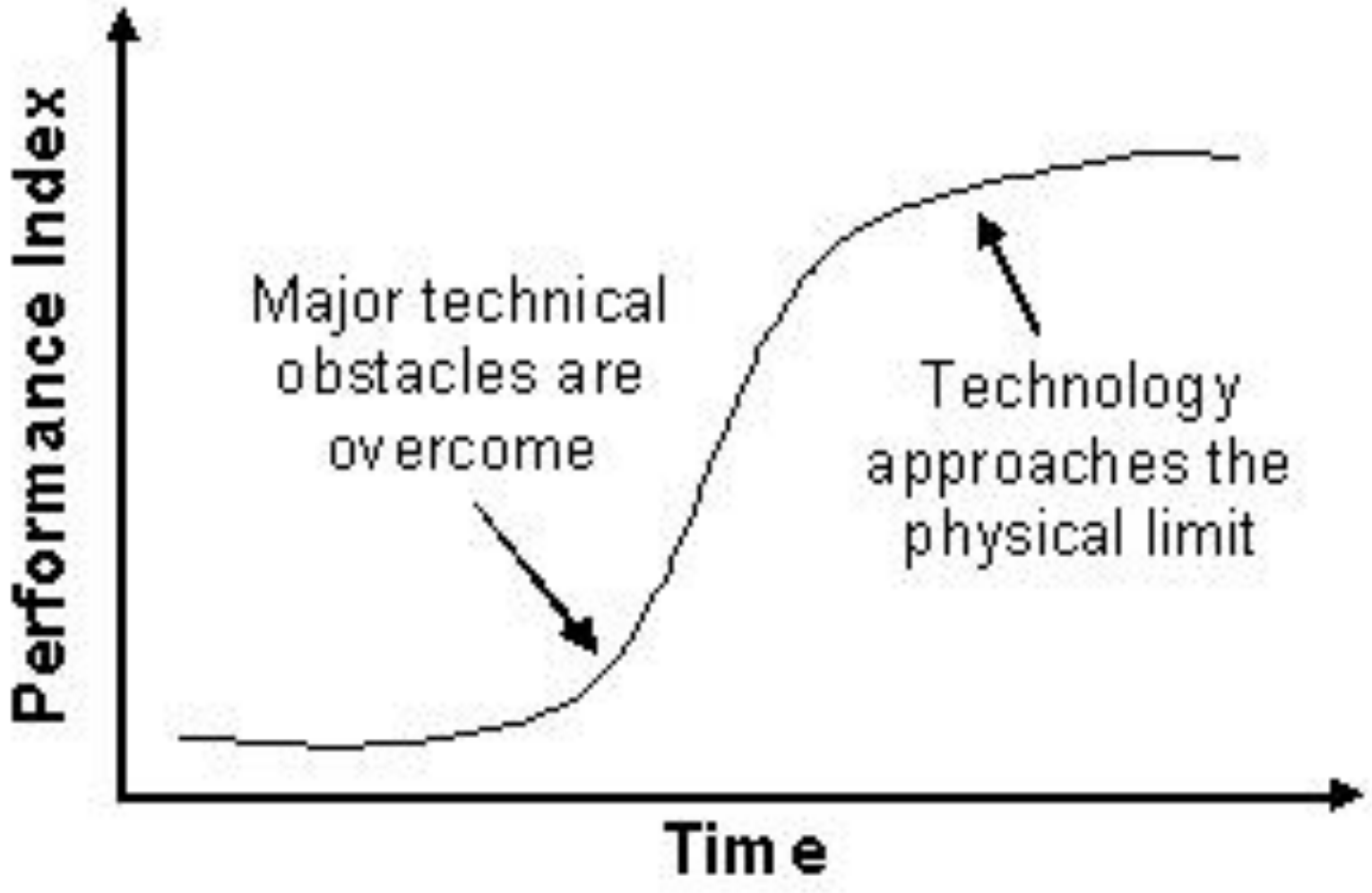
Light can be represented both:

