Applied Solar Expertise

# Importance and Evidence for Cost Efficient Electricity Storage

## Forum Solarpraxis

## Berlin, 27th November, 2014

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Chairman of Supervisory Board Solarfabrik AG
Member of Supervisory Board SMA Solar Technology AG and ISFH
Member of Board of Trustees at FhG-ISE, ZSW and NEXT

# Outline

Importance for cost efficient electricity storage

The astonishing predictive power of Price Experience Curves (PEC)

PEC for Li - ion batteries

Development of storage cost (LCOS) [€ct/kWh]

# Importance for cost efficient electricity storage (case Germany)

Increase of installed PV systems from today (38 GW ~ 35 TWh) towards 70 GW (~65 TWh) towards 200 GW (~180 TWh) needs increasingly storage

1) →40 GW: On weekends with max power need ~40 GW

2) → 70 GW: During the week at midday with max power need ~70 - 90 GW

3) → 200 GW: more & more storage needed (in all cases increase of self consumption!)

Today's LCOE for PV ~ (8-14) €ct/kWh

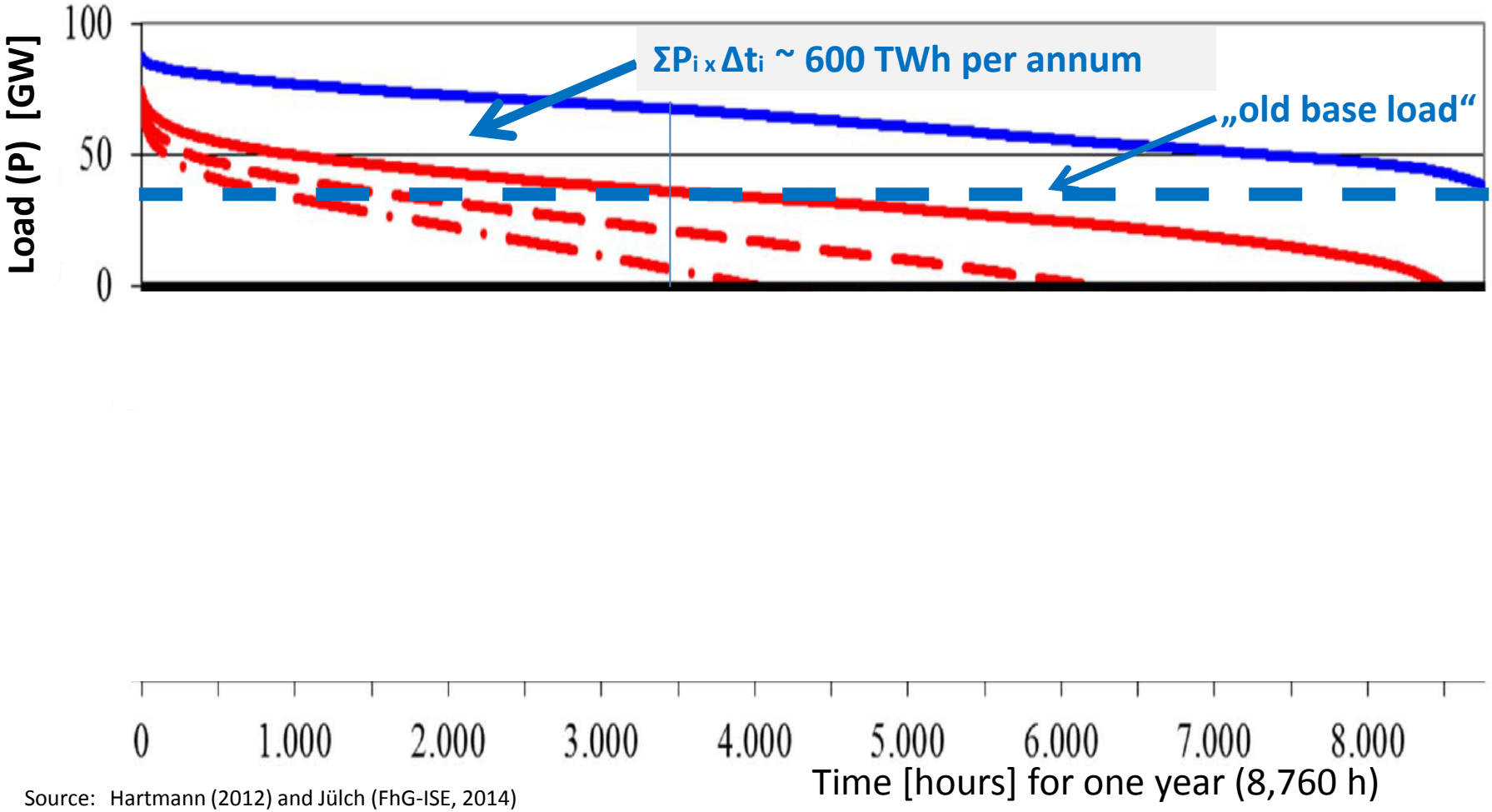
Today's price for retail electricity ~ (25-30) €ct/kWh and for SME's ~ (15-20) €ct/kWh

Once we achieve for LCOS (levelized cost for storage) ~12 €ct/kWh for households and ~9 €ct/kWh for SME's, both the PV installations and the battery market will „explode"

Today's storage cost is still well above 40 €ct/kWh … (at least for private households)

