Joint Research Centre

the European Commission's in-house science service

Serving society
Stimulating innovation
Supporting legislation

Solar Photovoltaics – A driver for decarbonisation and where it is manufactured

Arnulf Jäger-Waldau

PV manufacturing in Europe Conference

Brussels 19 May 2017

European Commission

JRC's Mission and Role

Vision:

"To play a central role in creating, managing and making sense of the collective scientific knowledge for better EU policy."

"As the science and knowledge service of the Commission our mission is to support EU policies with independent evidence throughout the whole policy cycle."

Serving society, stimulating innovation, supporting legislation

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The Joint Research Centre

€ 386 million Budget annually, plus € 62 million earned income

Independent of private, commercial or national interests

30% of activities in policy preparation, 70% in implementation

125 instances of support to the EU policy-maker annually

More than 100 economic, bio-physical and nuclear models

Focus on the priorities of the Commission (80% of activities co-designed with partner DG's)

6 locations in 5 Member States: Italy, Belgium, Germany, The Netherlands, Spain

Policy neutral: has no policy agenda of its own

42 large scale research facilities, more than 110 online databases

1500 core research staff, out of around 3000 total staff

83% Of core research staff with PhD's

Over 1,400 scientific publications per year

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- Technology Trends
- PV Manufacturing
- Capacity Expansion
- Report on Assessment of Photovoltaics Study
- Conclusions

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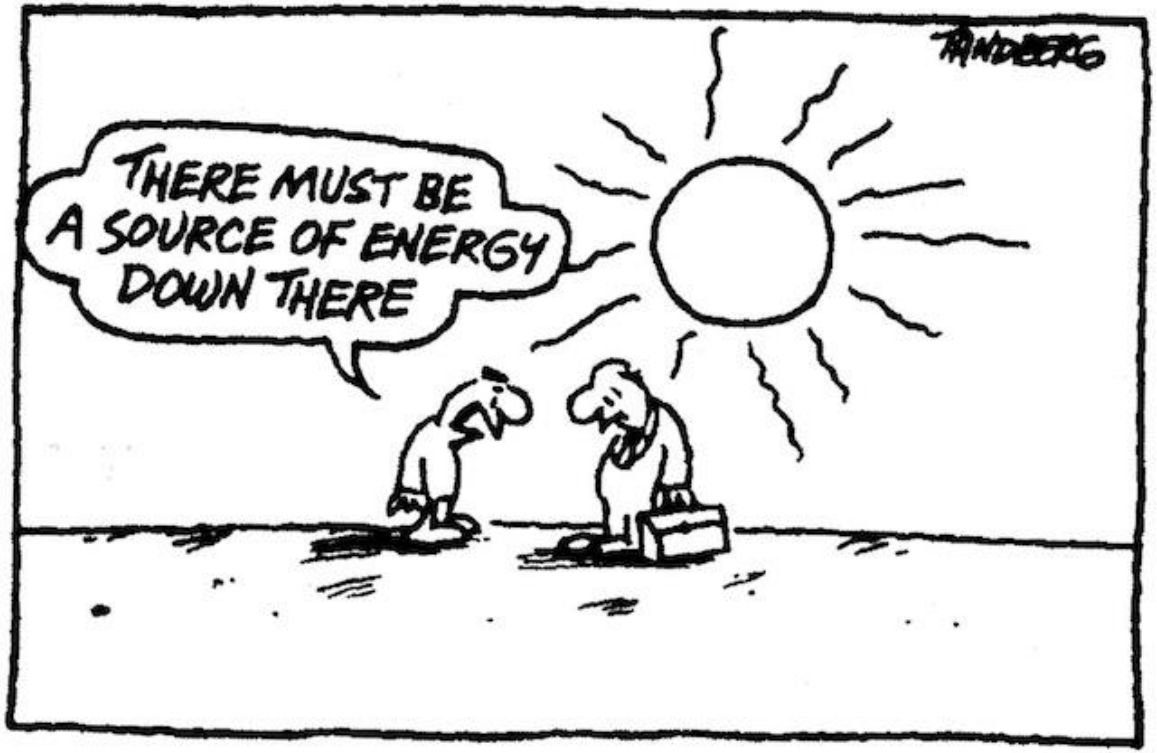
Why Decarbonisation of Electricity