As photon and as Electromagnetic wave

Nano Antenna effect history

- **1973 -** Robert Bailey, along with James C. Fletcher**, received a patent (US 3760257) in for an "electromagnetic wave energy converter".**
- **1984** - Alvin M. Marks **received a patent in for a device explicitly stating the use of sub-micron antennas for the direct conversion of light power to electrical power**
- **1996 -** Guang H. Lin **reported resonant light absorption by a fabricated nanostructure and rectification of light with frequencies in the visible range**
- **2002 - ITN Energy Systems, Inc. published a report on their work on optical antennas coupled with high frequency diodes.**
- **2015 -** Baratunde A. Cola's research team at the Georgia Institute of Technology, **developed a solar energy collector that can convert optical light to DC current, an optical rectenna using carbon nanotubes.**

New innovation S curve



The dream

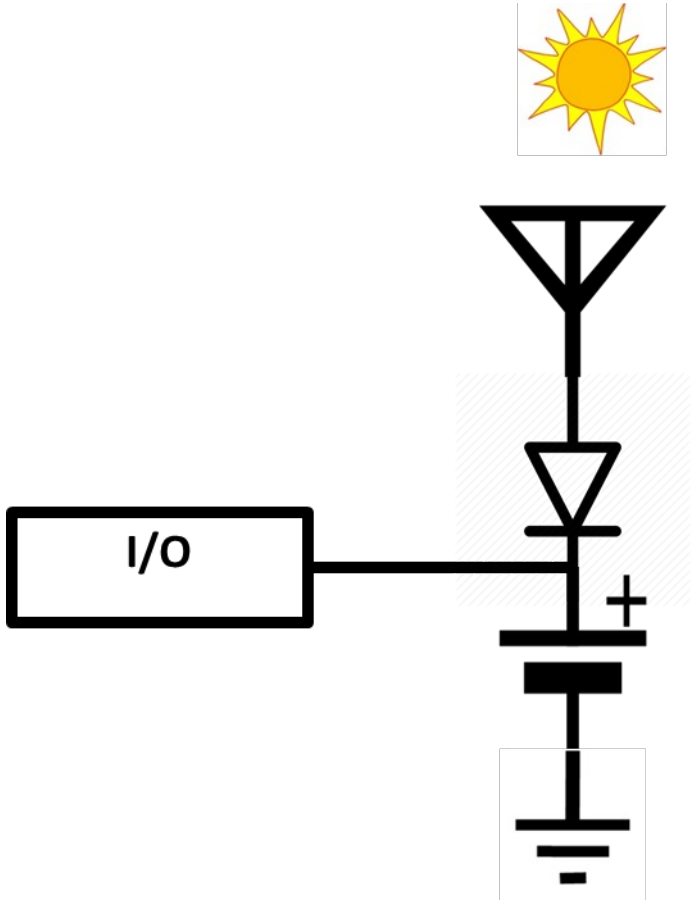
- Efficiency of Nano Antenna cell – app. **85% !!!** - Practically estimated app. 60%
- Steven Novack estimates the current cost of the antenna material itself as around 5 - 11 USD / m^2 in 2008

GreEnergy project goal

- **targeted efficiency of the overall system is 20-40%,** while the **theoretical efficiency …., at an estimated system cost below €100 per 1m2.**

GreEnergy challenges

- To design
  - GreEnergy system
    - Efficient nano-antennas
    - Efficient diode
    - Energy storage
    - Architectures design and evaluation
    - Integration
  - Large scale fabrication
- Expertise needed
  - Modelling and design
  - Fabrication and measurements
  - Integration
  - Design to cost
  - Large scale fabrication processes



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AMO

NOGAH Photonics Ltd

Aalto-yliopisto

ihp

SCIPROM Science, Management & Communication

Università Politecnica delle Marche

Università degli Studi di Udine

Thank you for your attention

More information is available at **www.greenergy-project.eu**

GreEnergy

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