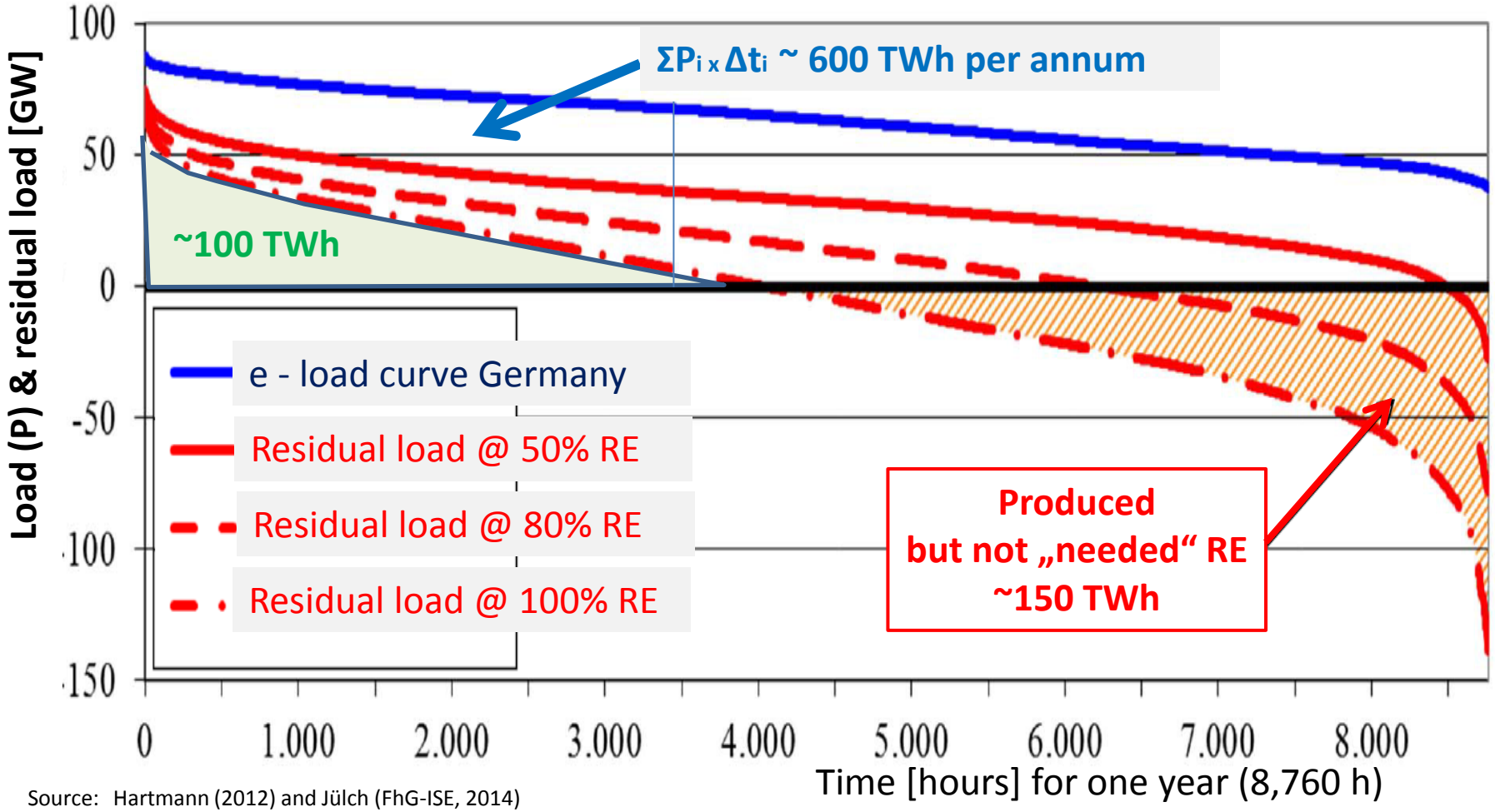
Source: Own considerations (2014)

# Germany‘s load curve



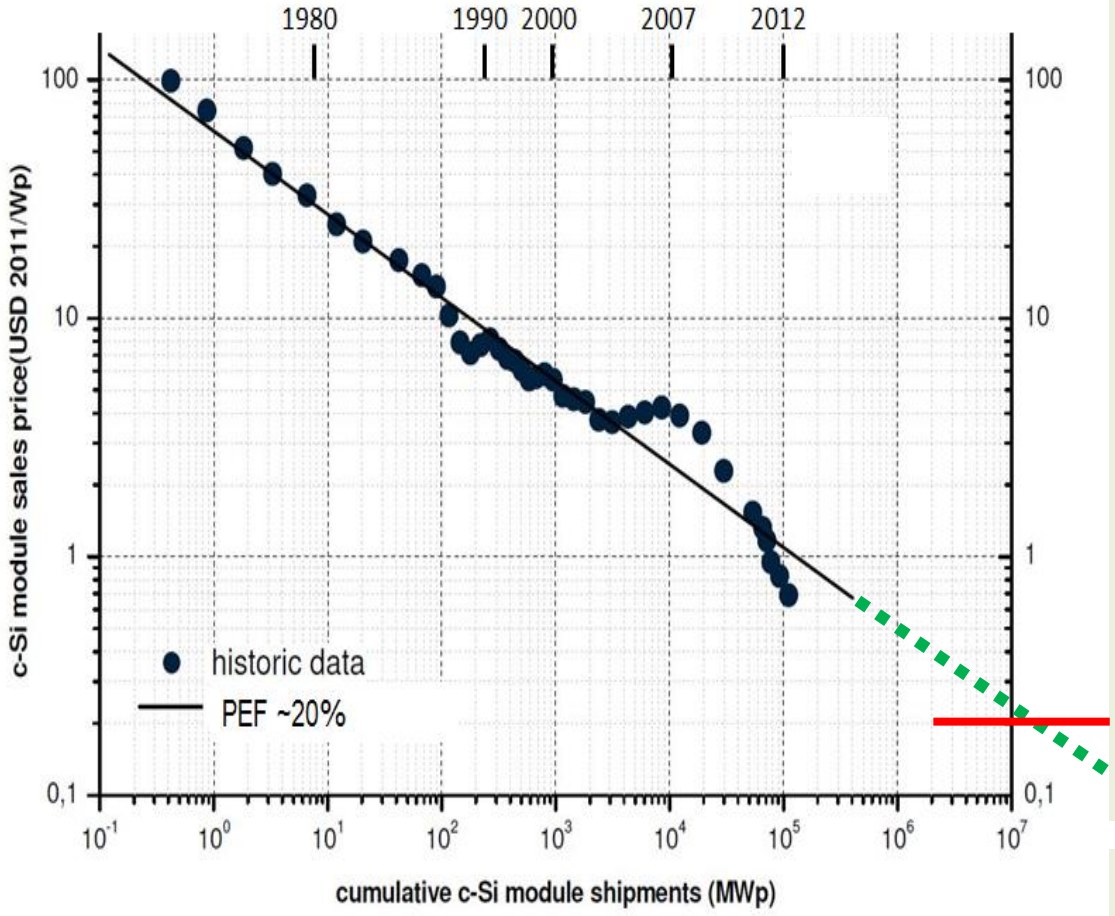

Source: Hartmann (2012) and Jülch (FhG-ISE, 2014)

