International Solar Alliance Expert Training Course

In partnership with the Clean Energy Solutions Center (CESC)

Dr. David Jacobs

Session 4: Solar PV Grid Parity – Concepts and Implications

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Supporters of this Expert Training Series

International Energy Transition

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ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

IET – International Energy Transition GmbH

Dr. David Jacobs

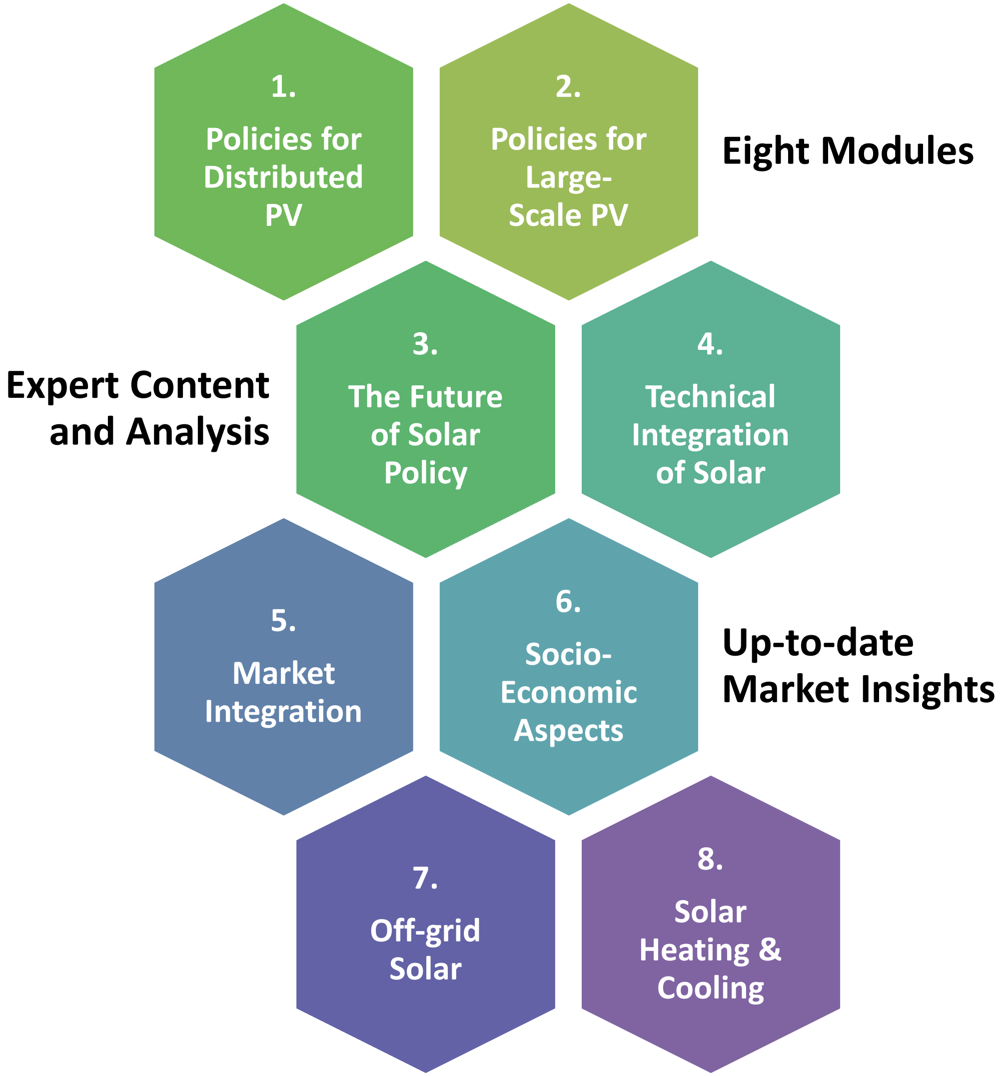
- Founder and director of IET
- Focus on sustainable energy policy and market design
- 15+ years experience in renewable energy policies
- 60+ publications on energy and climate
- 40+ countries work experience (consulting and presentations)

Training Course Material

This Training is part of Module 1, and focuses on grid parity

<u>Related training units are:</u>

- ✓ Session 2 (Intro to solar policies)
- ✓ Session 6 (Net Metering)
- ✓ Session 7 (NET-FITs)
- ✓ Session 8 (Rate design)



Overview of the Training Session

1. Introduction: Learning Objective

2. Understanding the Simplistic and more Advanced Concept of Grid Parity

3. Further Reading

4. Knowledge Check: Multiple-Choice Questions

Introduction:

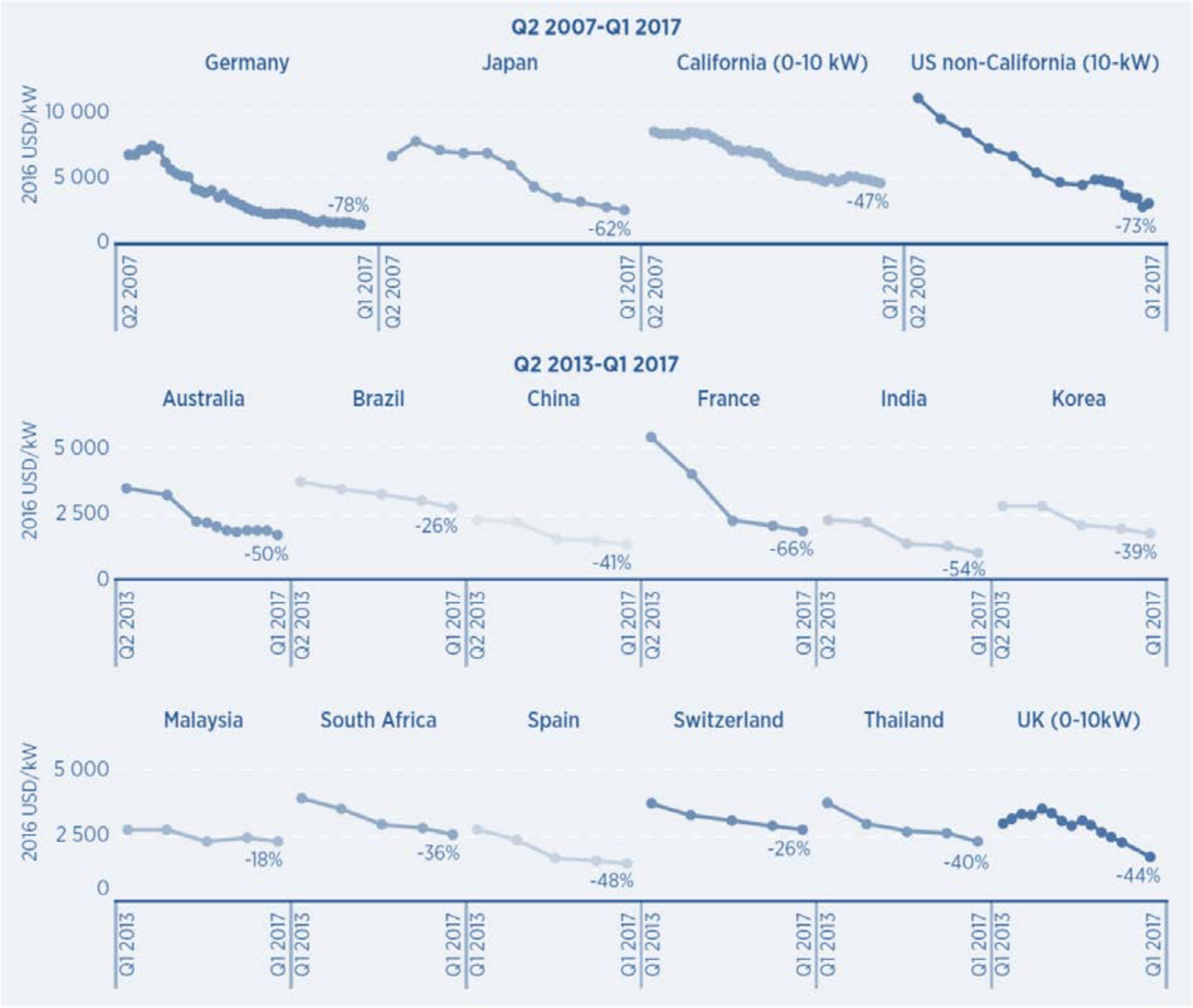
Learning Objective

Learning Objective

- Understand the (simplistic) concept of grid parity
- Understand the nuances of grid parity (including other cost competitiveness benchmarks, the components of the retail electricity market, rate design, etc.).
- Understand the “death spiral” argument
- Understand risk related to project finance via self-consumption

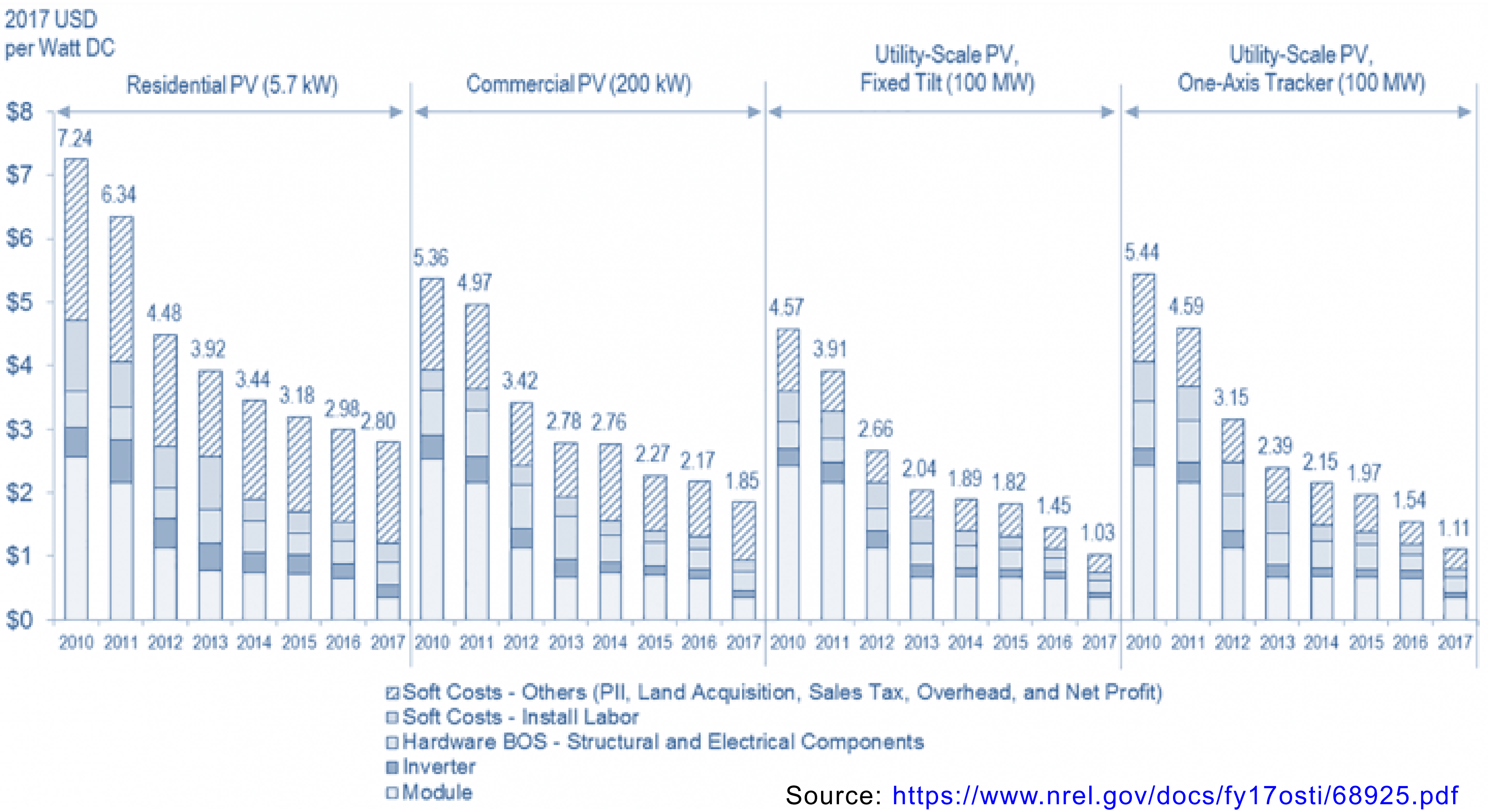
Background: Decreasing Costs for Solar PV and Increasing Retail Prices

Sharp cost decline for residential PV in the past 10 years



Source: IRENA Renewable Cost Database.