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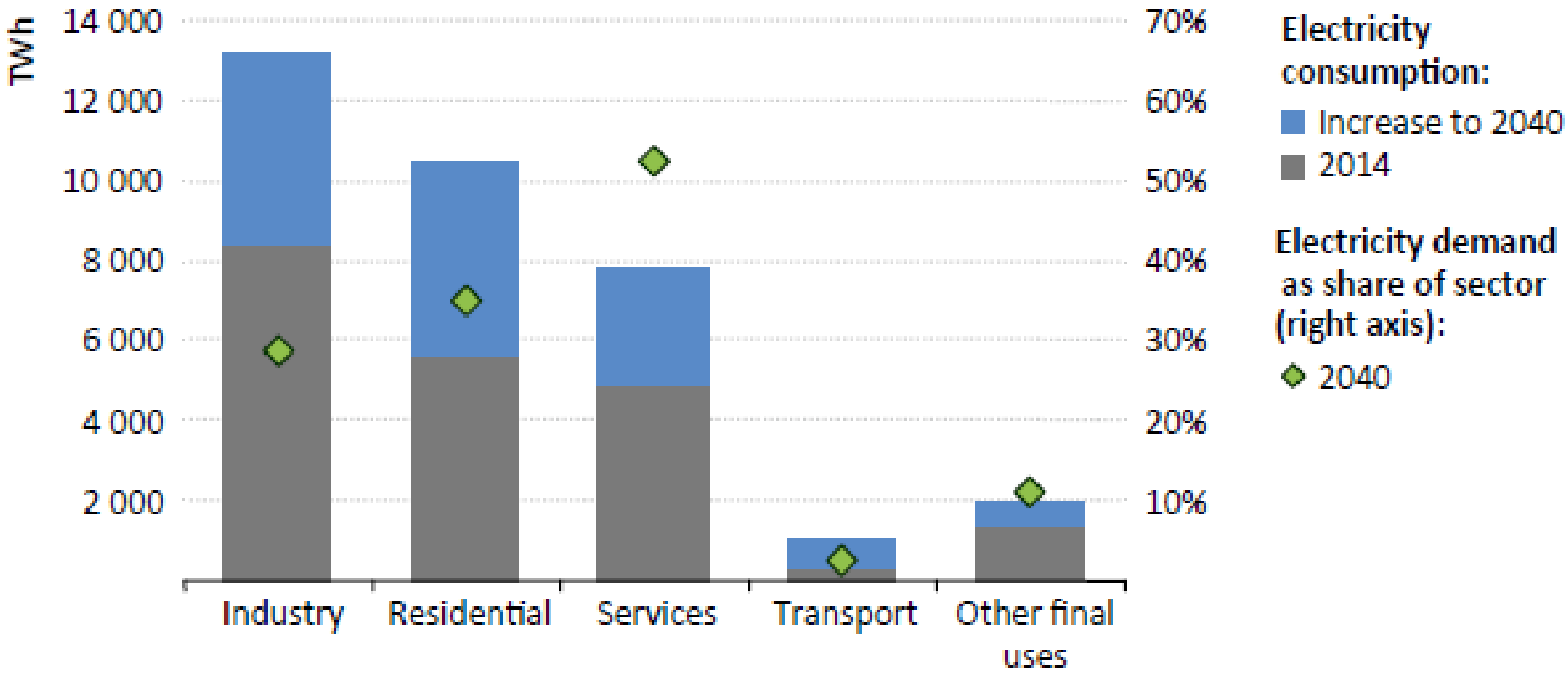
Electricity Demand Projection



2014: ~ 23,800 TWh

2040: ~ 39,000 TWh

Data source: IEA WEO 2106

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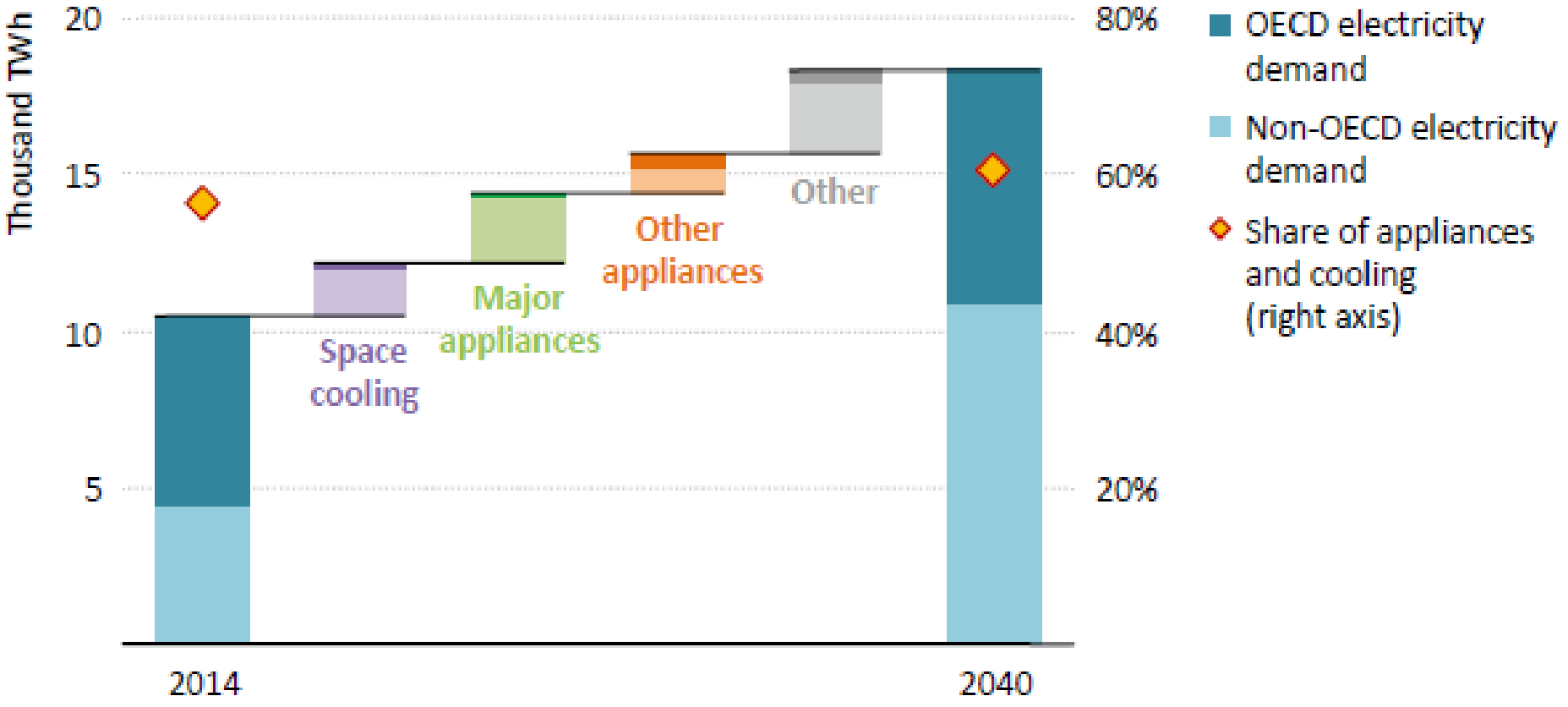
Electricity Demand in Buildings