# Germany‘s load curve and residual load with Renewable Energy (RE)




Source: Hartmann (2012) and Jülch (FhG-ISE, 2014)

# Photovoltaic modules: Price Experience Curve - PEC




Source: ITRPV 2013

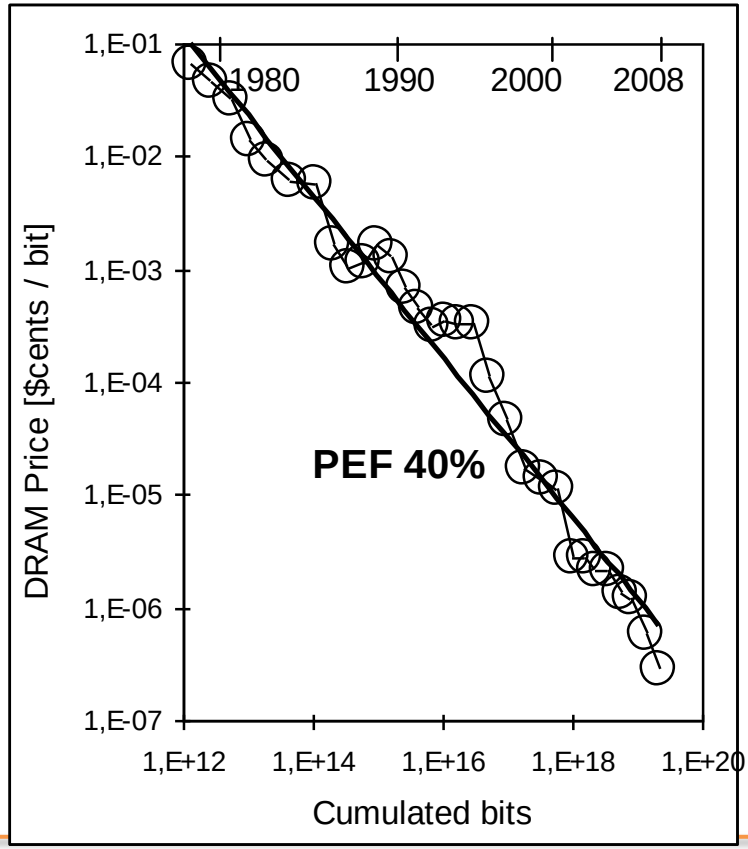
**„Grenzkosten c-Si Module“**

- **Wafer**
  200x200mm², 80/70µm,
  12$/kg, eta 25% $ct/W 2
  andere Mat. $ct/W 2
- **Zelle** $ct/W 2
- **Modul**
  Do-Glas a 1,4 mm $ct/W 4
  Verschalt&Verkaps $ct/W 3
  Kabel, b-rail etc $ct/W 3
- **OPEX (~80%)** **$ct/W 16**
- **Rest (~20%)** **$ct/W 4**