Costs Declining in all Market Segments



Source: https://www.nrel.gov/docs/fy17osti/68925.pdf

Rapidly falling prices for PV and batteries

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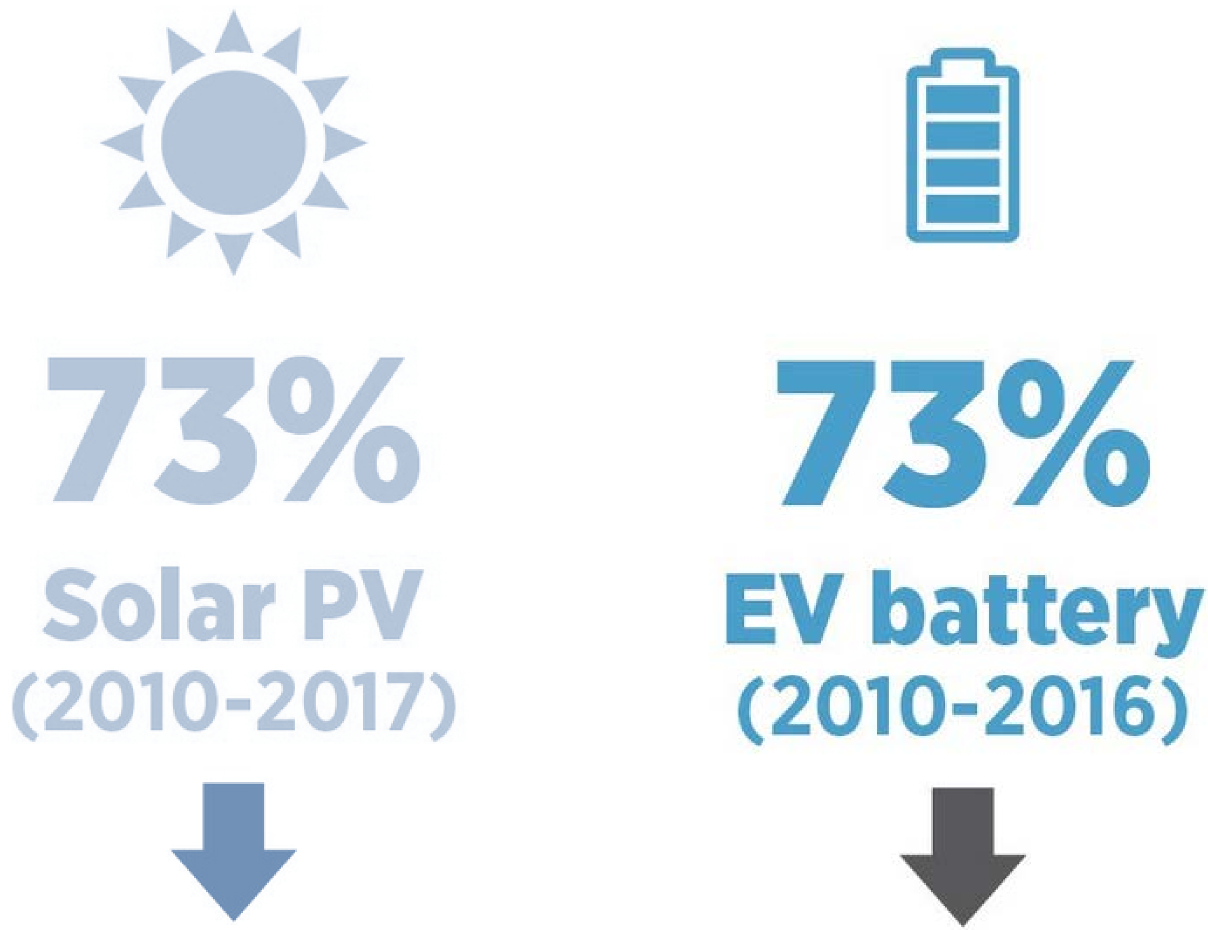
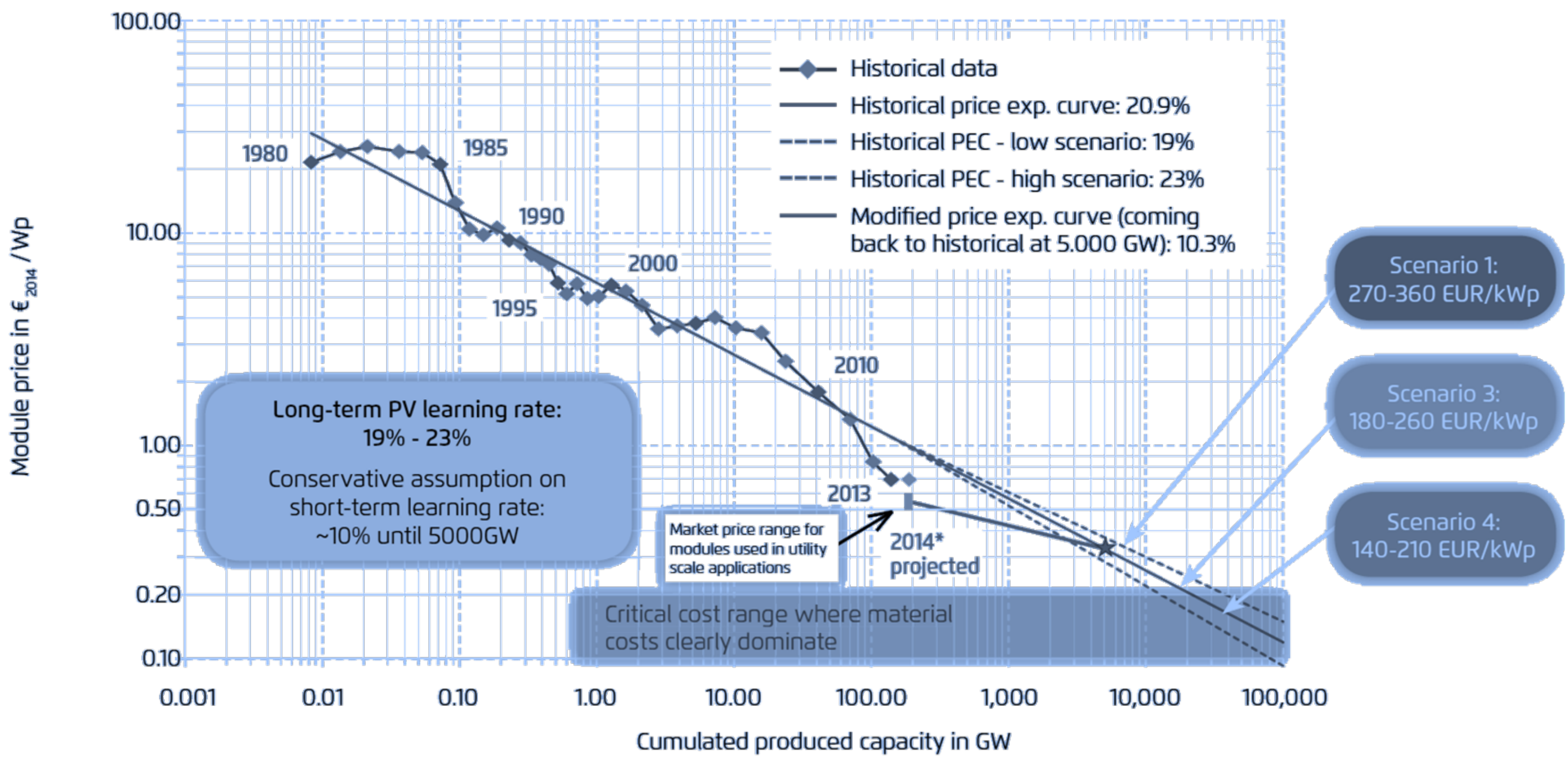


Source: IRENA 2017 (cost data)

Further cost decline of PV is expected

- Ranging from 1.4 -2,1 €cent/kWh in 2050 (for utility scale systems)

Future module prices in different scenarios based on the historical "learning rate" Figure E2



Source: Agora 2015

Further cost decline of PV is expected

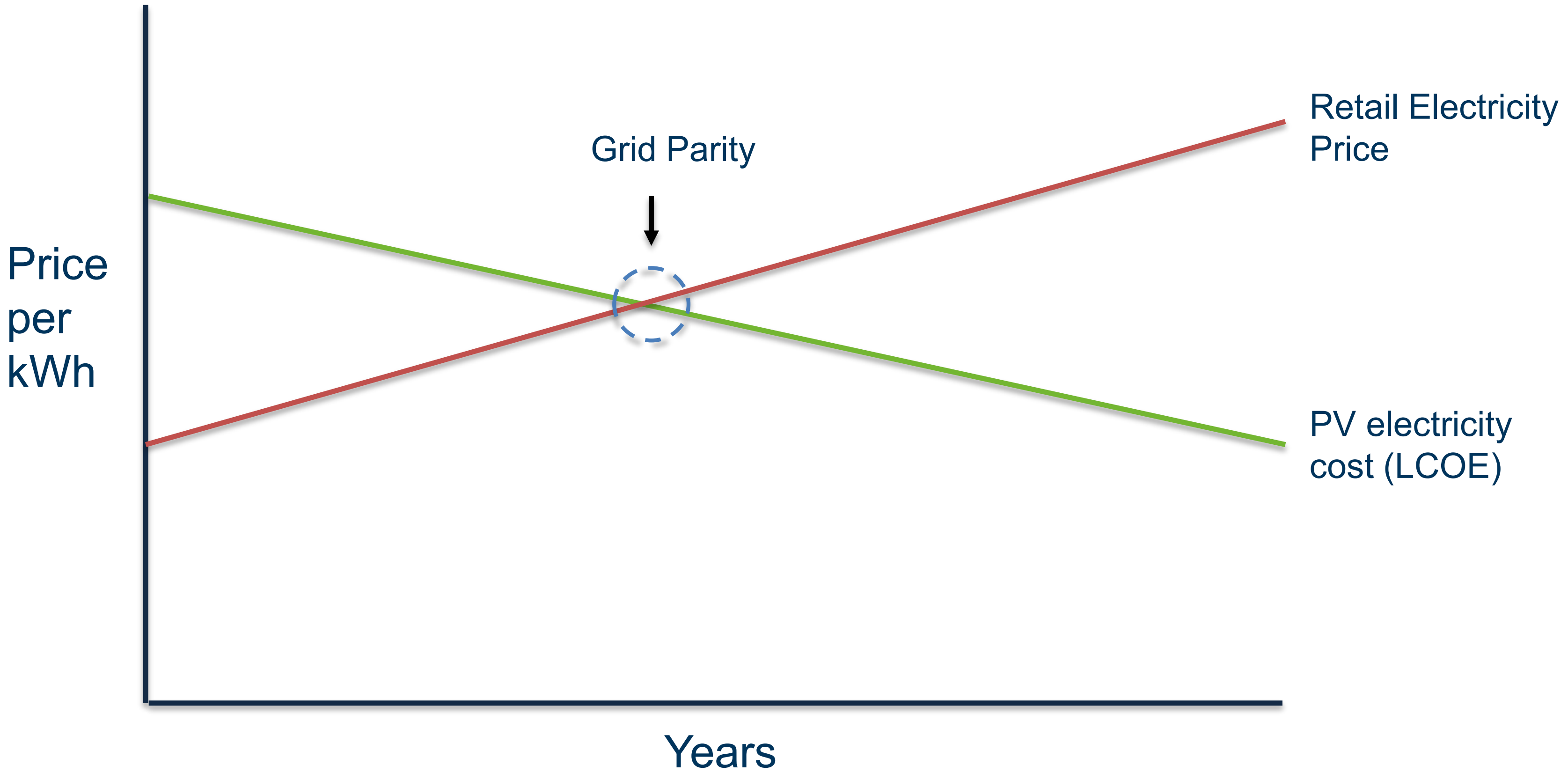
- March 2016, **Mexico**: 1,853MW auctioned at USD 3.2 c/kWh (15 yr agreement)
- August 2016, **Chile**: 12,430GWh were auctioned at USD 2.91 c/kWh (20 yrs)
- March 2017, **UAE**: 350MW were auctioned at USD 2.42 c/kWh
- October 2017, **Saudi Arabia**: 300 MW were auctioned for USD 1.79 c/kWh (!!) (25 yrs)

Increase in retail electricity prices

- Various reasons for the increase of retail electricity prices:
  - Elimination/reduction of subsidies
  - Expansion of grid infrastructure
  - Carbon pricing
  - Higher capital costs for nuclear and coal (FINEX)
  - Legacy costs of RE support mechanisms

The (Over-Simplistic) Concept of Grid Parity/Socket Parity

Simplistic illustration of grid parity



Source: IET

Simplistic grid parity and "self-consumption"

Source: Eclareon 2013

Simplistic Claims related to Grid Parity

„Once we reach grid parity, solar PV no longer needs subsidies“.

„Solar PV will be cost-competitive“

Simplistic Claims related to Grid Parity

„Grid Parity is the final nail in the coffin of centralized electricity markets and utility businesses (and the victory of distributed generation)“

„After reaching Grid Parity, everyone will produce electricity on its own and no longer buy from the utility“.