Data source: IEA WEO 2106

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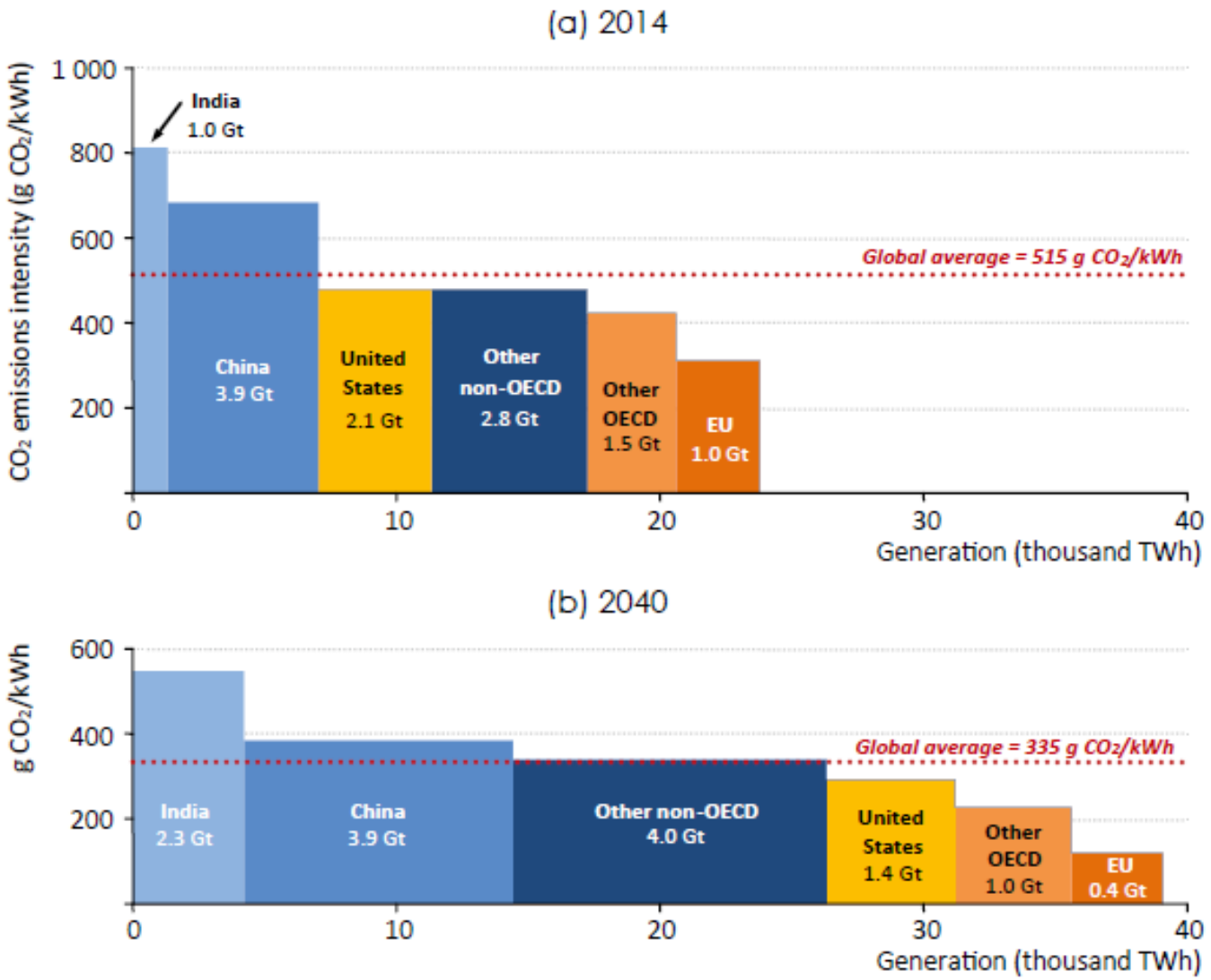
Carbon Intensity of Electricity



Data source: NPS IEA WTO 2106

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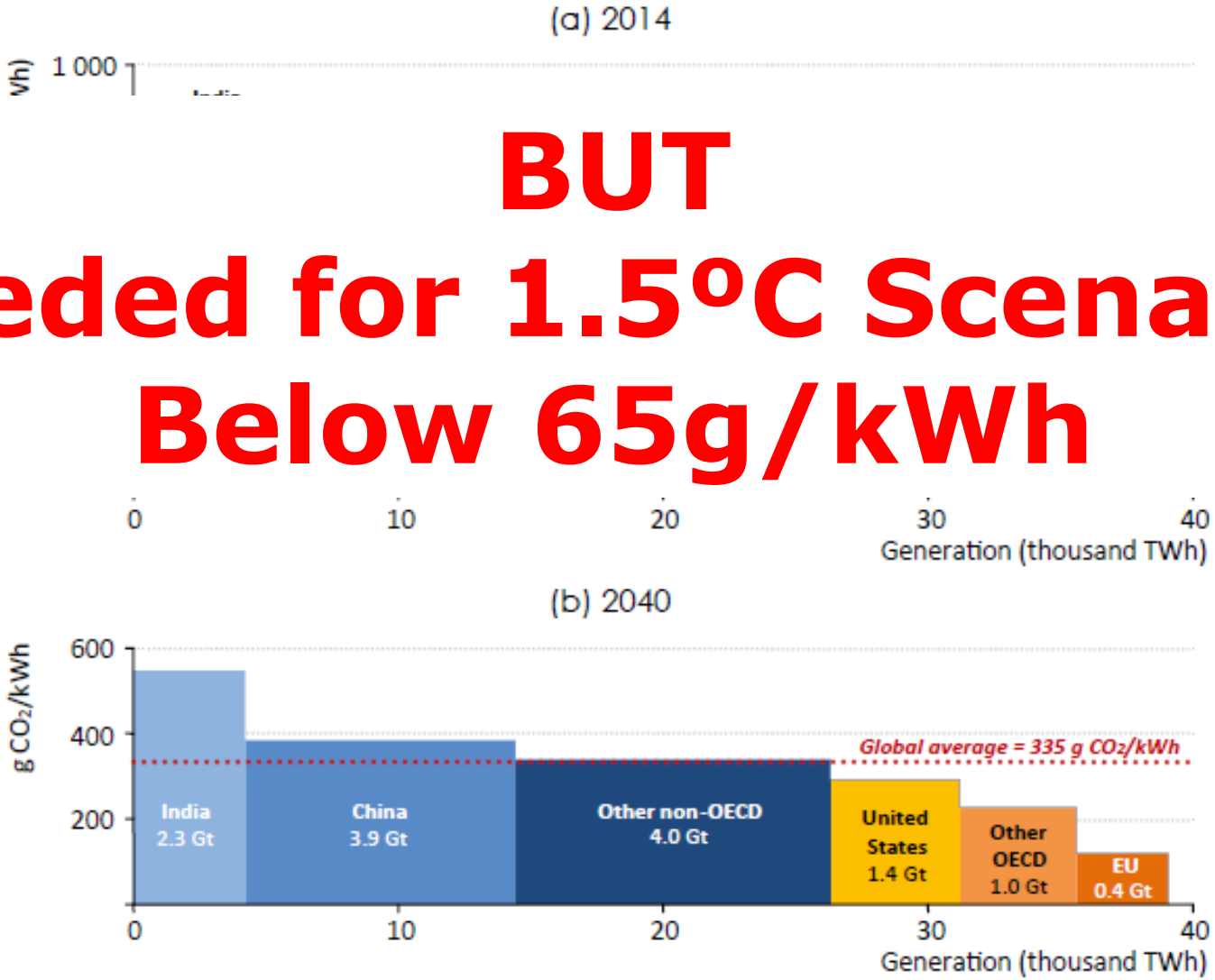
Carbon Intensity of Electricity