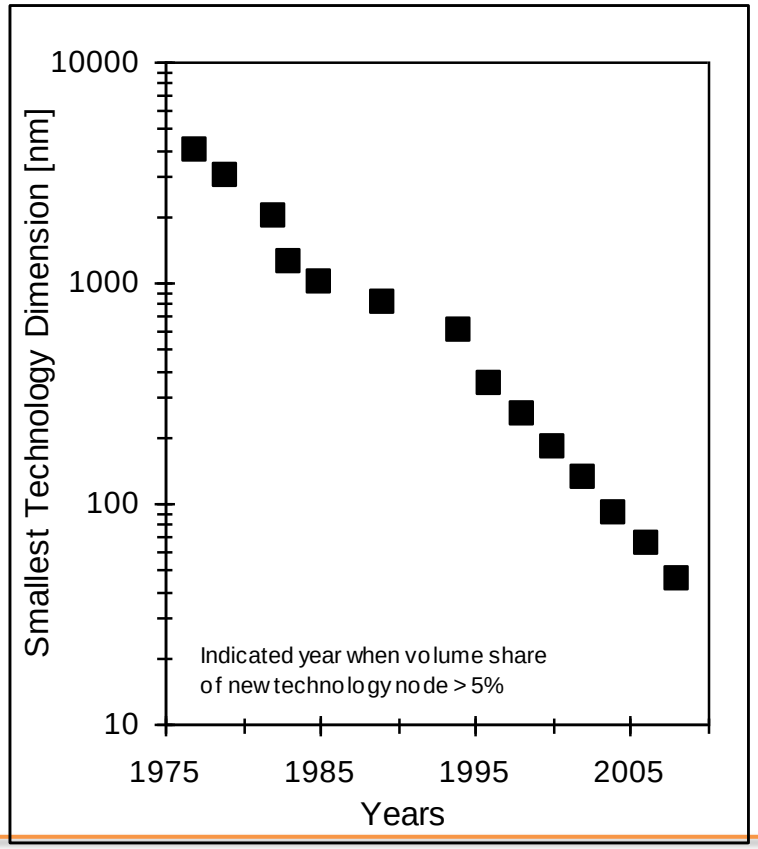
- **Gesamt** **$ct/W 20**

# DRAM – Moore´s Law

## Experience Curve



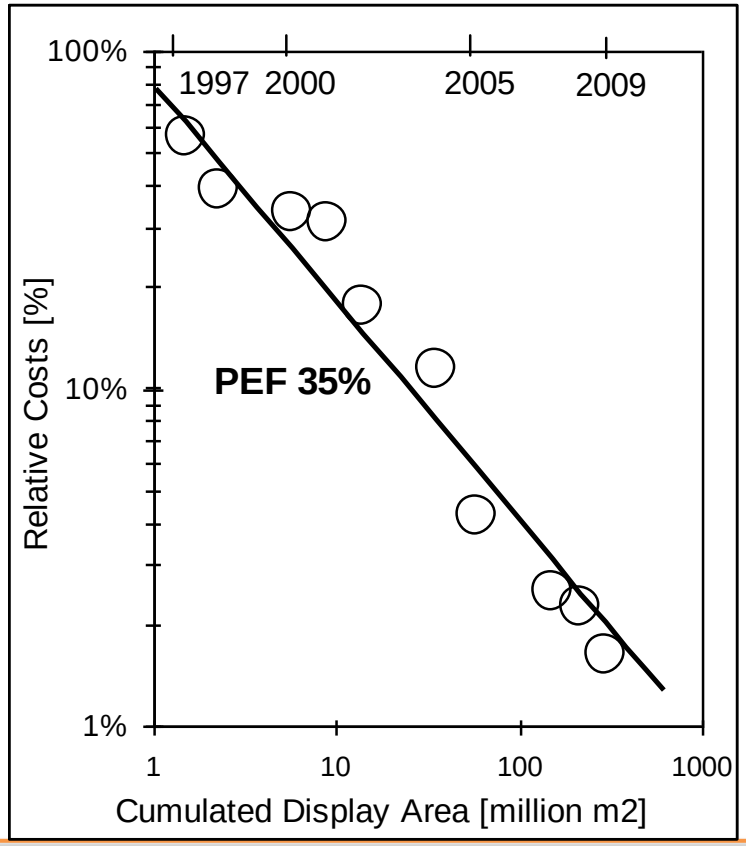

## Driven by Technology



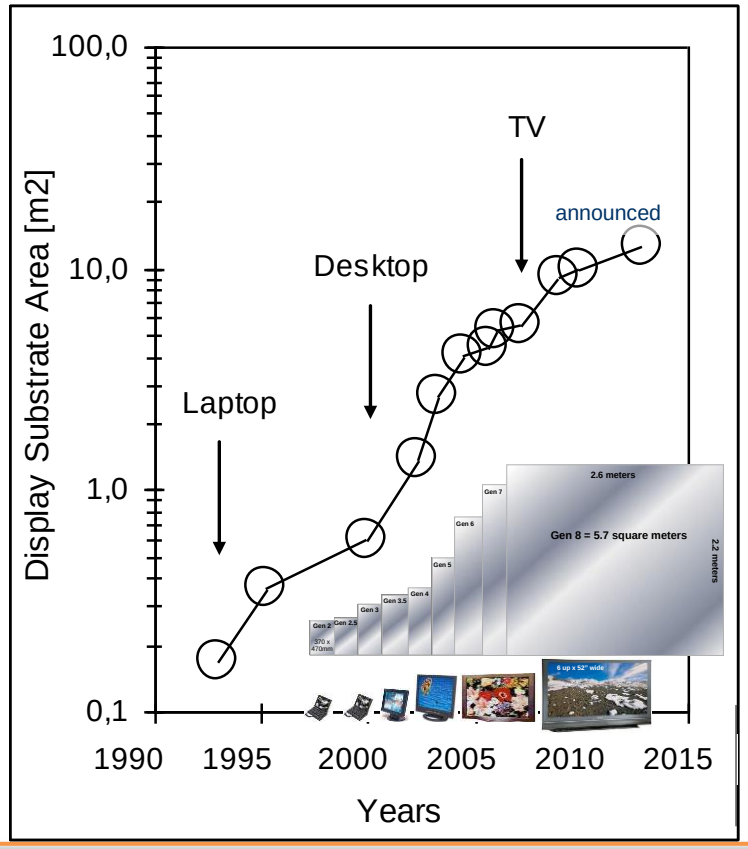

Source: Applied Materials, Semiconductors Group

# Flat Panel Display

## Experience Curve

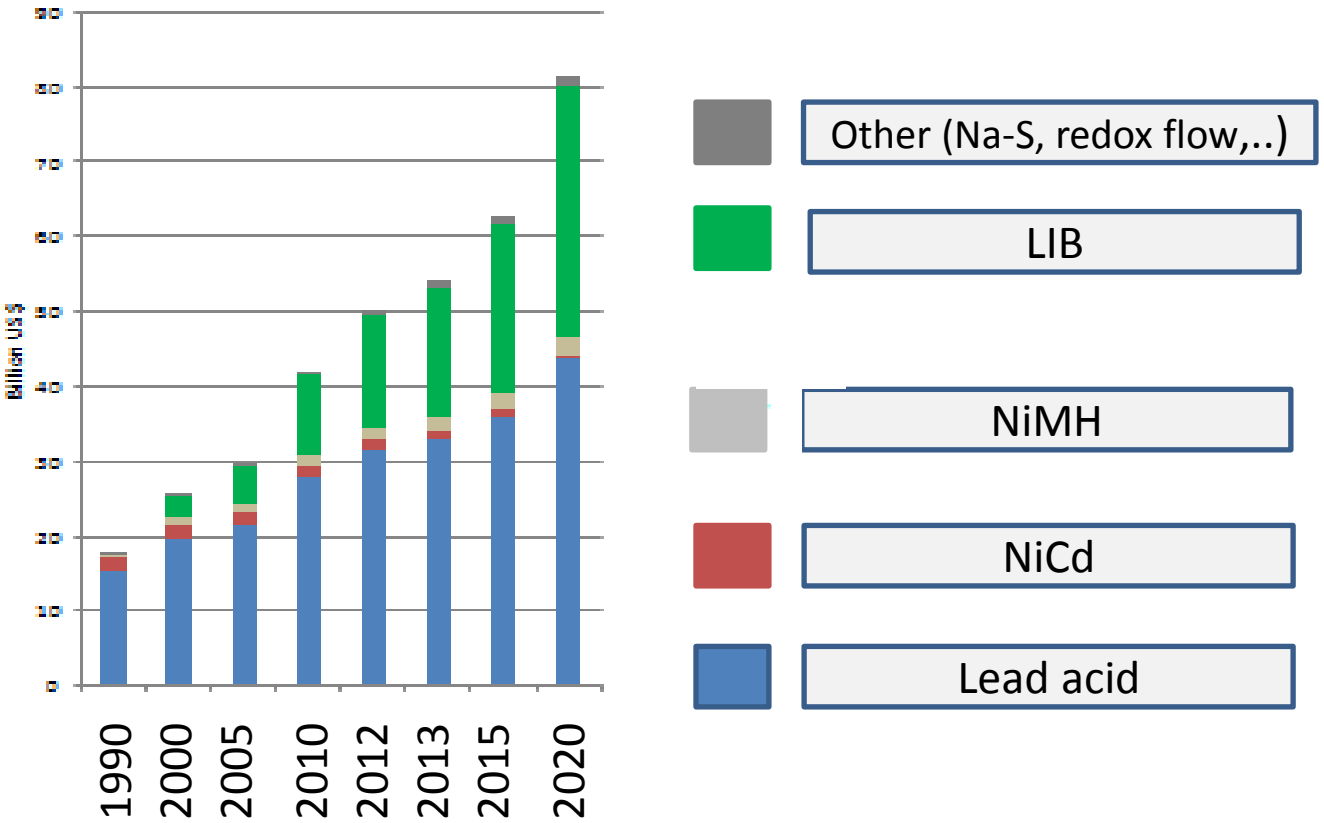