Grid Parity: A More Detailed Analysis

Grid Parity and Customer Classes

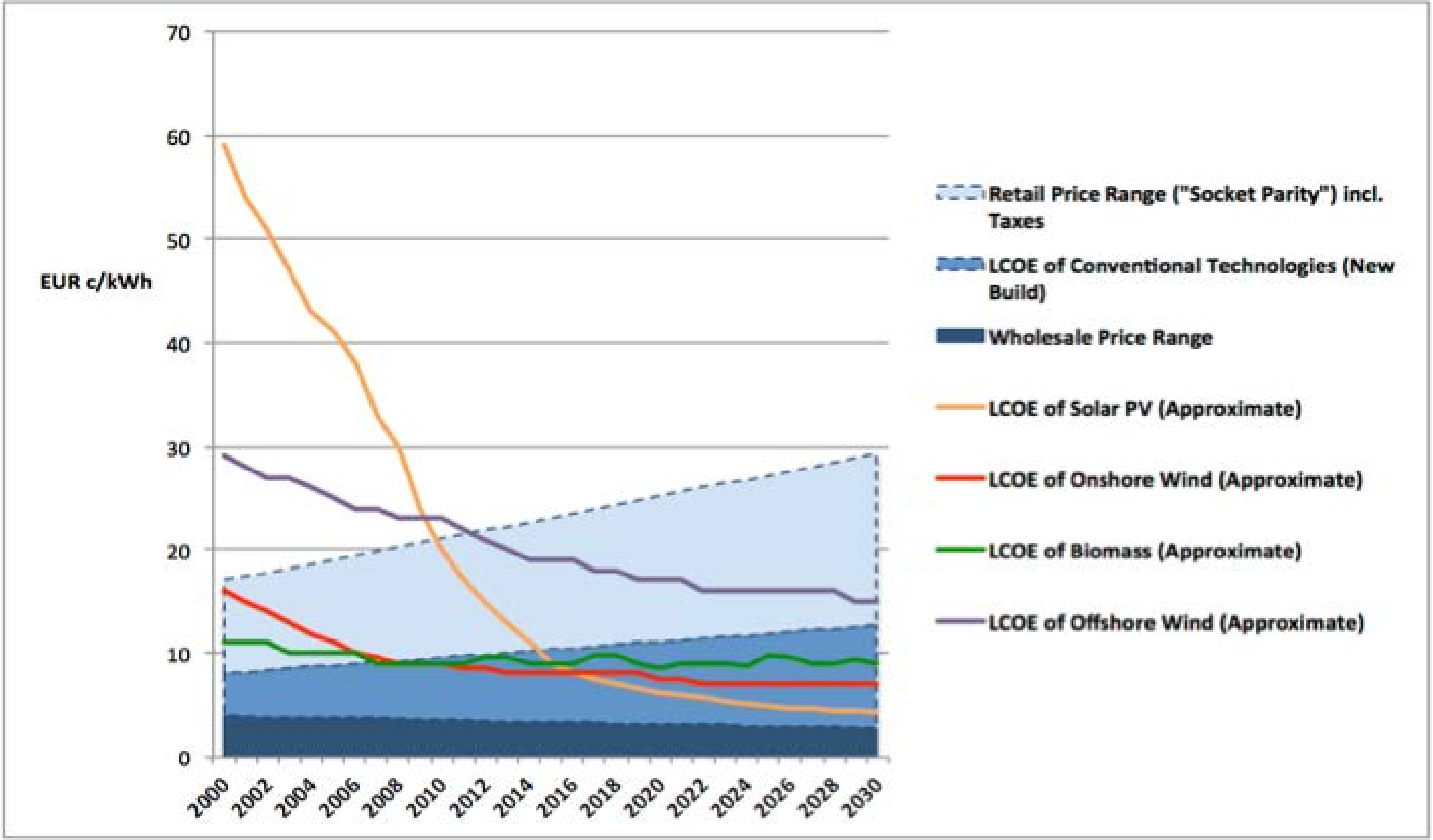
- Grid Parity is NOT the only benchmark for solar competitiveness!

Other Cost Competitiveness Benmarks

Cost Competitiveness Benchmark	Relevance for Solar PV
Retail parity ≈ Grid Parity	Relevant for distributed generation, behind-the-meter
LCOE Parity	Relevant for markets with integrated, least-cost electricity planning
Avoided Costs Parity	Relevant for monopolistic markets
Wholesale Parity ≈ Generation parity (markets) = O&M costs of fossil fuel based power generation	Relevant for fully liberalized markets

Source: IET based on IEA-RETD 2016

Other Cost Benmarks

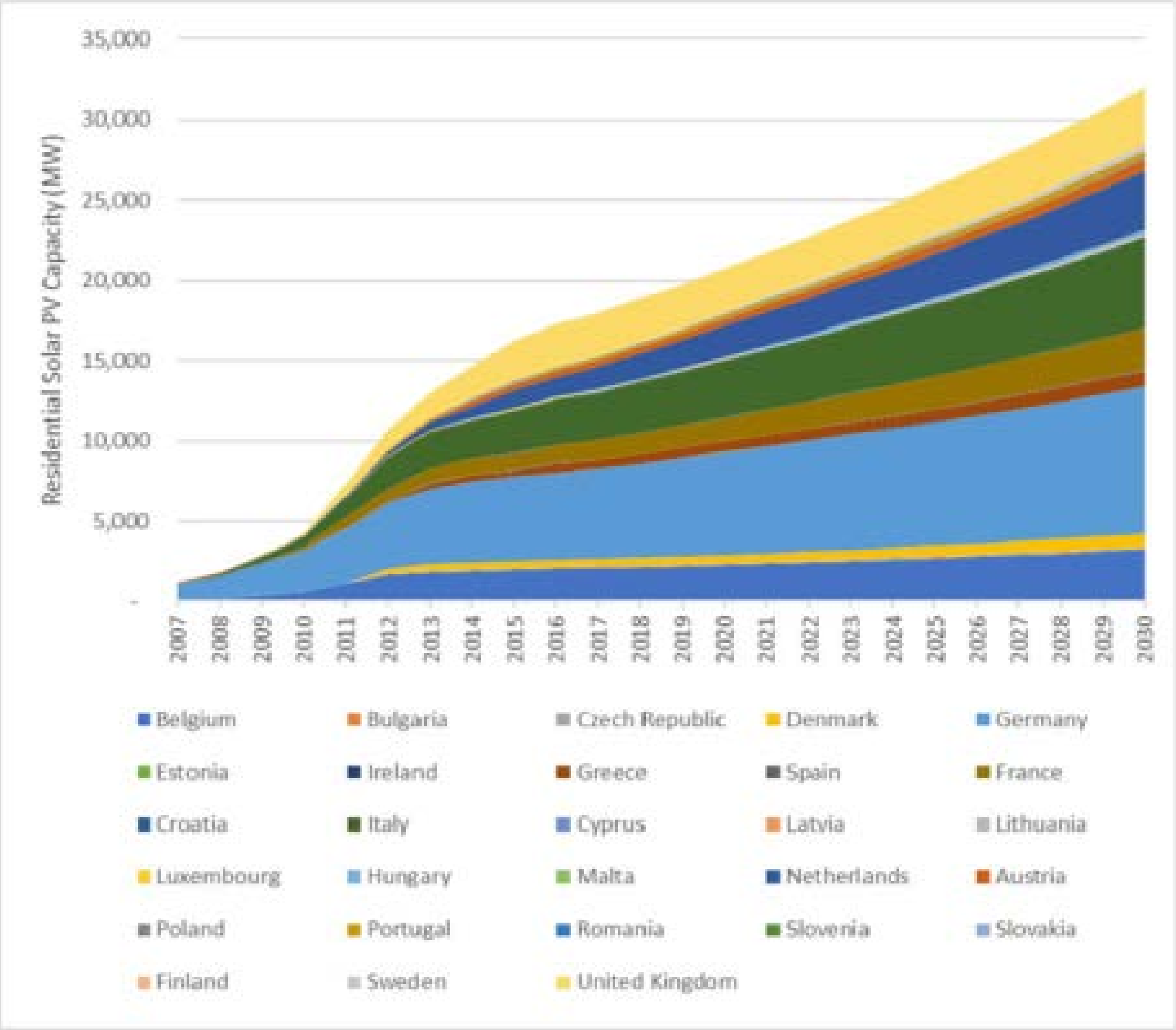


Limitations for Self-Consumption

- Not all solar PV is deployed on roof-tops

Uptake of Residential Solar PV in the EU

Residential Solar PV is becoming a major source of new power generation



https://ec.europa.eu/commission/sites/beta-political/files/study-residential-prosumers-energy-union_en.pdf

Most solar PV deployment is related to large-scale systems

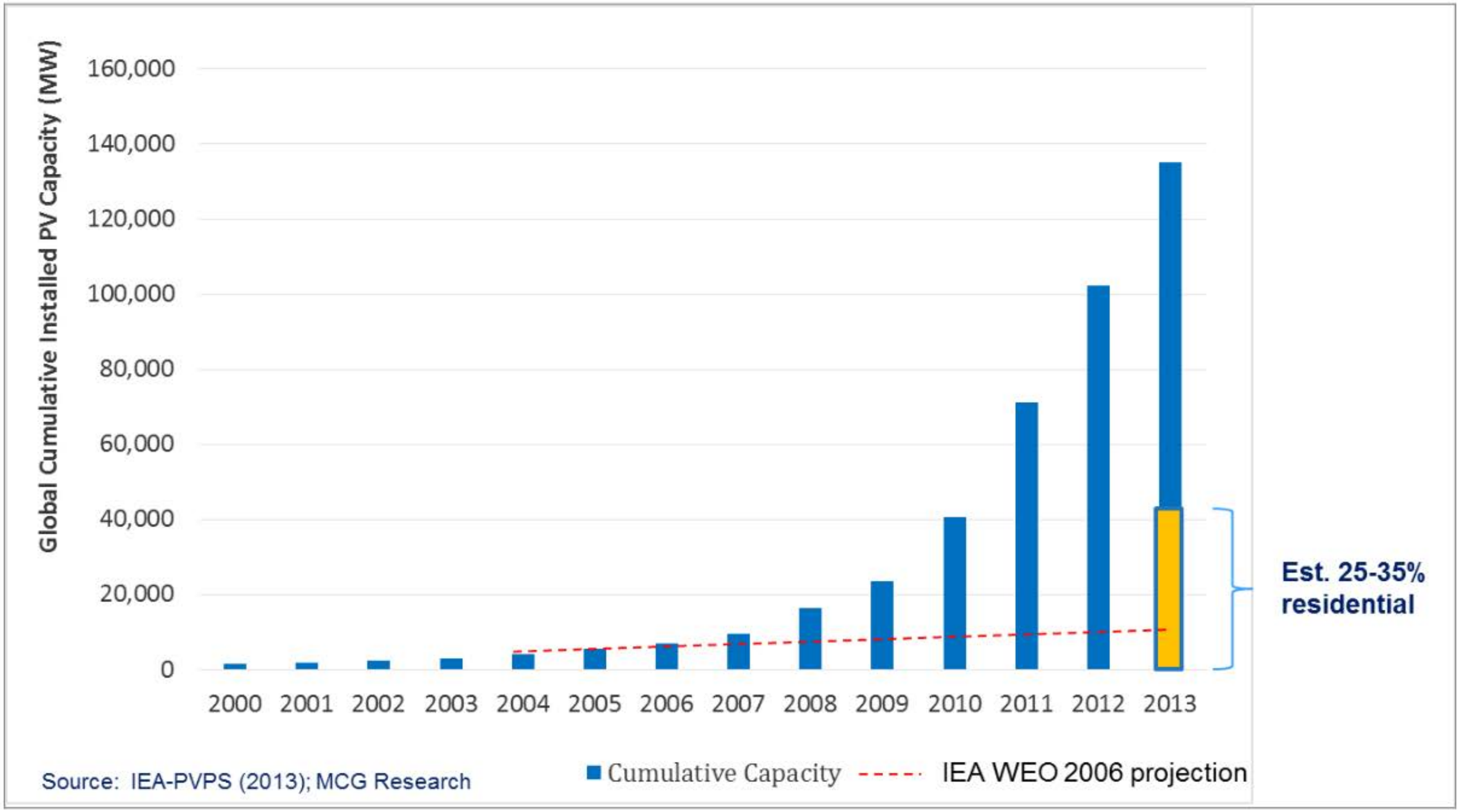


Figure 2: Evolution of Cumulative PV Capacity (MW); global residential share only estimated for 2013
Source: IEA PVPS (2013)

Source: IEA RETD 2014

Share of “residential” versus “utility-scale” depends on policy environment!