BUT

Needed for 1.5ºC Scenario: Below 65g/kWh

Data source: NPS IEA WTO 2106

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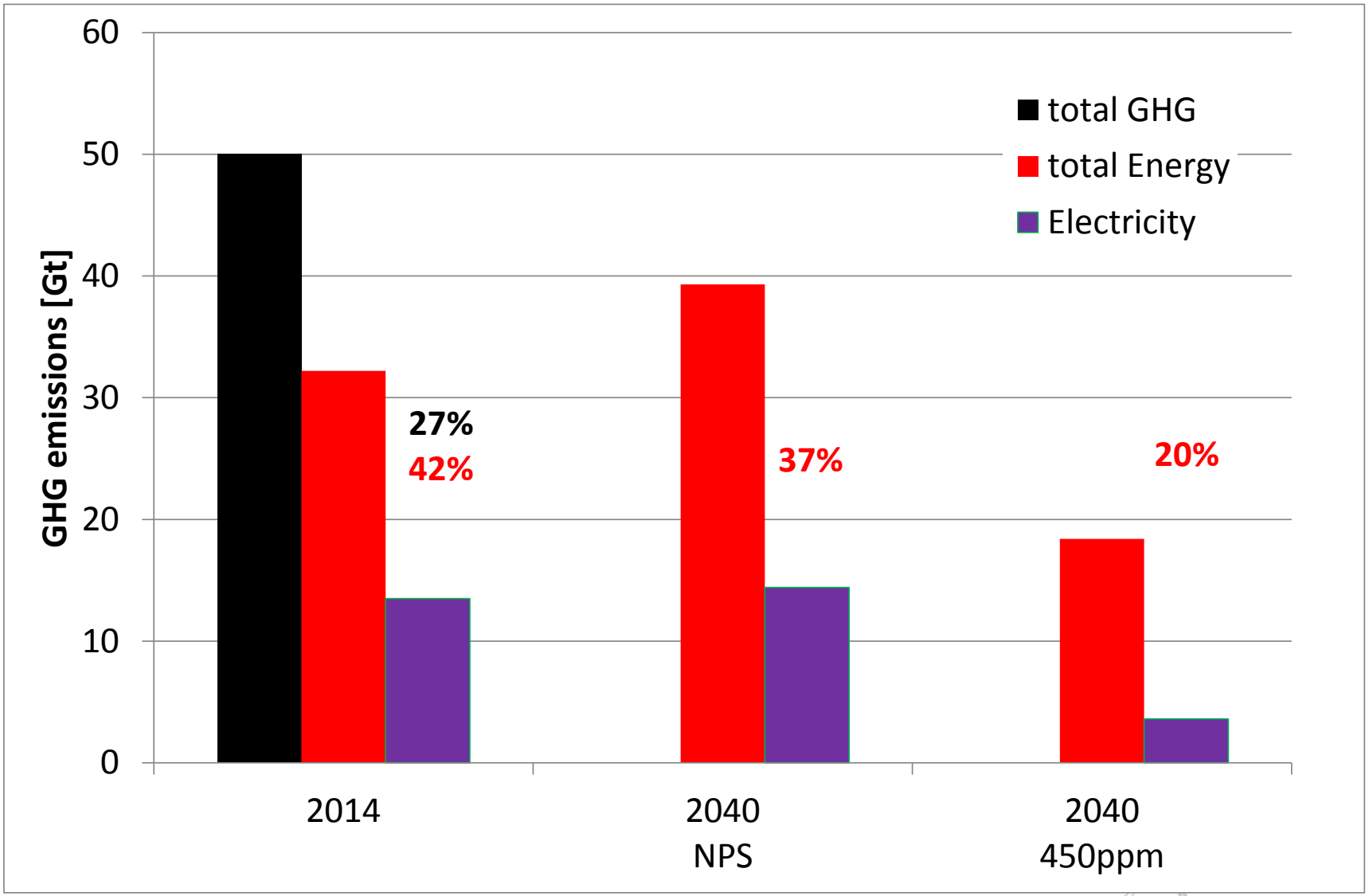
GHG emissions of Electricity