## Driven by Technology



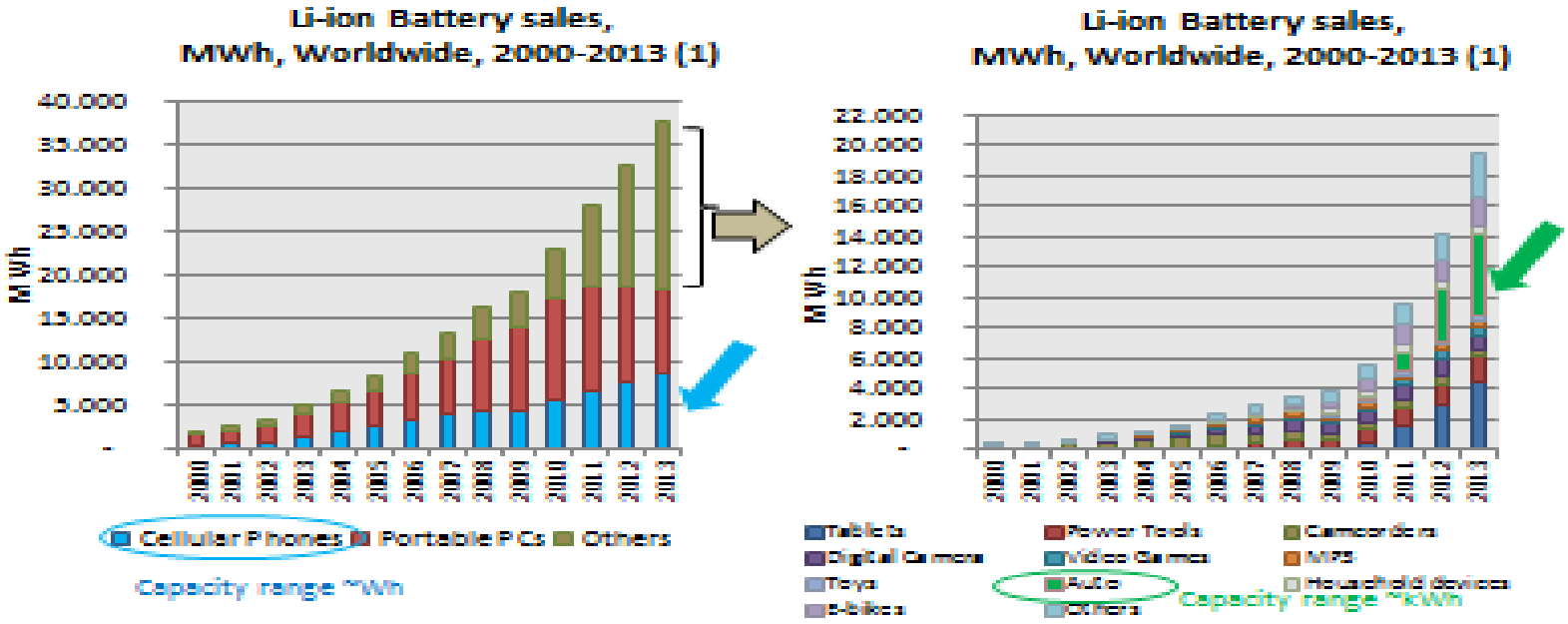

Source: Applied Materials, Display Group, 2009

# Development of the global battery market for all technologies



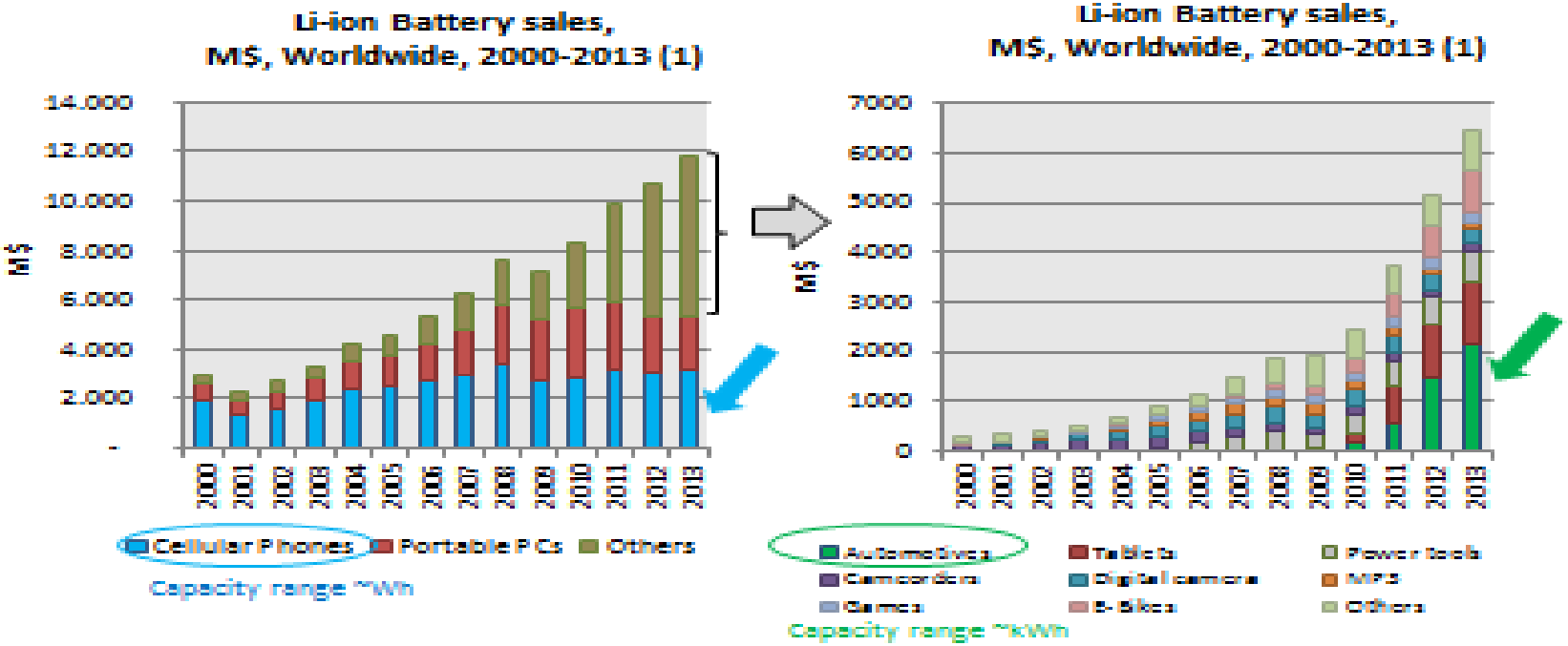

Source: until 2013 real data, afterwards estimates, graph from C. Pillot (2014), avicenne