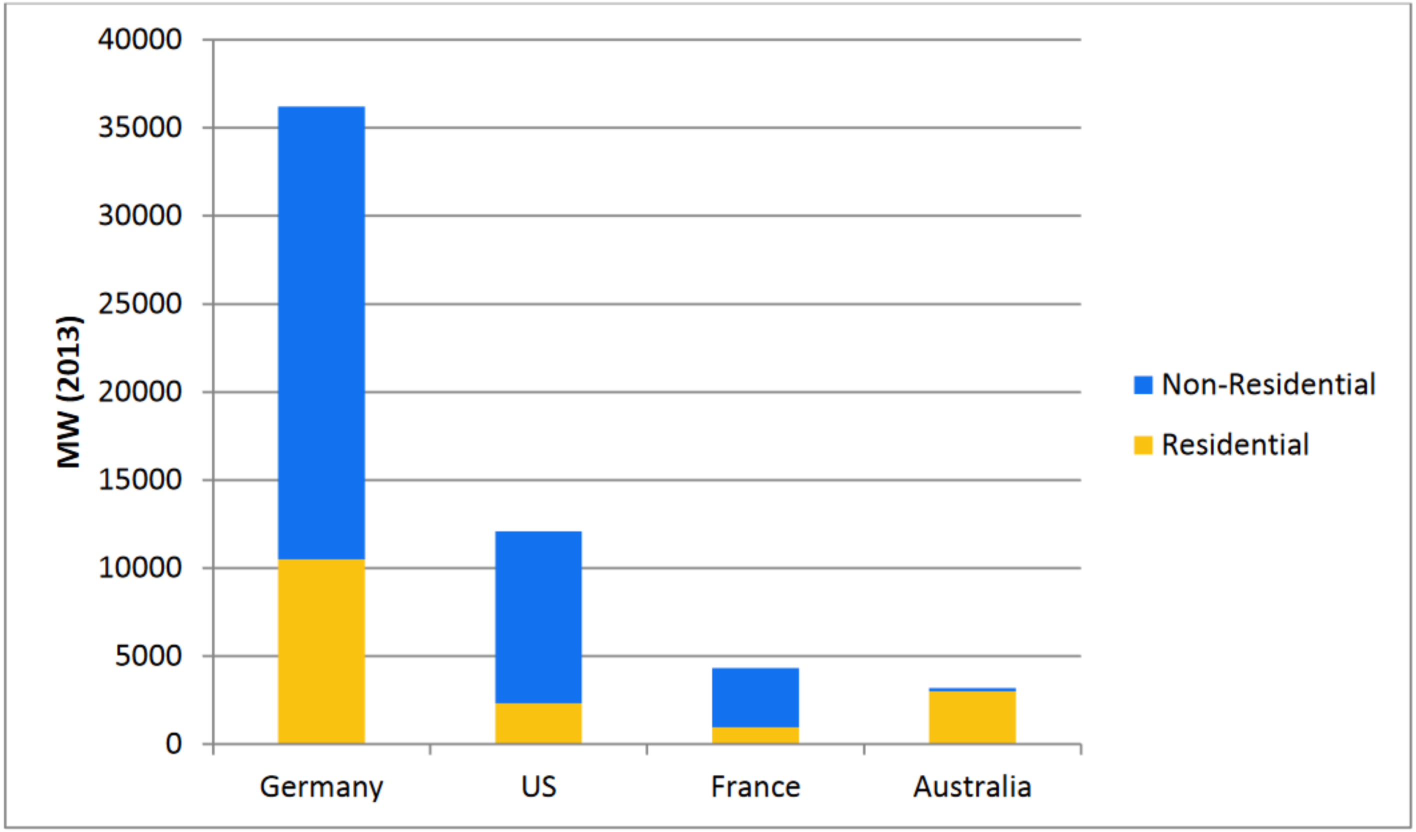


Figure 3: MW of residential and non-residential PV installed in major global markets[9]
Source: (Wirth, 2014; Brazalle, 2014; ERDF, 2014; Sherwood, 2013; Kann et al., 2014)

Source: IEA RETD 2014

Grid Parity and Self-Consumption Policies

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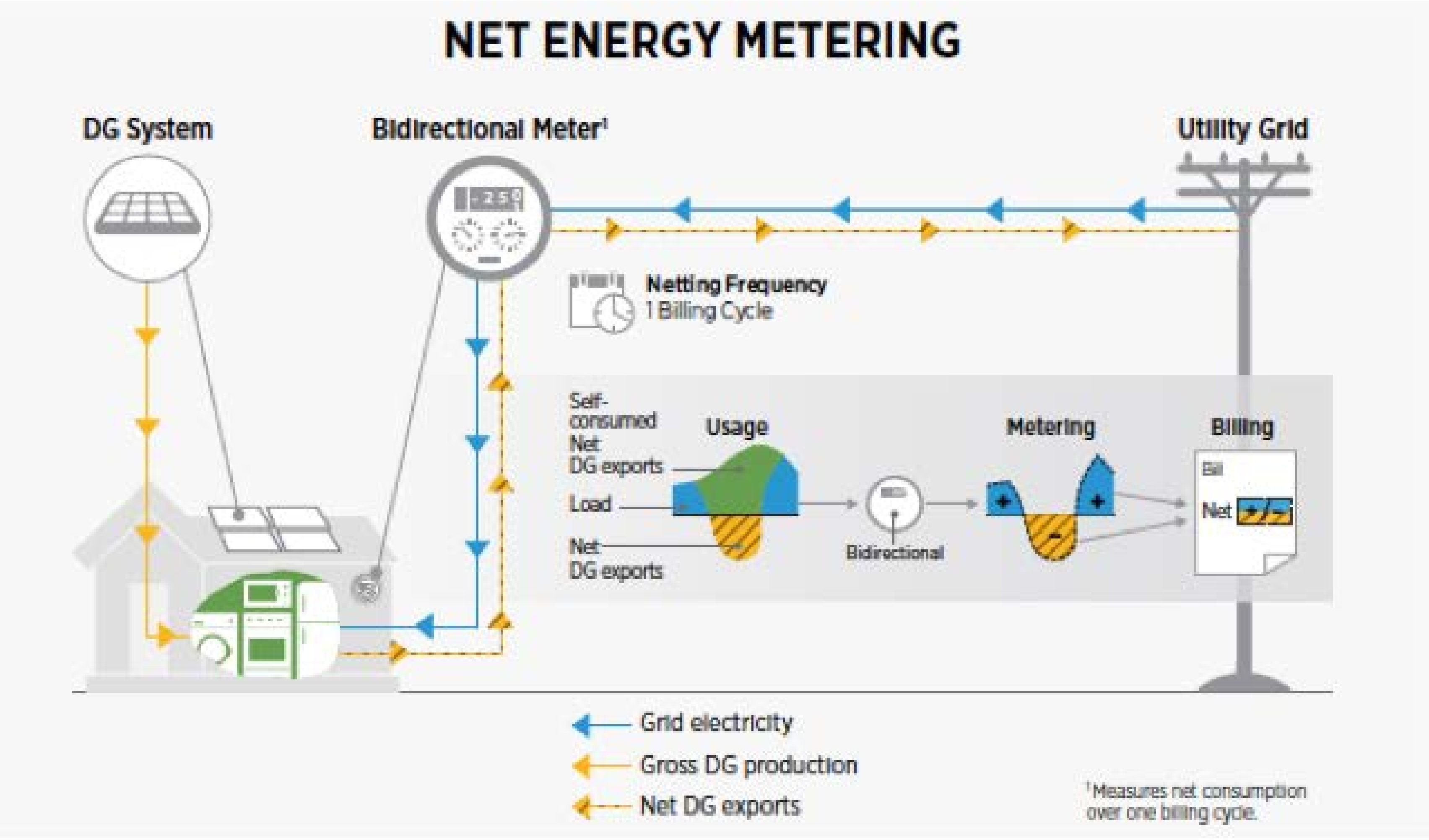
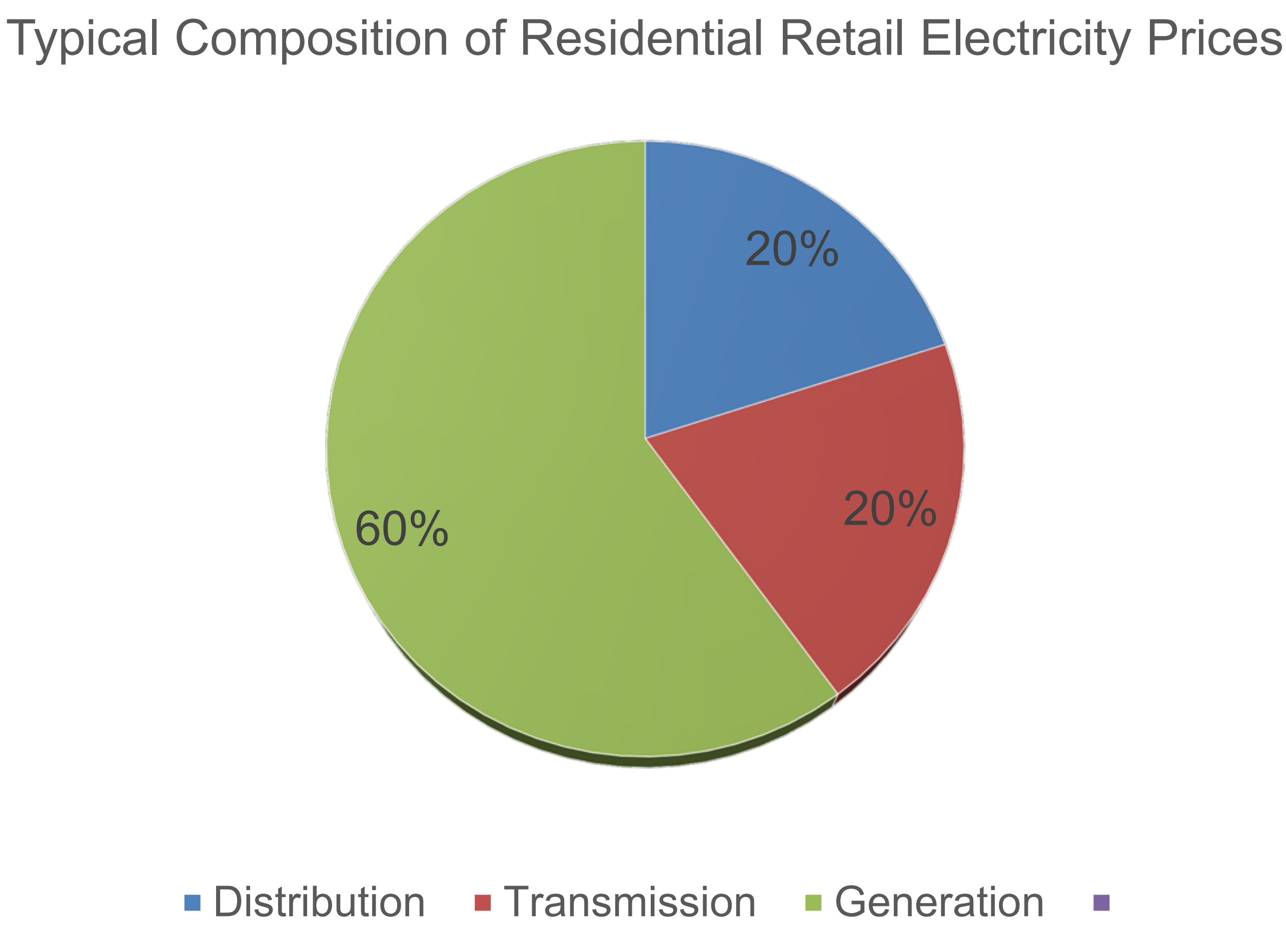
- The full retail electricity price is not the appropriate competitiveness benchmark

Net Metering 1.0

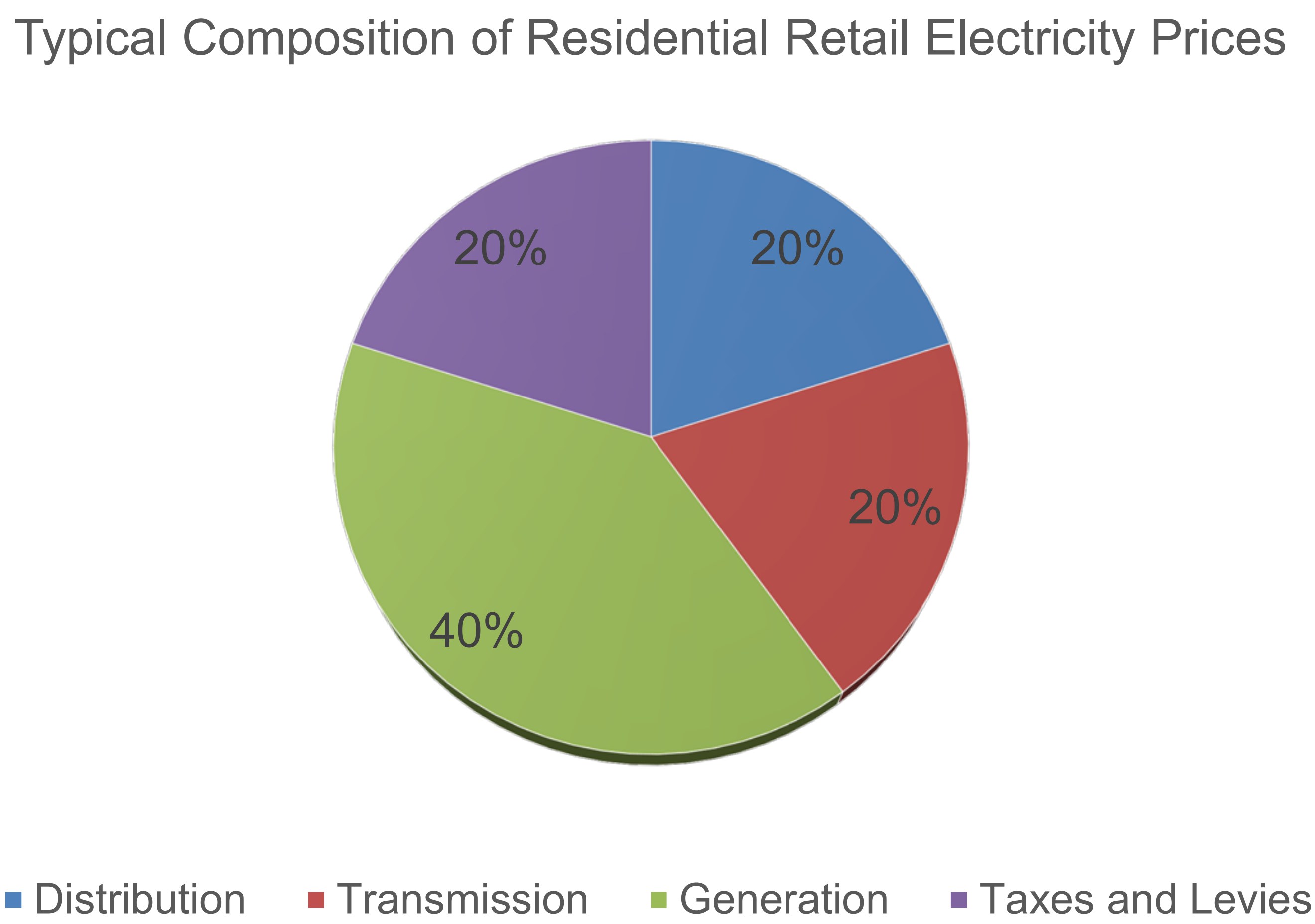


Source: https://www.nrel.gov/docs/fy18osti/68469.pdf

Typical Retail Electricity Price (Residential)