Data source: IEA WTO 2106

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Technology Trends

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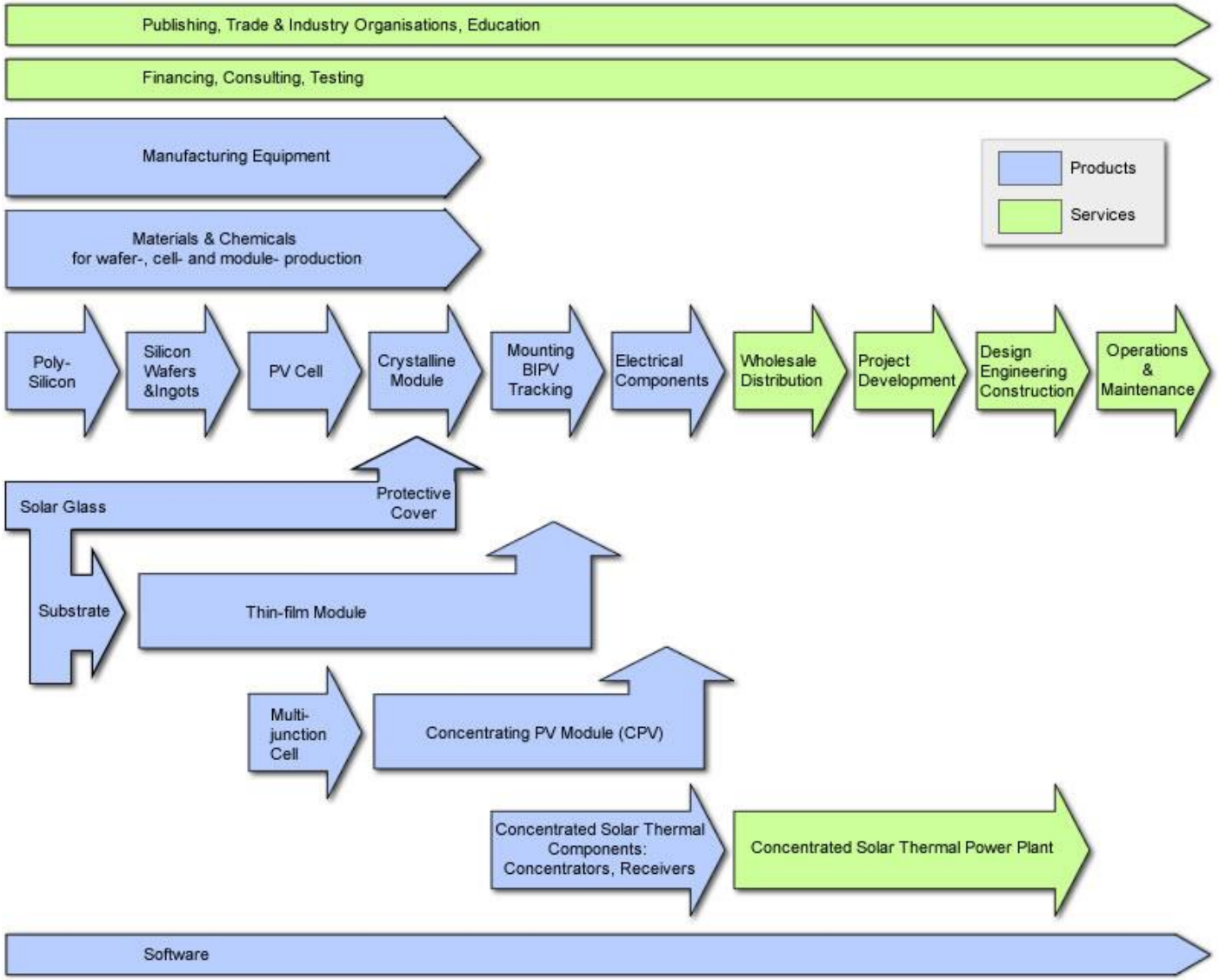
PV Value Chain



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Thin Films

Commercial CdTe modules

Q1/2012 (12.4%)
Q1/2017 (16.7%) +34.7%

Commercial CIGS modules

2010: between 7 and 11%
Q1 2017: between 12 and 15.1%

Commercial silicon tf modules

2010: between 5 and 8%
Q1 2017: between 5 and 11%

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Crystalline Silicon

Polysilicon

Siemens Process 2016: 65 –125 kWh/kg
FBR 2016: 20 – 50 kWh/kg

Power Output per Wafer

mc : 2011 (4.02W) 2016(4.78W) +18.9%
mono : 2011 (4.27W) 2016(5.01W) +17.3%

Polysilicon consumption of wafers

mc : 2011 (5.92g) 2016 (4.70g) – 20.6%
mono : 2011 (5.71g) 2016 (4.30g) – 24.7 %

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Crystalline Silicon

Average Cell Efficiency

mc	: 2012 (17.0%)	2016(18.9%)	+11.2%
mono	: 2012 (18.6%)	2016(20.9%)	+12.4%

Average Module Efficiency

mc	: 2012 (15.1%)	2016(17.5%)	+15.9 %
mono	: 2012 (15.6%)	2016(18.3%)	+17.3%

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Crystalline Silicon

New Production Technologies

- Passivated Emitter Rear Cells (PERC)
- 4 and 5 busbar solar cells (4BB, 5BB)
- Heterojunction Solar Cells
- Bifacial Solar Cells