# LIB sales for all applications in sold MWh



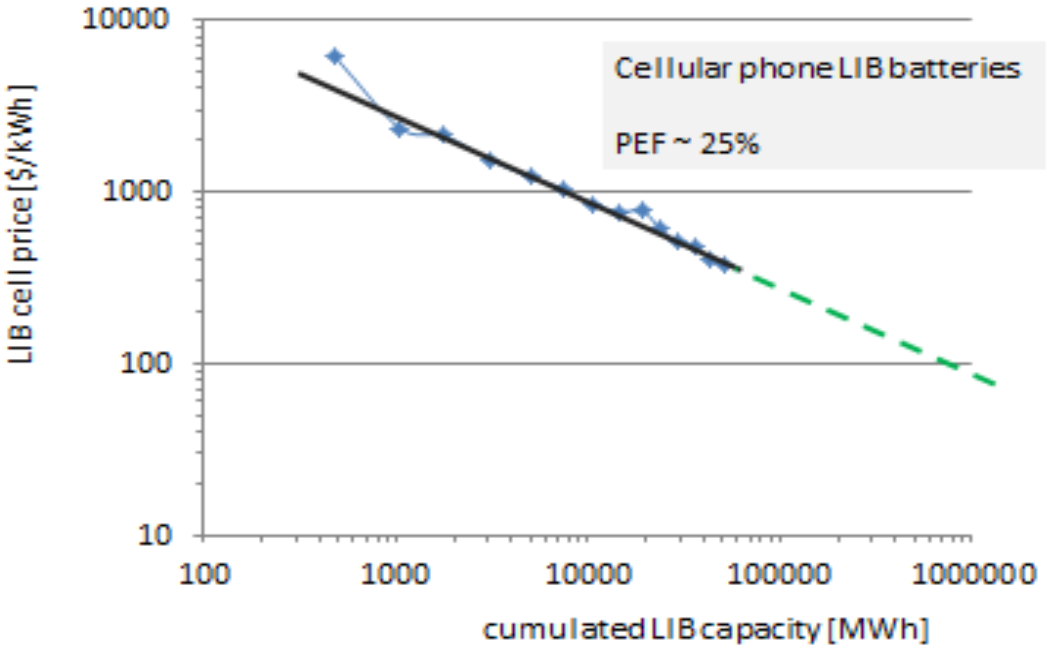

Ref.: C. Pillot (2014), avicenne

# LIB sales for all applications in sold M$ (million $)




Ref.: C. Pillot (2014), avicenne

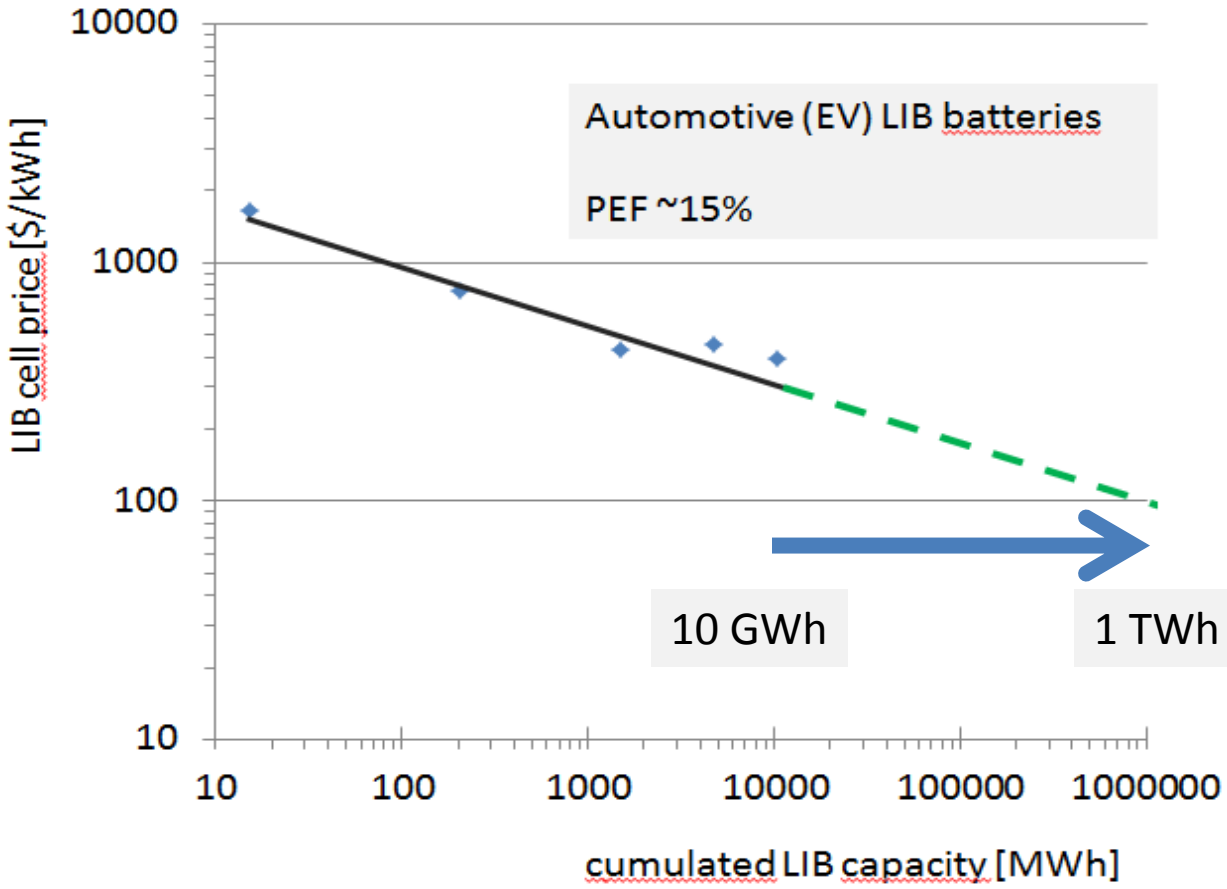
# PEC for cellular phone LIB's




green dotted line is extrapolation of past PEC

Source: raw data from personal communication C. Pillot, Avicenne

# PEC for LIB batteries for automotive applications

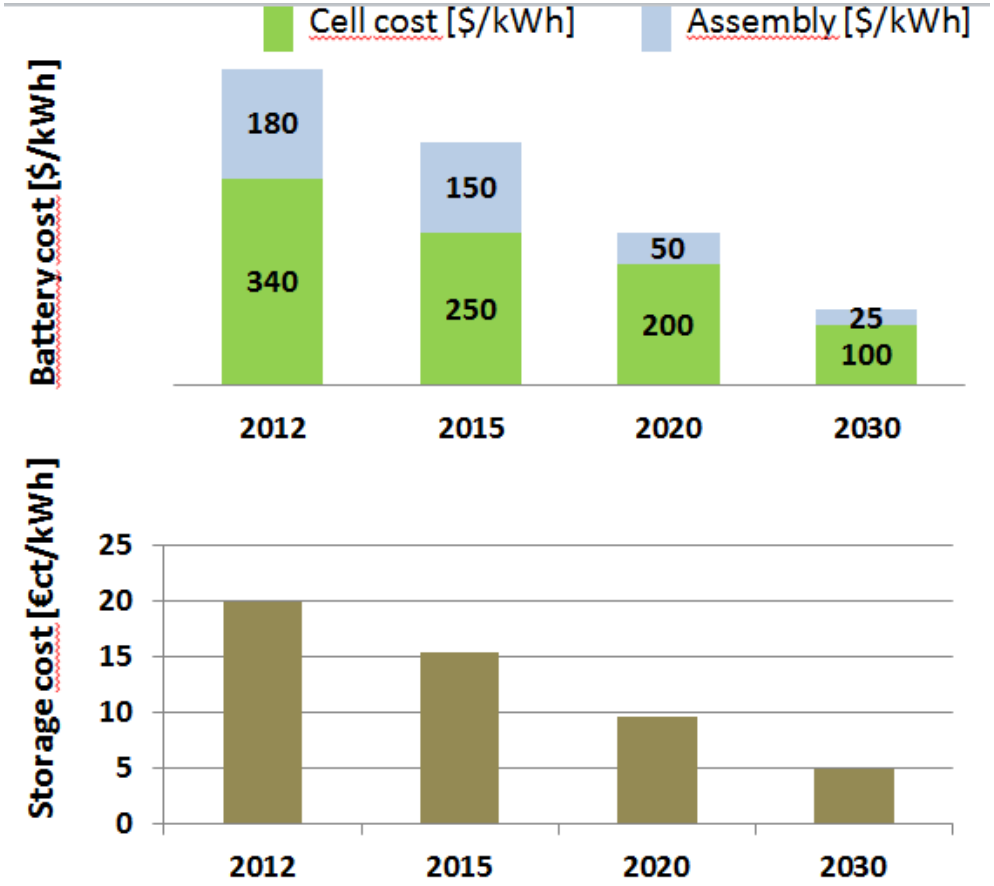