Typical Retail Electricity Price (Residential)



The Value of Distributed Solar

Features	Design Options
Value of Distributed Solar	• FIT levels • Retail electricity • Value of solar • Avoided costs • Wholesale electricity • No compensation

Net Metering 2.0 – Design Elements

Policymakers **assess the value of solar PV** within the specific jurisdiction
The roll-over provision and the **payment for access electricity are adjusted to the value of solar** (usually between the retail electricity price and the wholesale electricity price)
Prosumers are frequently forced into **time-of-use tariffs** (to incentivize more electricity system friendly behavior)
Prosumers need to **pay non-bypassable charges** which are part of the retail electricity price

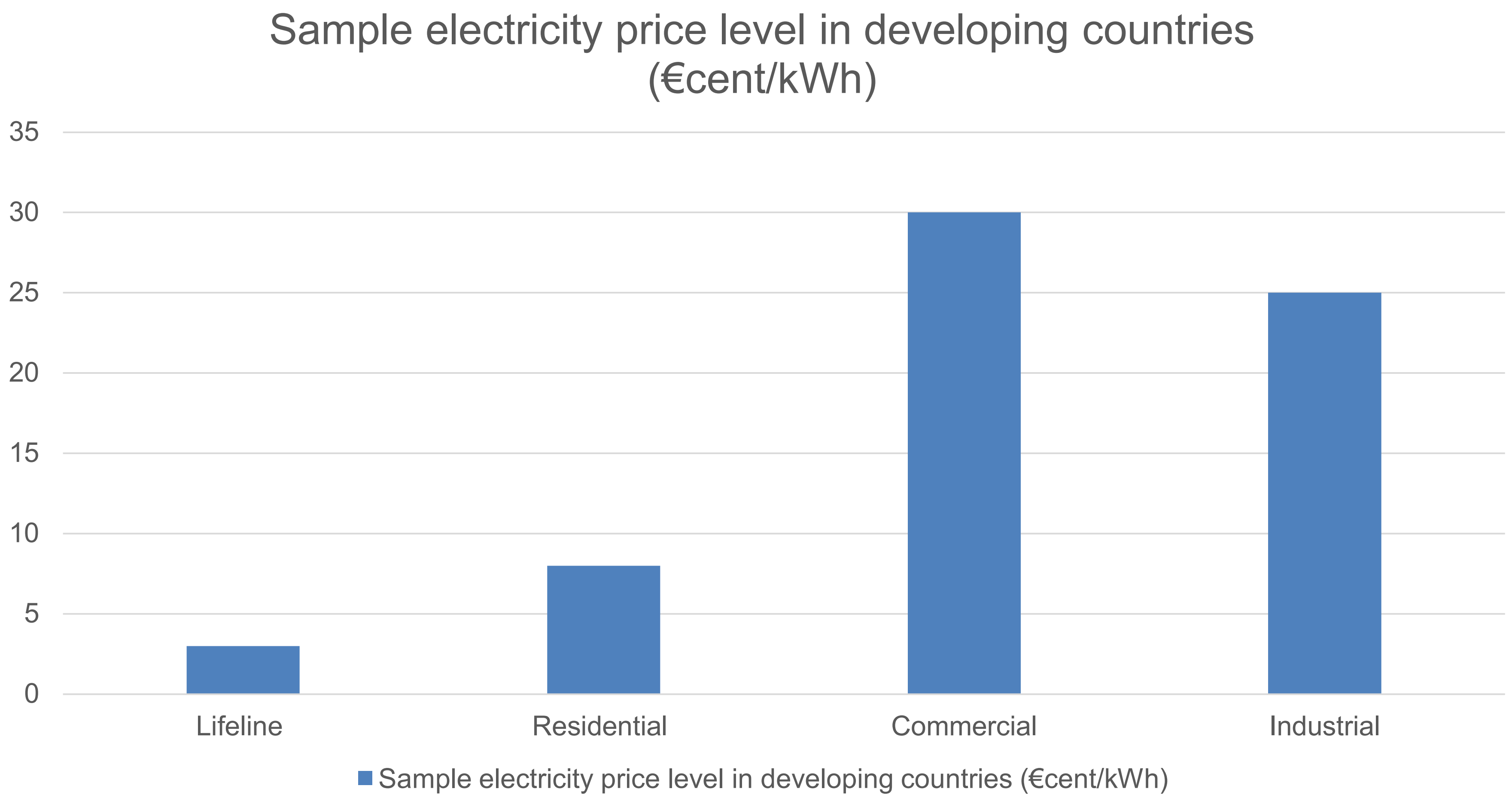
Grid Parity and Customer Classes

- Grid Parity differs from one customer class to the next

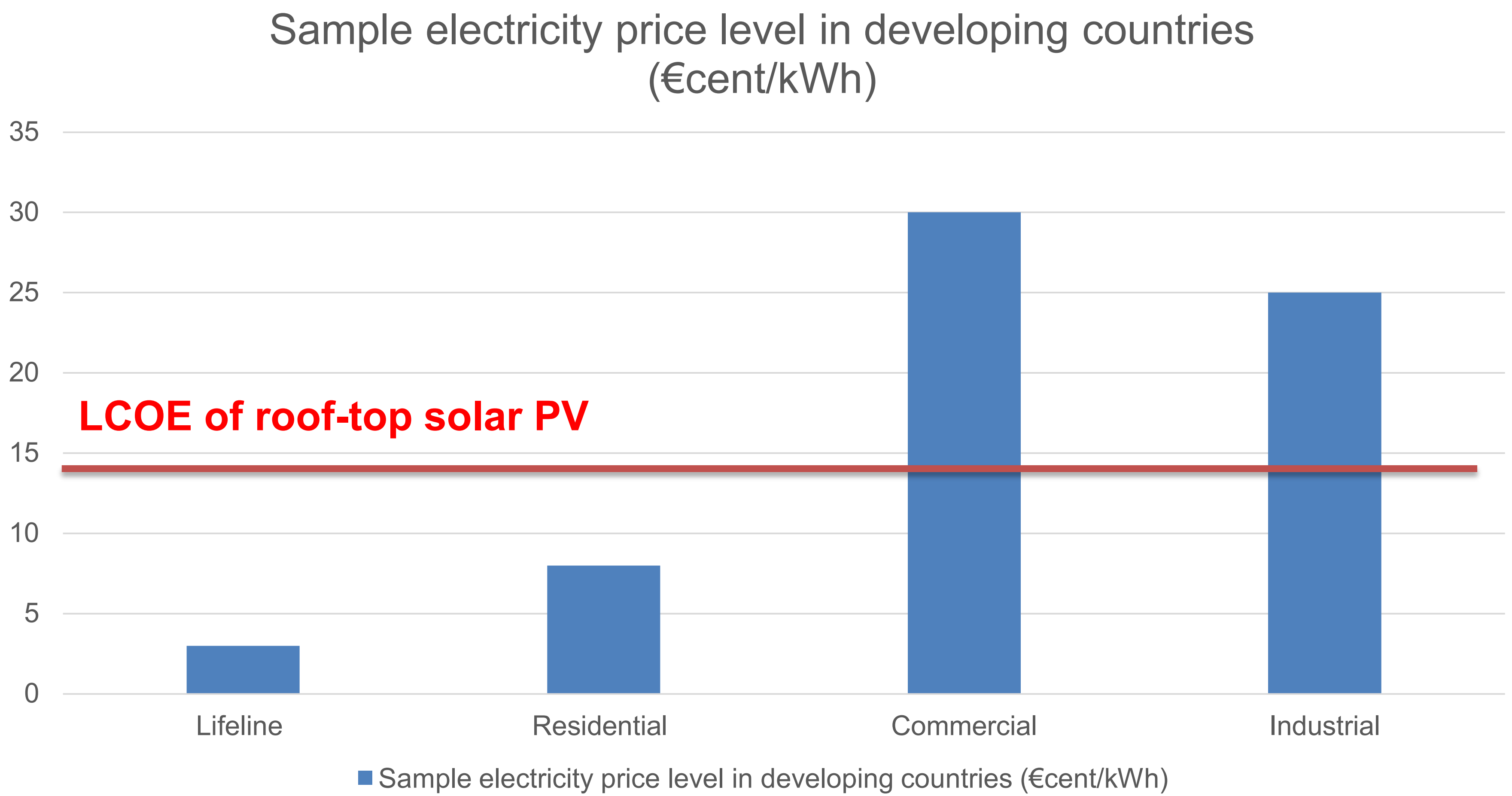
Grid Parity and Customer Classes

- Typical customer classification:
  - Low-income residential customers (lifeline tariff)
  - Residential customers
  - Commercial customers
  - Industrial customers
  - Industrial customers (energy-intensive industry)

Grid Parity and Customer Classes



Grid Parity and Customer Classes



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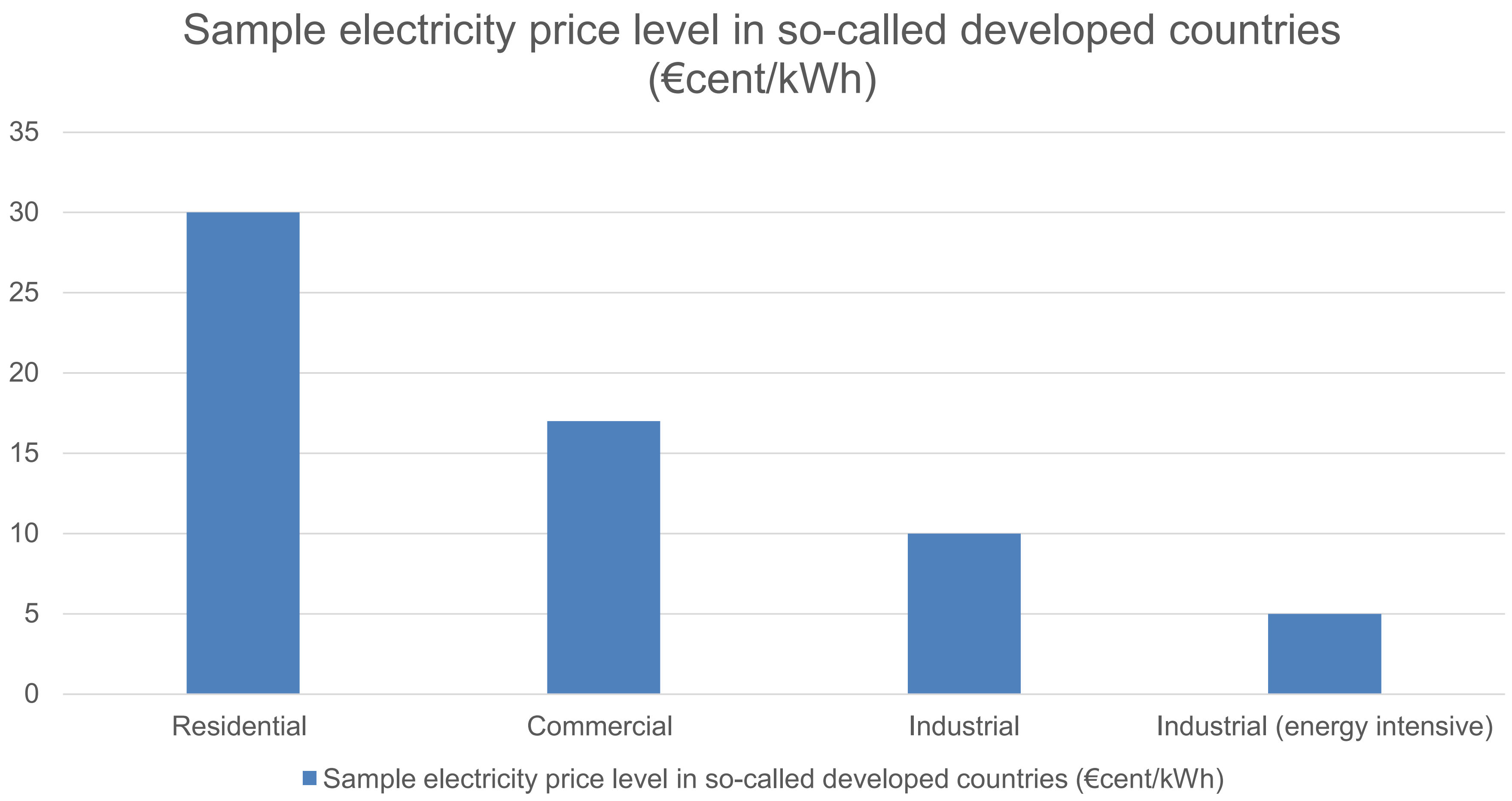
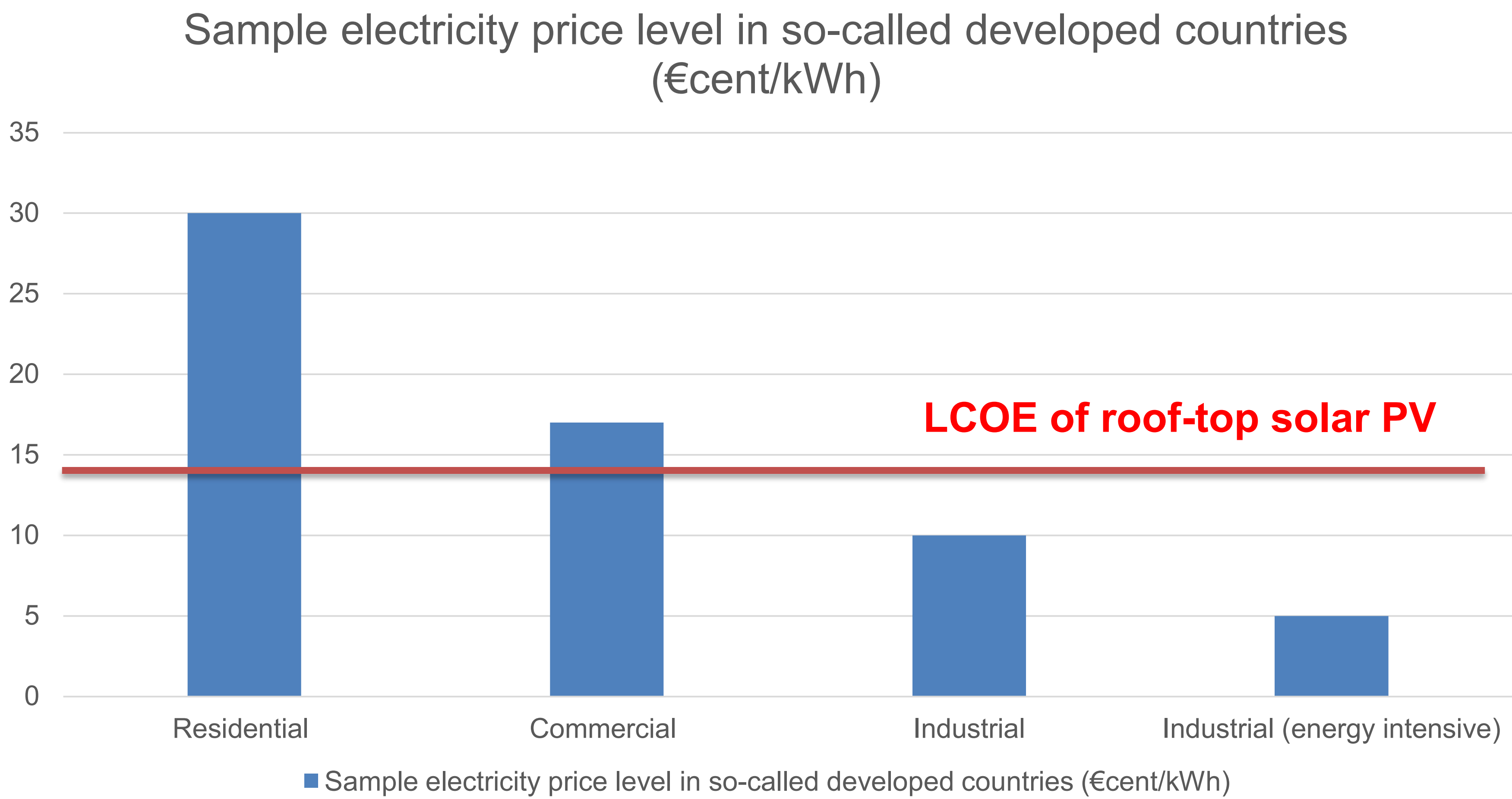
Grid Parity and Customer Classes