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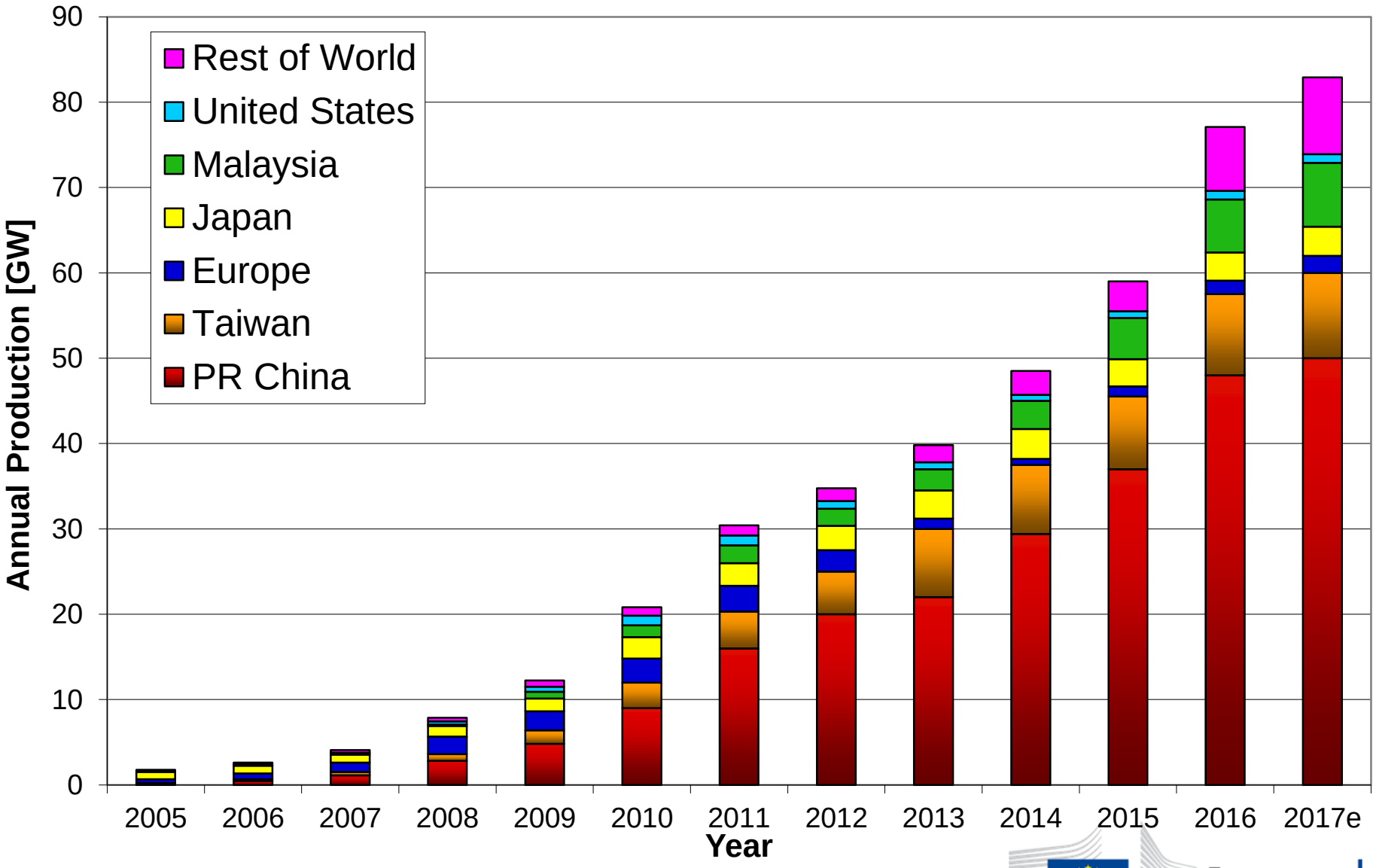
Annual PV Production



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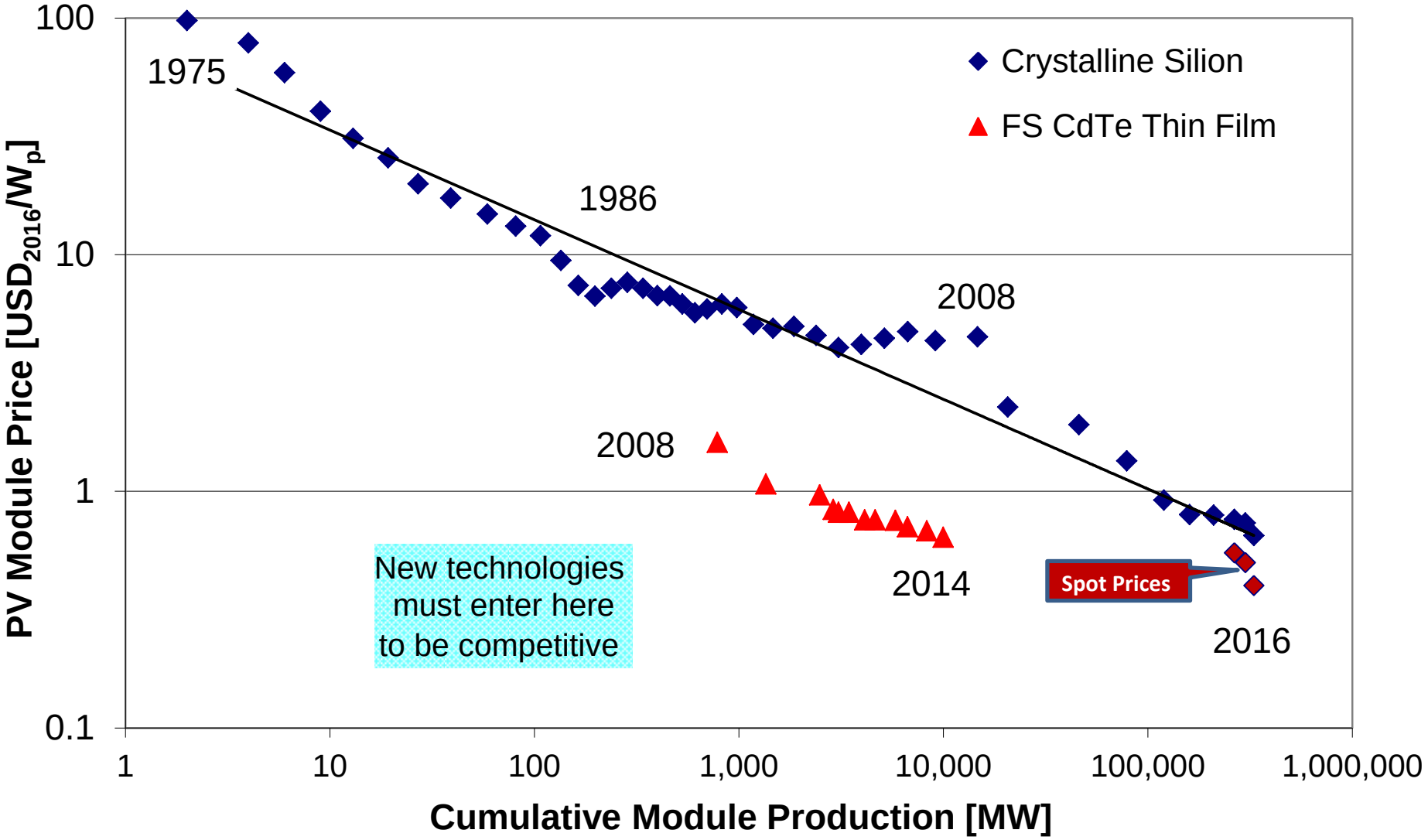
Module Price Experience Curve



