Future PV – From Generation to Storage

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Grid Parity

1) PV cost equal to consumer prices
   - Reached in Germany in 2011
   - But most electricity is generated when you don’t use it yourself
   - Excess electricity has to go back into the grid
Grid Parity

1) PV cost equal to consumer prices
2) PV cost equal to industrial generated electricity
   ▪ Large field in US, India, Middle East and South America already competitive with non-renewable
Grid Parity

1) PV cost equal to consumer prices
2) PV cost equal to industrial generated electricity
   - Also here, electricity is generated during the day
Grid Parity

1) PV cost equal to consumer prices
2) PV cost equal to industrial generated electricity
   - Also here, electricity is generated during the day
   - Some plants can be shut down during the day, but are needed again in the evening
   - This leads to lower utilization rates and thereby increased costs for non-renewable electricity

   Lower utilization $\rightarrow$ higher cost
Grid Parity

1) PV cost equal to consumer prices
2) PV cost equal to industrial generation prices
3) Use of PV does not increase total cost of electricity
   - With storage, electricity can be stored and used later
   - Grid parity consumers will be reached in 2016 for Germany

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* Model calculation for rooftop systems, based on 802 kWh/kWp (Frankfurt/Main), 100% financing, 6% interest rate, 20 year term, 2% p.a. O&M costs
Grid Parity

1) PV cost equal to consumer prices
2) PV cost equal to industrial generation prices
3) Use of PV does not increase total cost of electricity
   - With storage, electricity can be stored and used later
   - Grid parity consumers will be reached in 2016 for Germany
   - This means that part of power plants are no longer needed and can be closed

Combination of Solar and Storage can replace fossil fuel energy generation completely instead of replace only fuel
Learning Curves Solar and Storage

LITHIUM-ION EV BATTERY EXPERIENCE CURVE COMPARED WITH SOLAR PV EXPERIENCE CURVE

Steam learning curve for both PV and storage
As storage market is still small strong price drops are expected

Note: Prices are in real (2014) USD.

Source: Bloomberg New Energy Finance, Maycock, Battery University, MIT
Different kinds of storage

- **Batteries**
  - Based on Lithium-ion for home users
  - Larger installations with Li-ion or redox flow batteries

- **H\textsubscript{2} generation**
  - Used for generating heat (Mixing with natural gas)
  - Used for direct electricity generation (Fuel cell)
How to reduce cost further

- Economy of scale

- Reduced price devices
  - Less consumables
  - Cheaper materials

- Efficiency improvement
  - Higher conversion
  - Longer lifetime
Reduced cost

Use of organic materials in crystalline photovoltaics

- Replace expensive inorganic layers ($\text{SiN}_x$, $\text{Al}_2\text{O}_3$) with PEDOT:PSS
- Low cost processing at ambient conditions
- Top efficiency of 20.7%\(^1\)

\(^1\) Prof. dr. Jan Schmidt, ISFH
Reducing cost

High efficiency leads to smaller projects

Standard PV System
Example: 34'000 m²

MB HJT PV System
Savings: 22% = 7'800 m²
Increased efficiency: changes in contacting

- For double sided contacted cells, number of busbars increases or goes to zero
- Shift from double-sided contacted to back-contacted concepts

*ITRPV 2015: Worldwide market share for different busbar technologies.*

*ITRPV 2015: Worldwide market shares for different cell technologies.*
Increased efficiency

- Breaking through the 25% barrier
  - Use of tandem cells
  - Perovskites as low cost material

- III-V materials for very high efficiency
Storage

- More efficient H₂ formation
  - Lower activation energy
  - Higher yield
  - Better separation from O₂
Storage

- Decrease total system cost for solar selfconsumption

- Increase energy density and durability for storage and mobile energy

Porocarb® by Heraeus

Synthetic carbon material with tunable porosity and pore size distribution. Porocarb® retains ionic pathways at high electrode loadings.
Conclusions

- Strong synergy between Solar and Storage

- Clear path forwards for Solar
  - Cost reduction
  - Efficiency improvements

- Storage is just starting
  - Huge cost reduction and efficiency improvements in the coming years

- Heraeus is present in all markets
  - And will keep innovating to enable further growth

For questions and/or remarks, please contact me at: Arno.Stassen@Heraeus.com