Grid Parity and Customer Classes



Customer Classes and Payback Periods

- Different customers also have diverging expectations related to amortization periods (payback time):
  - Residential (developed countries): 10-15 yrs
  - Commercial (developed countries): 5-8 yrs
  - Residential/commercial (developing countries: Less than 5 yrs.

Customer Classes and IRR Expectations

- Different customers also have diverging IRR expectations:
  - Residential (developed countries):
    - Relatively low IRR expectations (depending on alternative investment opportunities)
    - Frequently not IRR drive: value of property can increase by having solar PV on roof-top
    - Other motivation factors (e.g. status symbol)
  - Commercial (developed countries): 8% or higher
  - Residential/commercial (developing countries): 10-20%

Grid Parity and Rate Structure

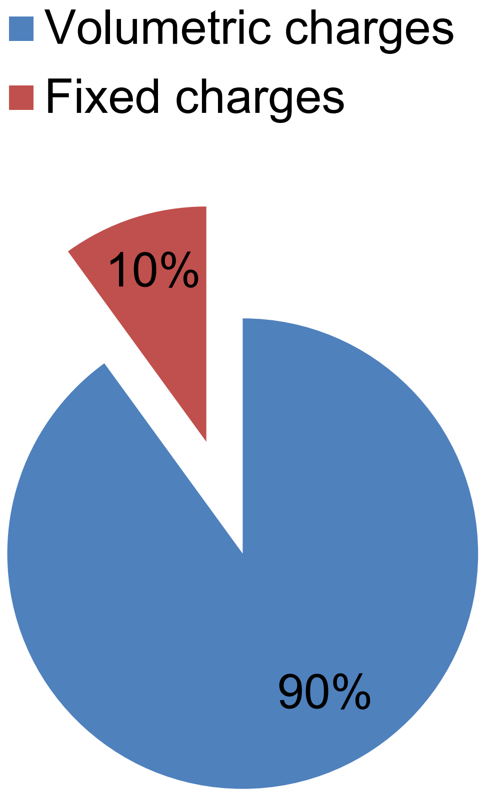
- Grid Parity differs depending on the rate structure

Rate Design for Residential Customers

Typical electricity bill (for **residential customers**) consist of two components:

- Volumetric charges:
  - Energy related costs (varying with the use of energy)
  - Per unit of consumption (e.g. kWh)
- Fixed charges:
  - Customer related costs (cost for meters, meter reading, billing, etc.).
  - Per billing period (e.g. once a month)

Typical composition of residential bills

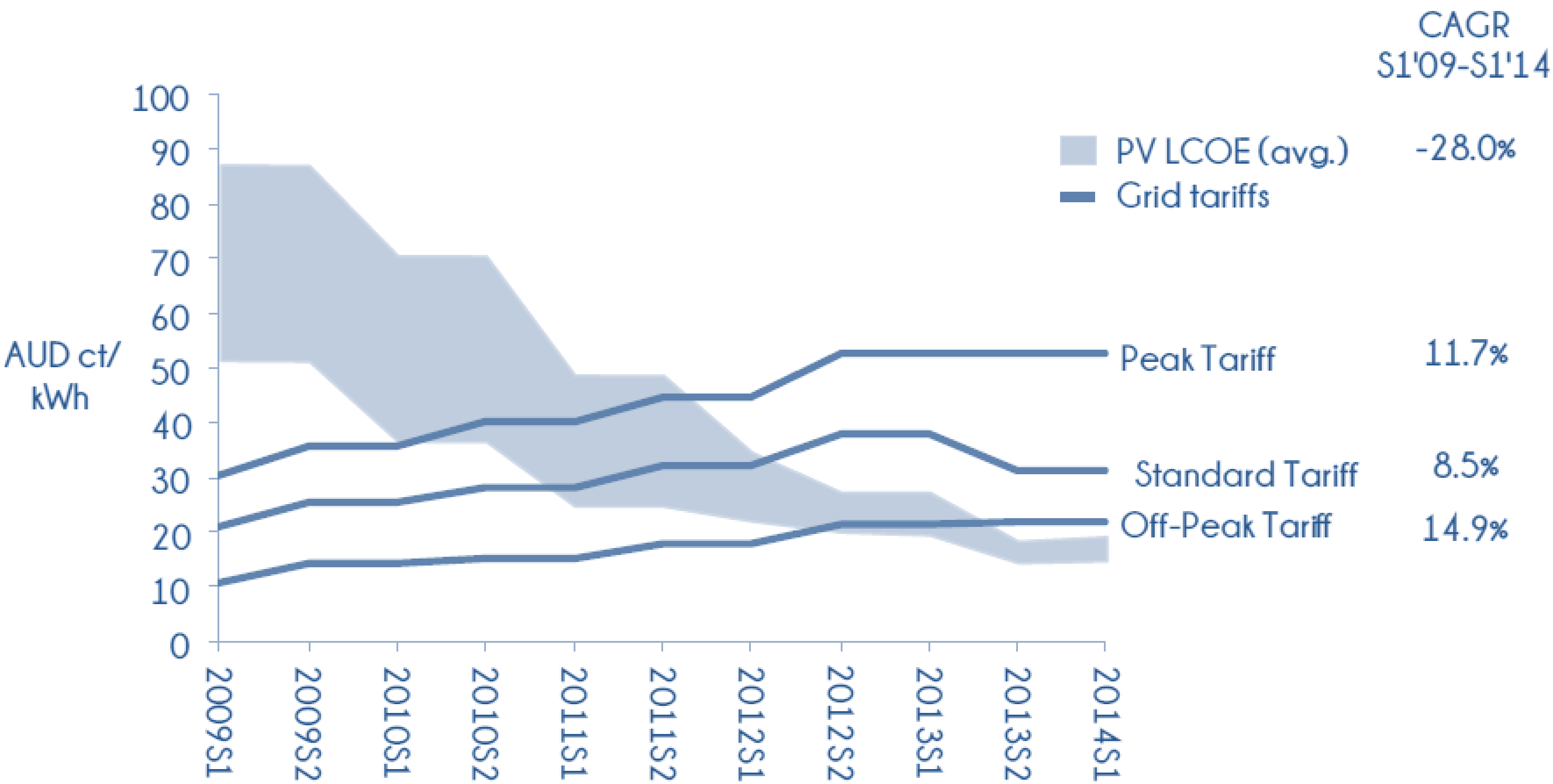


Fixed Charges: Disadvantages

- **Fixed charges** delay grid parity.

- **Disincentive for new technologies**: Unfairly penalize solar system owners (why not introduce a fixed charge for insulating your home, or efficient AC units?)

Grid Parity for Time-of-Use Rates



Source: Creara 2015

"Grid Parity" in the Case of Subsidized Retail Electricity Prices (Residential)

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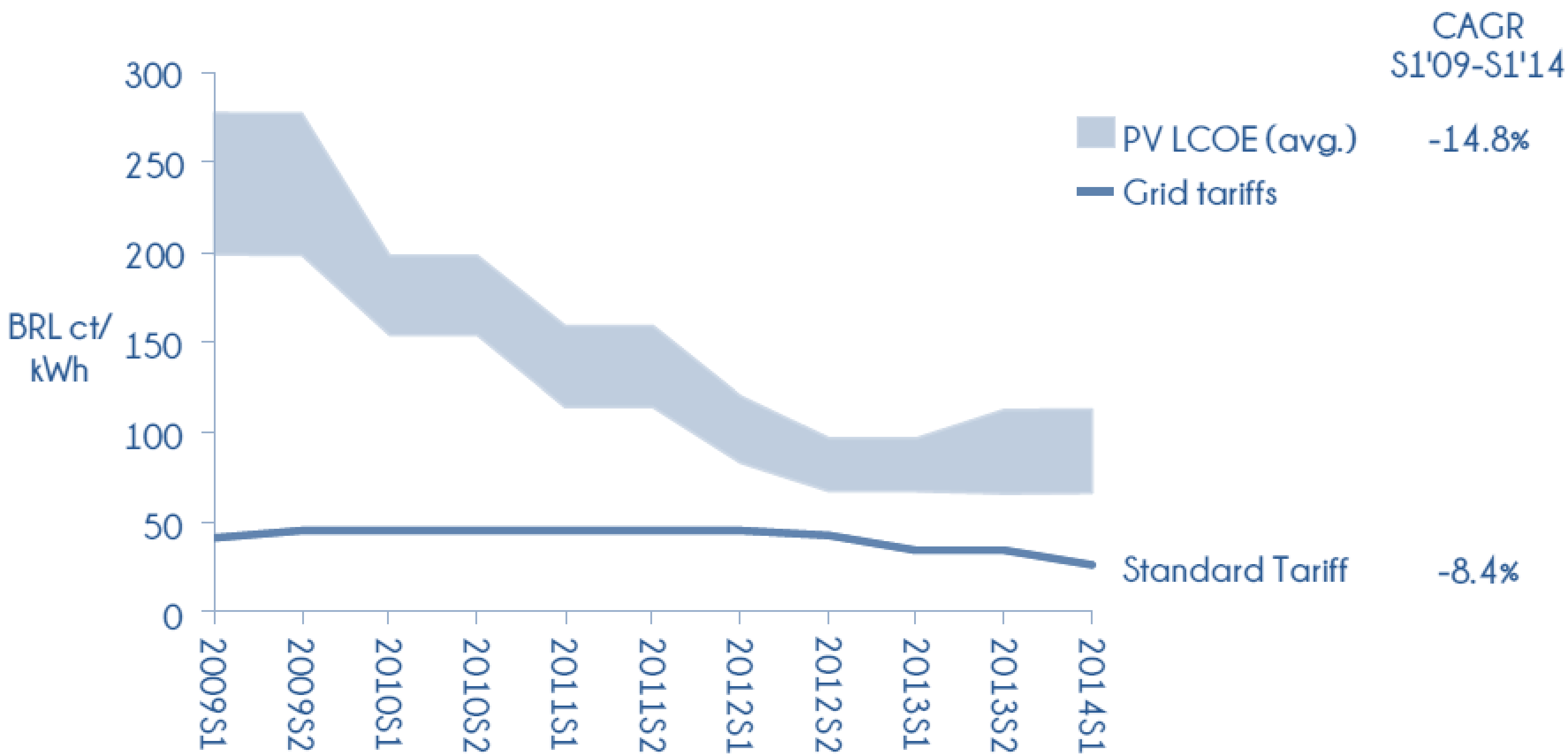


Source: Creara 2015

Session 8: Rate Design

Check out
Session 8
(Rate Design)

Barriers to roof-top PV uptake based on Grid Parity and Self-Consumption

Limitations for Self-Consumption

- The available roof space can be a barrier to self-consumption

Barriers to Self-Consumption: Roof-space

- GIS based analysis of available (stable) roof-space is required
- Roofs of low-income households are frequently not sufficiently stable (developing countries)
- Landlord-tenant problem: Who is the owner of the roof-space (share of rental property)?
- Incentives to use the entire roof-space for solar PV or maximization of self-consumption ratio?