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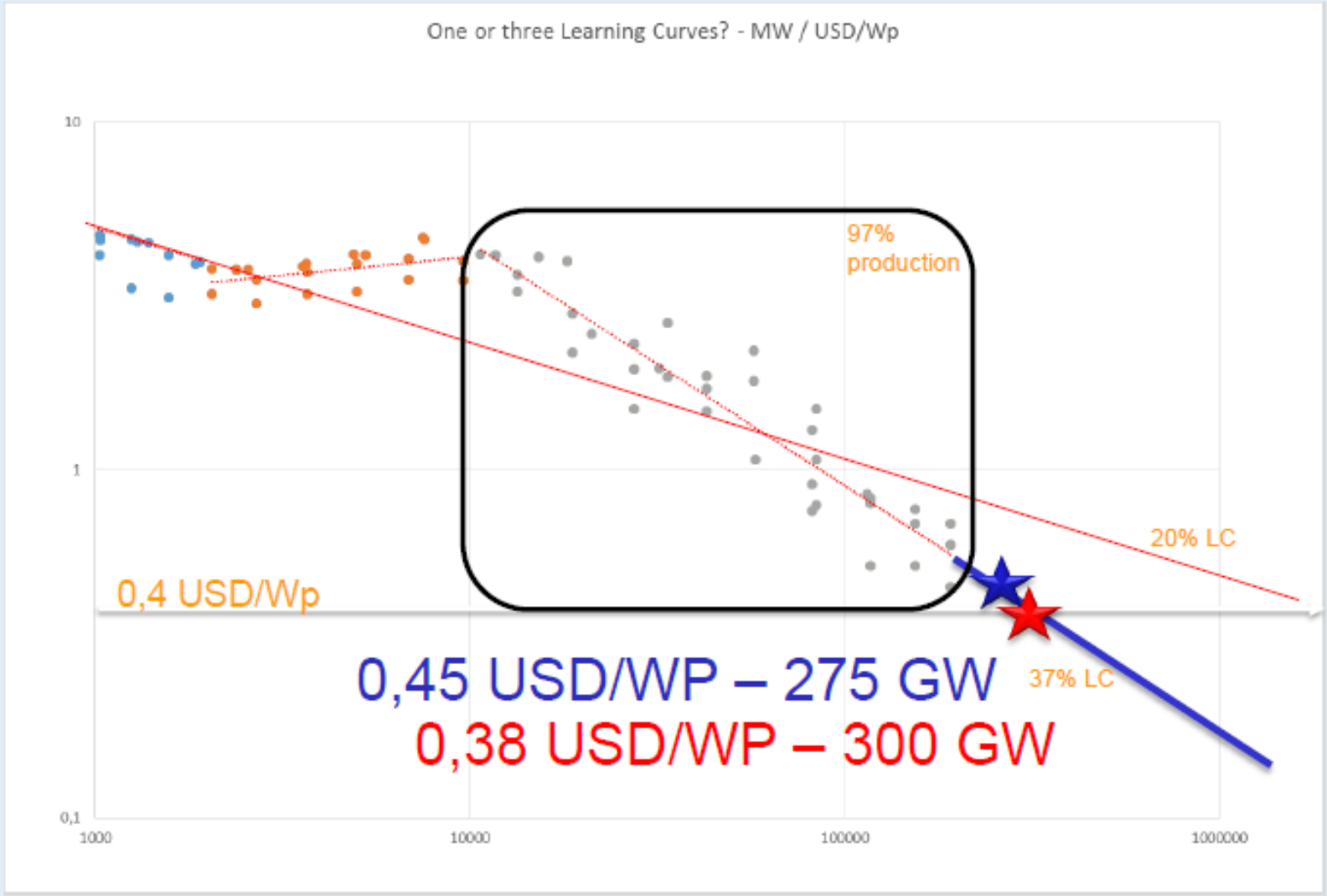
Module Price Experience Curve



Source: Becquerel Institute 2016

Solar Cell and Thin Film manufacturing in EU and Turkey

Name of Company	Country of Production	Cell Capacity [MW]	Module Capacity [MW]	Ownership
Solarworld	DE, USA	1070 (320)	950 (550)	29% Quatar Solar 20.85% Dr. Asbeck 50.15% free float
China Sunergy	CN, TR	800 (300)	900 (300)	OTC traded n/a
Aleo Solar	DE	200	200	Sino-American Silicon Products (TW)
AVANCIS (tf)	DE	120	120	China National Building Materials Group Corporation (CN)
Solland	NL	135	135	Trina Solar (CN)
3SUN	IT (tf & HJ)	160 (80)	160 (80)	ENEL Green Power (IT)
Solibro	DE	120	120	Hanergy (CN)
Calyxo (tf)	DE	85	85	Solar Fields (USA)
Photowatt	FR	75	75	EDF Group (FR)
Baltic Solar Energy	LT	70	70	private
Solsonica	IT	40	144	GALA Group (PTC with 14.46 free float)
Solarion (tf)	DE	20	20	OC3 AG, a subsidiary of Turkish NUH Group (TR)
Solaria Energia y Medio Ambiente SL	ES	? (250)	? (250)	PTC n/a