For comparison: PV between 2000 and 2010 had CAGR (cum) of 41%

CAGR (cum. Vol.) = 31 p.a. for 2030

Source: Raw data from personal communication C. Pillot (2014), avicenne; PEC curve constructed by author

# LIB cell- and battery cost and resulting storage cost




LCOS (Levelized Cost of Storage) can be up to a factor of two higher depending on application (installation, BOS, power electronics)

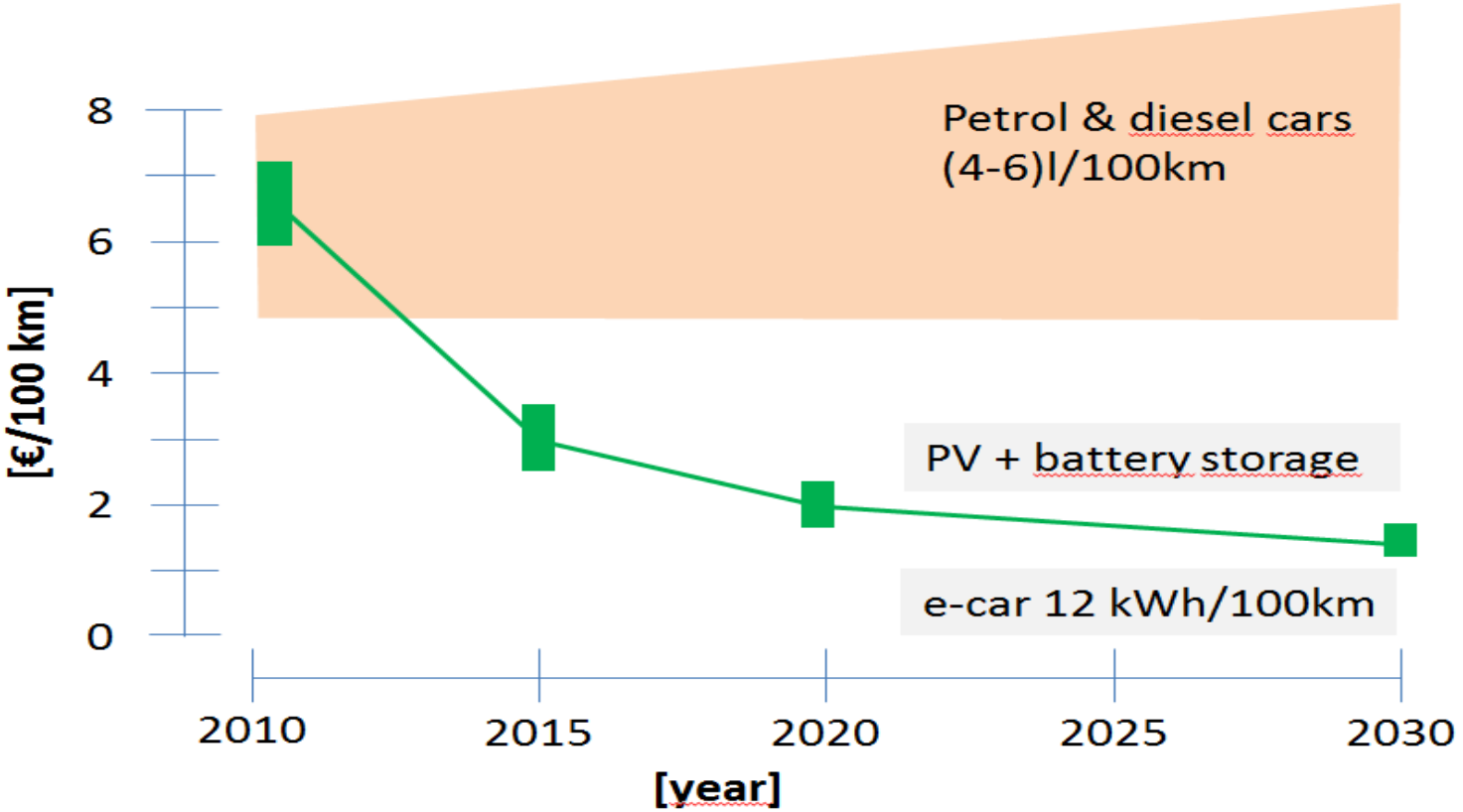
Simplified calculation for the cost of a stored kWh by a LIB battery:

- Lifetime 5,000 cycles
- Financing cost ~ same as investment
- Usable capacity per cycle ~80%

Cost per kWh = (I x 2)/(5,000 x 0.8)

Source: LIB cost 2012, 2015 and 2020 from C. Pillot (2014), avicenne; 2030/35 LIB cost, storage cost and conclusions are own estimates

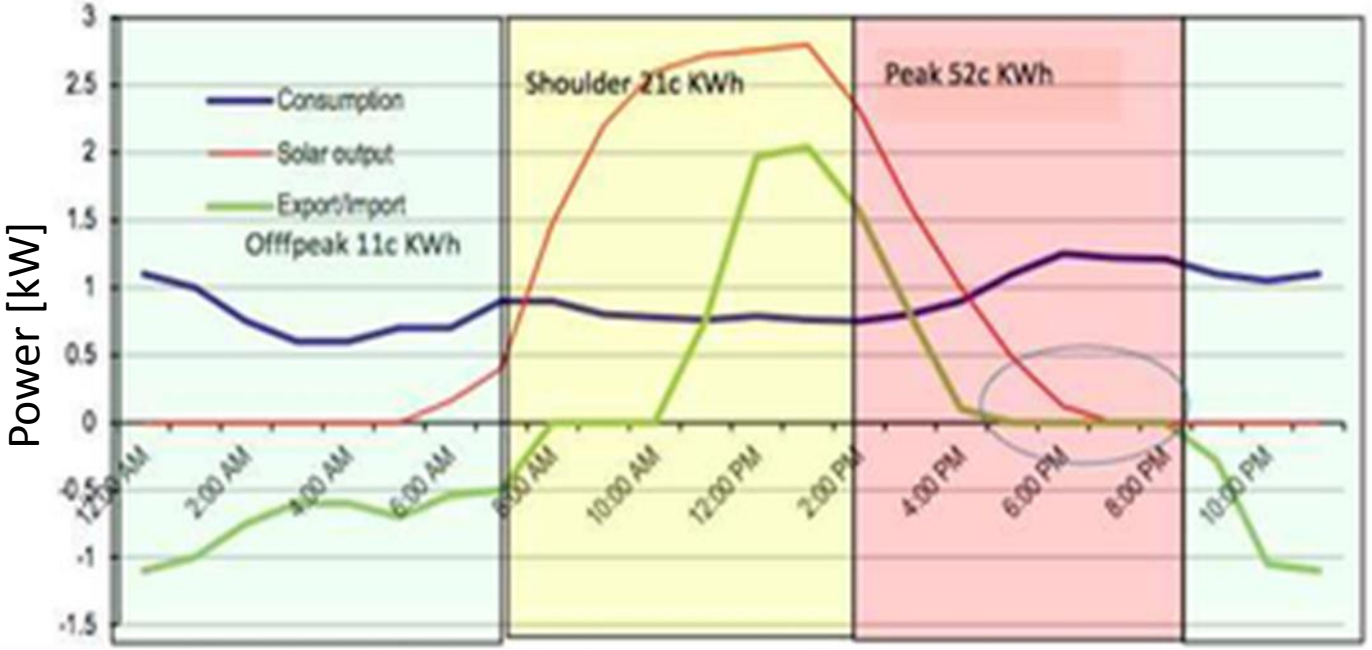
# Fuel cost per 100 km for conventional cars and electricity & storage cost for e-cars




| | | | | |
|---|---|---|---|---|
| BSC [€ct/kWh] | 40 | 15 | 10 | 5 |
| PV [€ct/kWh] | 10-20 | 7 -14 | 5 -10 | 4 -7 |

# Household consumption, solar output and net consumption with battery storage

8,000 kWh customer in Australia,
4 kW PV, 5 kWh battery, price ~18,000$ (with PV subsidy SREC)
PV electricity export to grid 6$ct/kWh




@ no fix cost for connection:

w/o PV&battery:
~$2,000 p.a.

With PV&battery:
Net revenue ~$150
Net gain ~$2,150

Source: UBSe

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**… und für alle, die mehr zum Thema PV, PEC und 100% Erneuerbare Energien lesen wollen:**

- Physik Journal, February 2014, W. Hoffmann „Perspektiven der Photovoltaik“

- Book by Wiley -Scrivener, W. Hoffmann
- „The Economic Competitiveness of Renewable Energy – Pathways to 100% Global Coverage“ (ISBN: 978-1-118-23790-8)

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# Thank You & vielen Dank!


## ACKNOWLEDGEMENT:

Thanks to Christophe Pillot from AVICENNE ENERGY (Paris) for providing the raw market data for the LIB-battery products



C. Pillot, AVICENNE ENERGY, *Li-ion battery material market review and forecasts 2012-2025,* (2013), http://www.sdle.co.il/AllSites/810/Assets/c%20pillot-avicenne.pdf



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