Limitations for Self-Consumption

- Access to and cost of capital can be a barrier to self-consumption

Barriers to Self-Consumption: Access to Capital

- Access to capital – especially for lower income households
- Disposable income (in developing countries)
- Economics (compared to other investment opportunities)

Barriers to Self-Consumption: Risk and Access to Capital

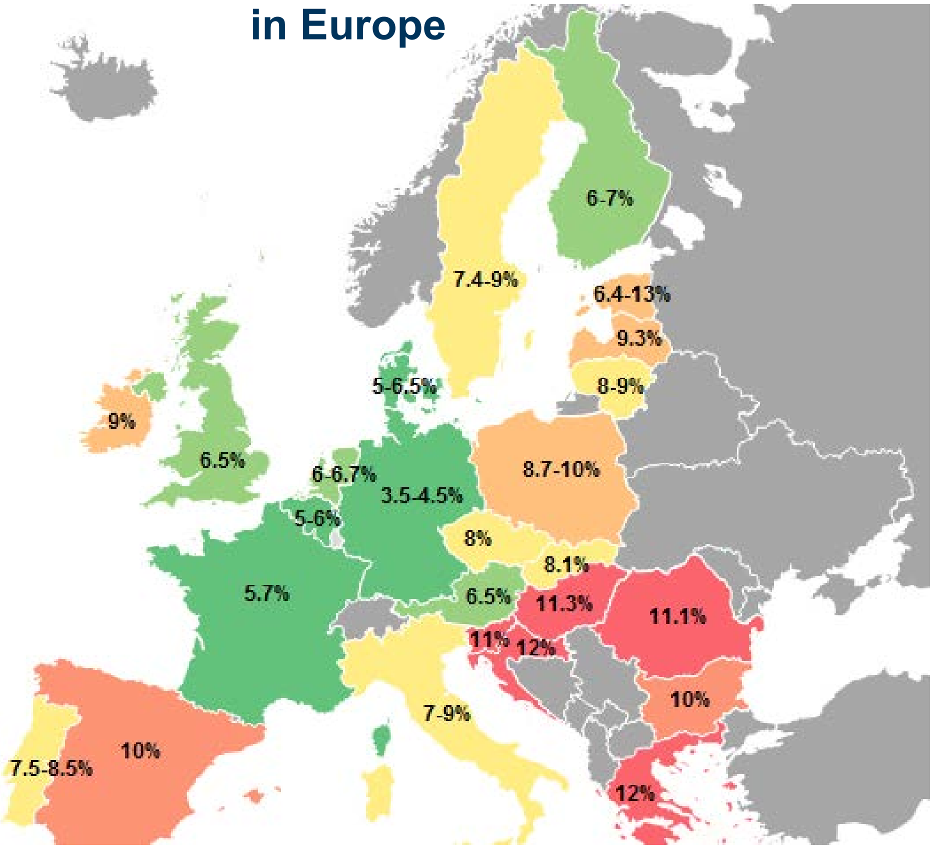
- Very high risk for investment based on "self-consumption" alone:
  - Changes in own electricity demand (especially for commercial prosumers)
  - Changes to rate design (e.g. introduction of fixed charges)
  - Introduction of other levies on solar customers (e.g. "solar tax")
  - Changes in Net Metering or other self-consumption regulations
  - Changes in tax laws
  - Changes in electricity market design/regulation

Barriers to Self-Consumption

- Lower risk jurisdictions with more stable policies tend to reach grid parity faster.

- Lower regulatory and market risk reduces the cost of capital

Cost of Capital Across Europe (WACC) for onshore wind energy in Europe



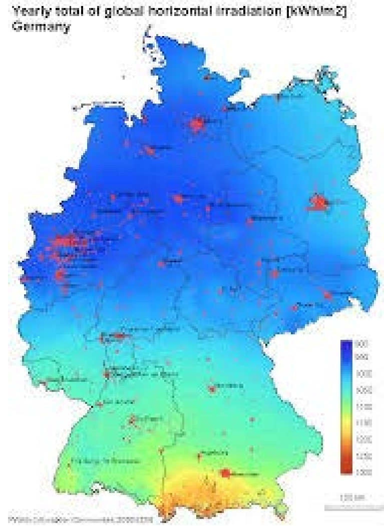
Source: Diacore Project, 2016

Cost of Capital Frequently more Important than Resource Quality

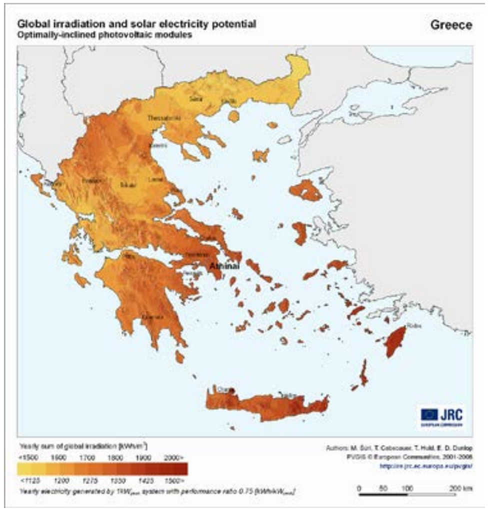
- The differences between financing costs in different countries (e.g. Germany vs. the Middle East) have a greater impact on LCOE than the differences in resource quality

- Lower FINEX (3.5– 4.5%) is why Germany can produce solar power for less than Greece (12%)

Germany



Greece



https://www.sciencedirect.com/science/article/pii/S0960148114006806#!

Excursion:

Grid Parity, Self-Consumption and the so-called “Death Spiral” (don’t use this terminology)

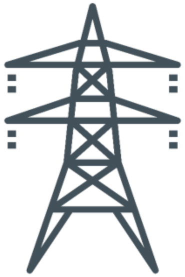
Simplistic Claims related to Grid Parity

„Grid Parity is the final nail in the coffin of centralized electricity market and utility businesses (and the victory of destributed generation)"

„After reaching Grid Parity, everyone will cost produce electricity on ist own and no longer buy from the utility".