CAPEX Development
Cell & Module Manufacturing

Year	Capacity [MW]	Country	CAPEX [mil. USD]	CAPEX/W [USD]
2011	1 000	USA	680	0.68
	1 000	China	510	0.51
2014	1 000	USA	430	0.43
2015	1 000	China	190	0.19
2016	1 000	China	60 hardware only	0.06
2017	600	China	97 N-HJ (hardware + tf infrastructure)	0.162

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Capacity Expansion

Technology
(in order of announced MWs)

- **PERC**
- **"standard c-Si technology"**
- **CdTe**
- **CIGS**
- **HJ**
- **Bifacial**

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Capacity Expansion

Where are the new plants build (top 5 in order of announced MWs)

- **India**
- **South Korea**
- **China**
- **Thailand**
- **Malaysia**

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Assessment of Photovoltaics (PV) Study 2015/RTD/SC/PP-03601-2015

- **Assessment of the current situation of the PV sector in Europe and worldwide**
- **Identification of options for a strategy to rebuild the EU PV manufacturing sector**

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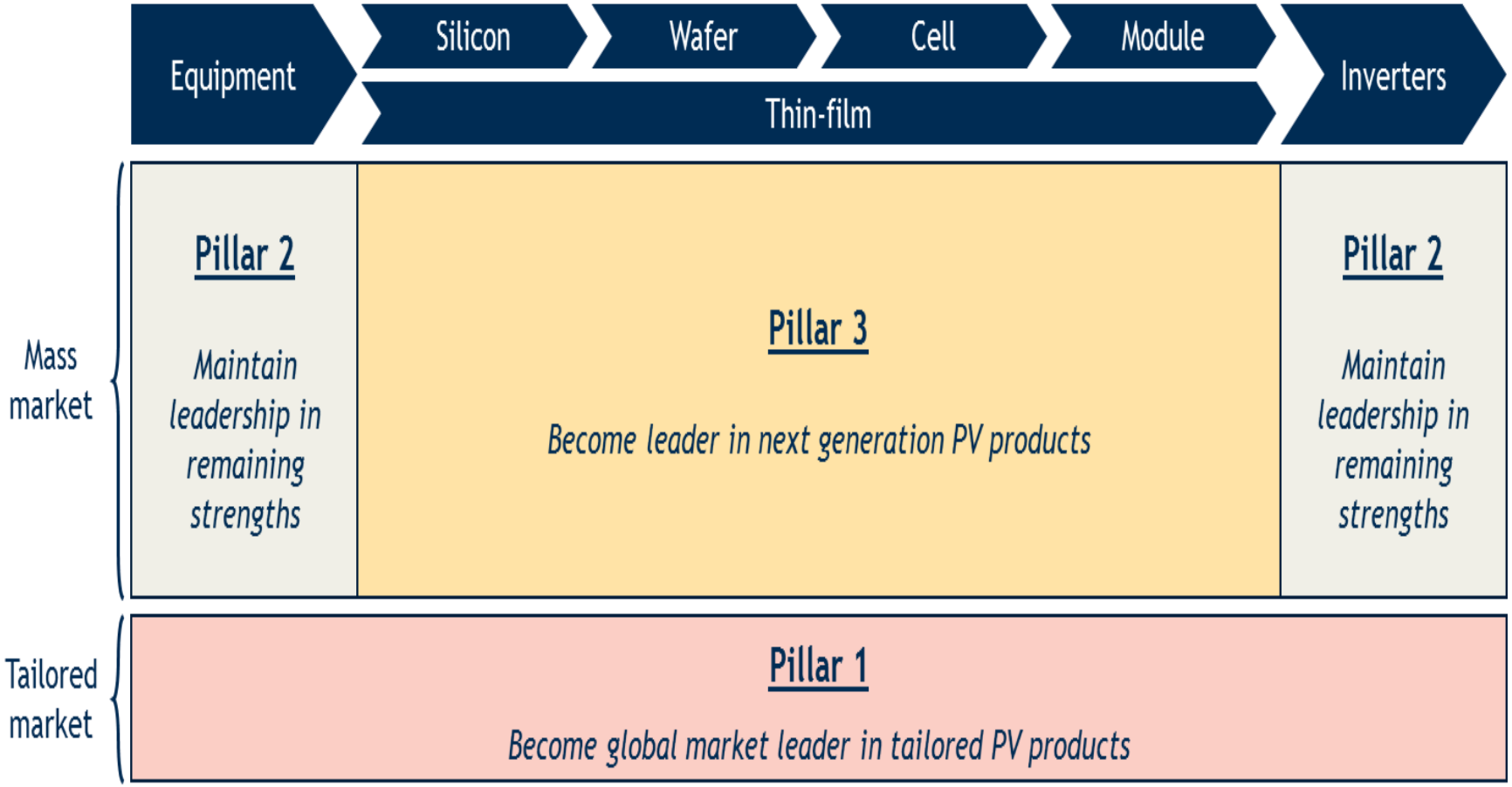
Possible Strategies



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Possible Implementation Measures

Type	Measure	Pillars of the strategy		
		1. Tailored products	2. Remaining strengths	3. Next generation technologies
Demand	Building obligations	✓	S	
	Public procurement	✓	S	
	Standardisation of BIPV products	✓	S	
	Panel and inverter labelling		S	✓
Supply	Access to capital for SMEs	✓	S	✓
	Cluster formation	S	✓	S
RD&I	Public research funding	✓	✓	✓
	Knowledge protection and transfer	S	S	✓
Trade	International cooperation	S	✓	S

Conclusions

- Decarbonisation of Energy sector mandatory for fullfilling the Paris Agreement
- Solar is one of the pillars to achieve this decarbonisation
- PV technology has made significant progress. In all technologies the progress has been greater than predicted in various roadmaps.
- Further material reduction per Wp ongoing
- PV cell and thin film capacity still larger than demand
- Shift of PV production


Thank you for your attention!