Excursion: The so-called Death Spiral

Network Costs



Non-prosumer

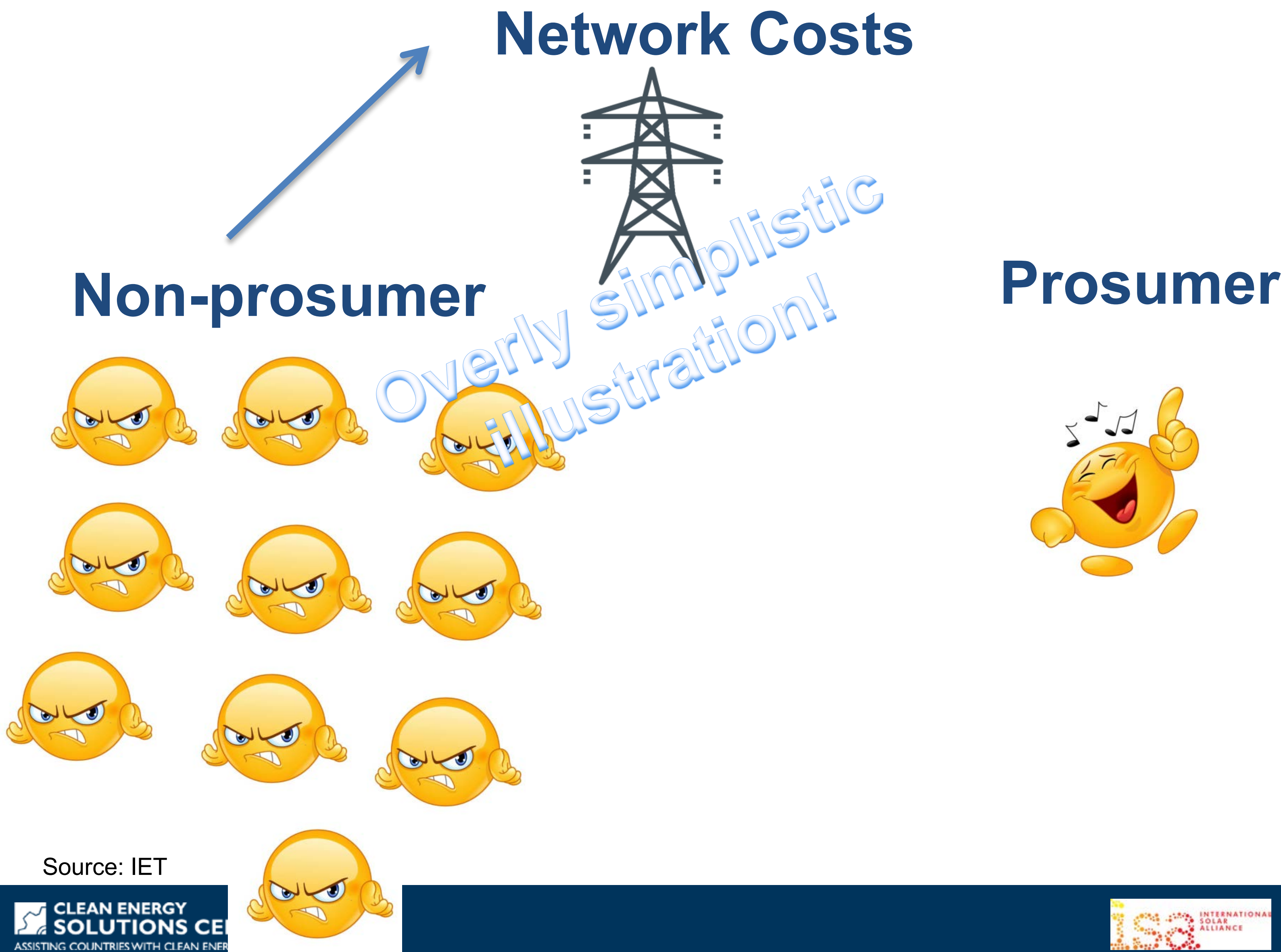
Prosumer

Source: IET

Excursion: The so-called Death Spiral

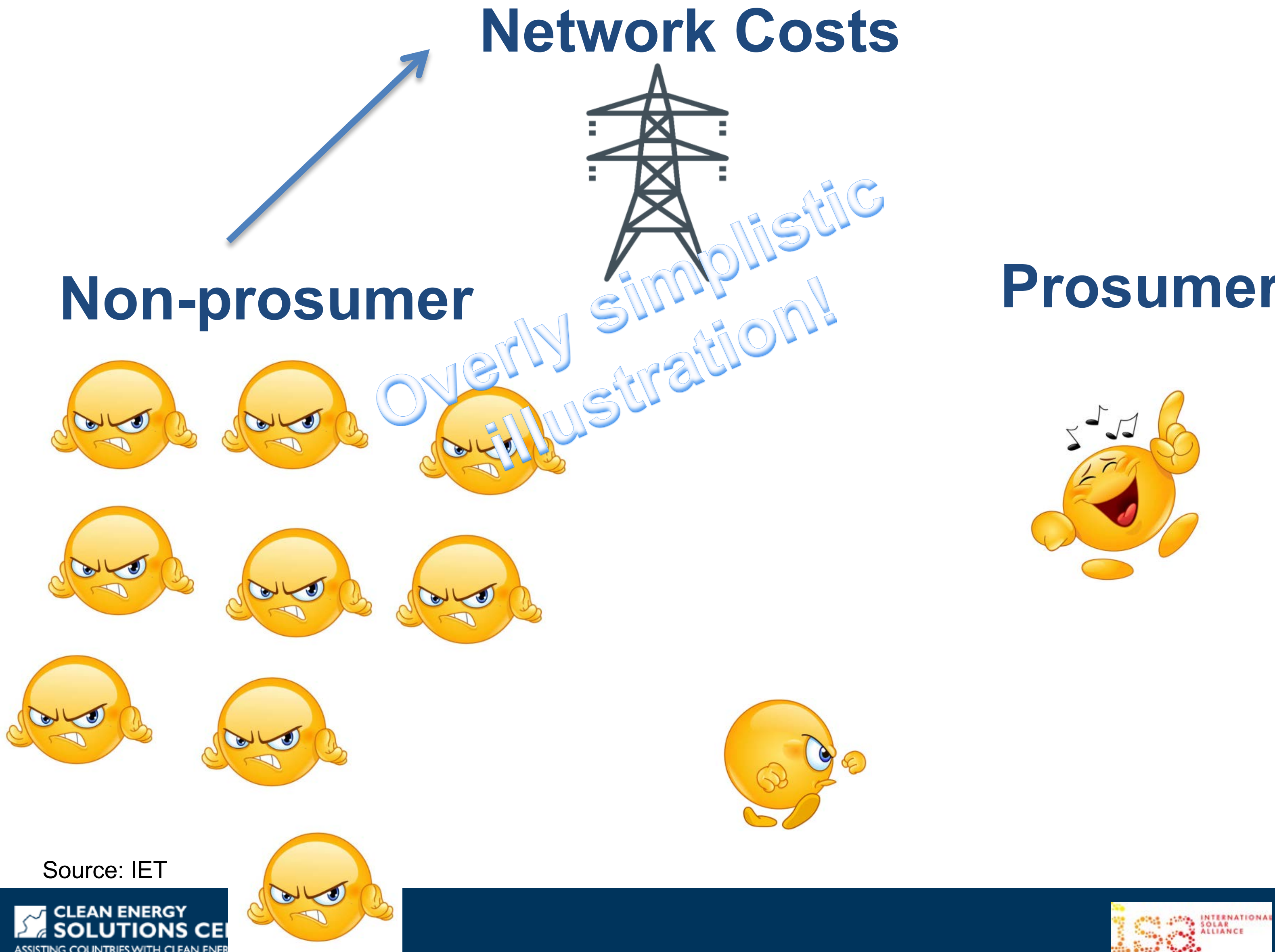
Source: IET

Excursion: The so-called Death Spiral



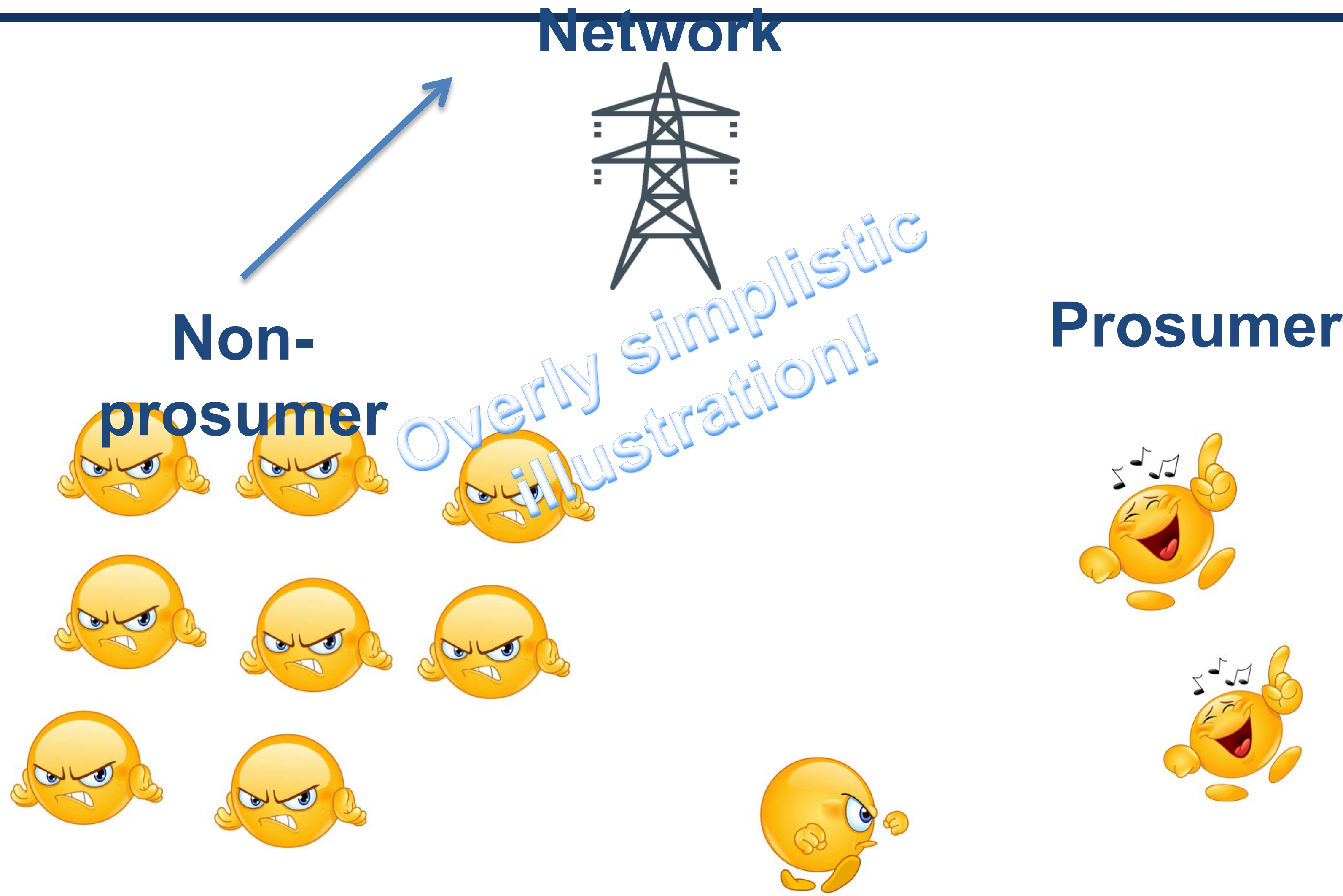
Source: IET

Excursion: The so-called Death Spiral



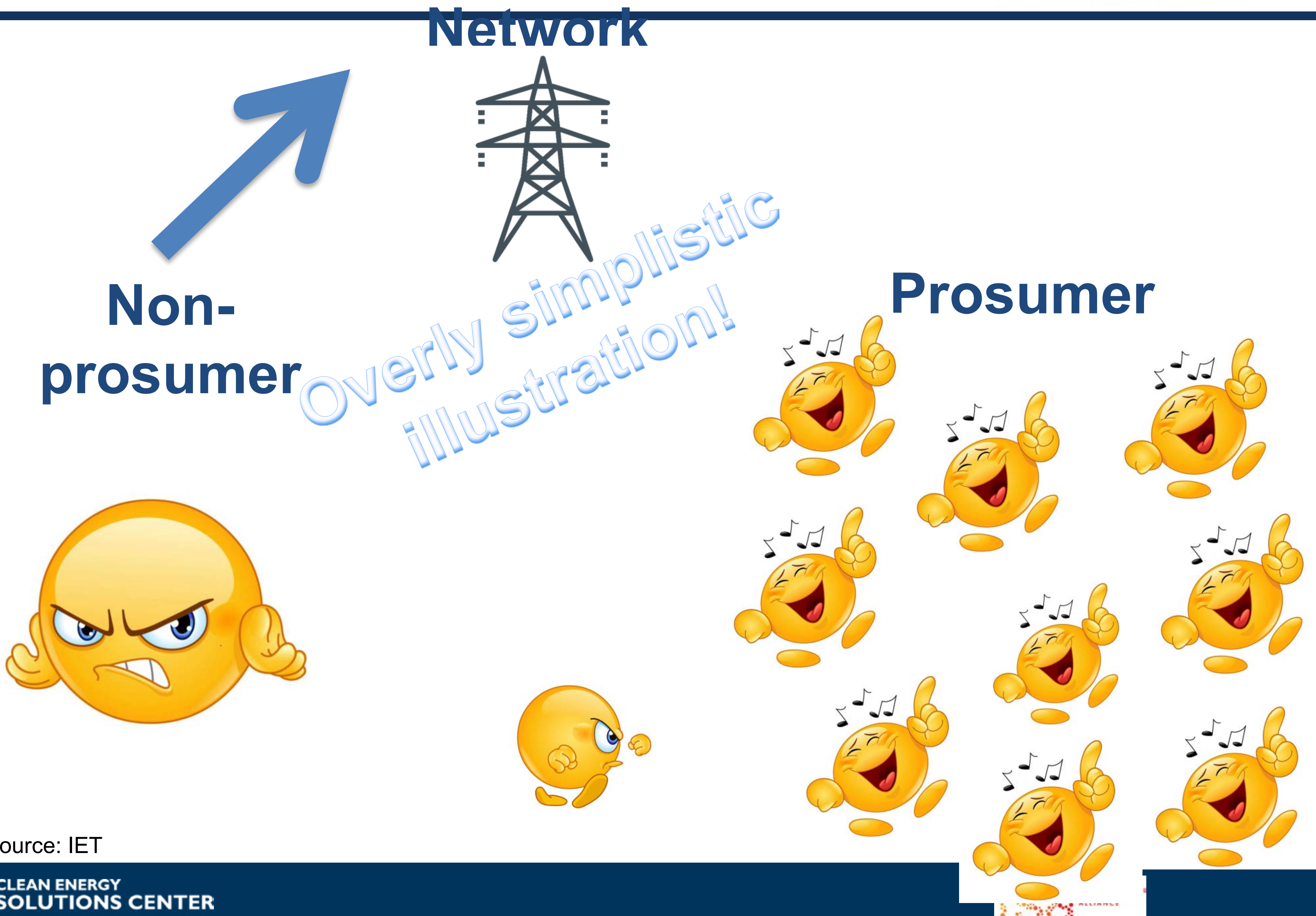
Source: IET

Volumetric Rates: Network Costs and Prosumers



Source: IET

Volumetric Rates: Network Costs and Prosumers



Source: IET

Excursion: The so-called Death Spiral

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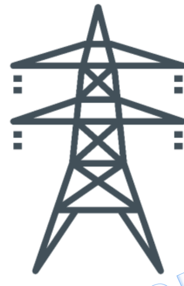
Network



Non-prosumer

Overly simplistic illustration!

Source: IET

The Death Spiral: Case Study Germany

- 2017: 1,688,000 PV systems!
- More than 1,5 million roof-mounted systems!!
- Retail electricity price is three times higher than the LCOE of roof-top solar!!!
- Attractive IRR and very short payback periods!
- Roof top potential: 182- 261 GW!!!

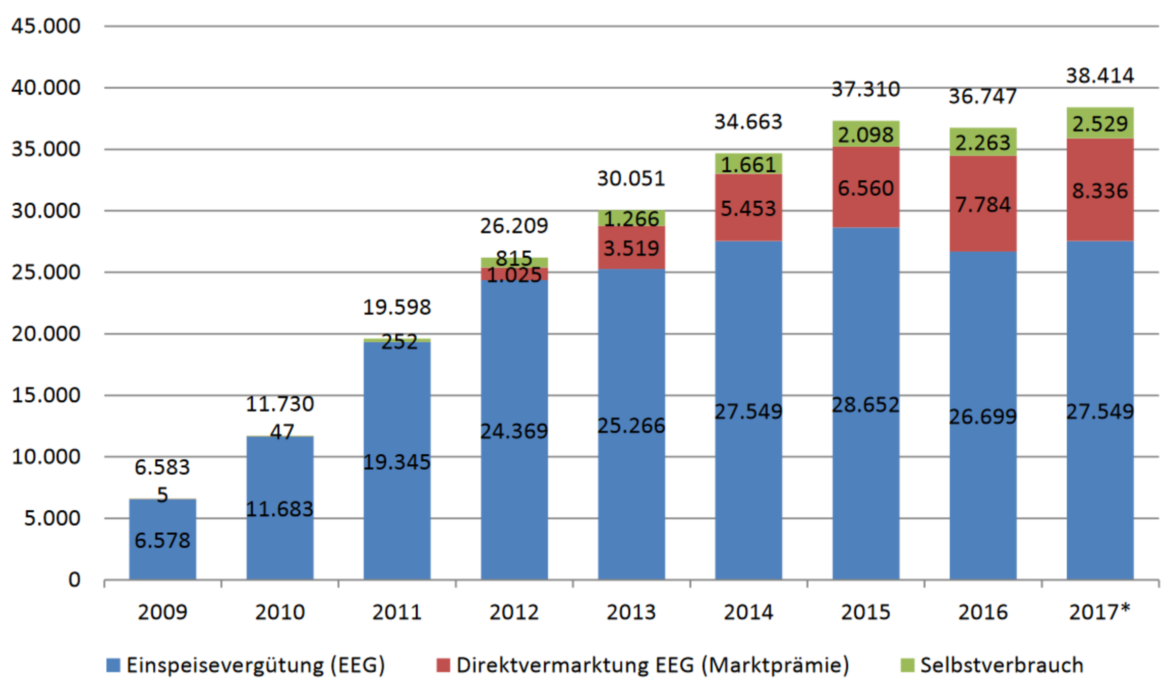
- **The perfect "death spiral"??????**

The Death Spiral: Case Study Germany

- 1,688,000 PV systems account for only 8% of electricity demand !
- 2.5 TWh self-consumed PV (6.2% of total PV generation)

- 0.5% of total electricity demand is PV self-consumption!
- PV self-consumption will increase in the future
- But certainly below 10%
- This is a small total market share !

Self-consumption (green) as a share of total PV electricity



Source: https://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/bmwi_de/bericht-eeg-4-solar.pdf?__blob=publicationFile&v=4

Summary

Summary

- Grid parity is an important milestone for distributed generation – but not the last nail in the coffin of utility businesses
- Grid parity is relatively complex:
  - Other cost competitiveness benchmarks
  - Customer classes: Not all customers will move towards self-consumption simultaneously
  - Rate design: Fixed charges and other modifications can delay grid parity
- There are additional risk for solar PV self-consumption which effectively slow down market growth

Further Reading/List of References

Further Reading on Grid Parity

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Further Reading on Net Metering

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Thank you for your time!

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Ideas for change

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6. Knowledge Checkpoint: Multiple Choice Questions