The Status of Photovoltaics: reviewing the technology and markets

Professor Nicola Pearsall
Emerita Professor in Renewable Energy
Northumbria University

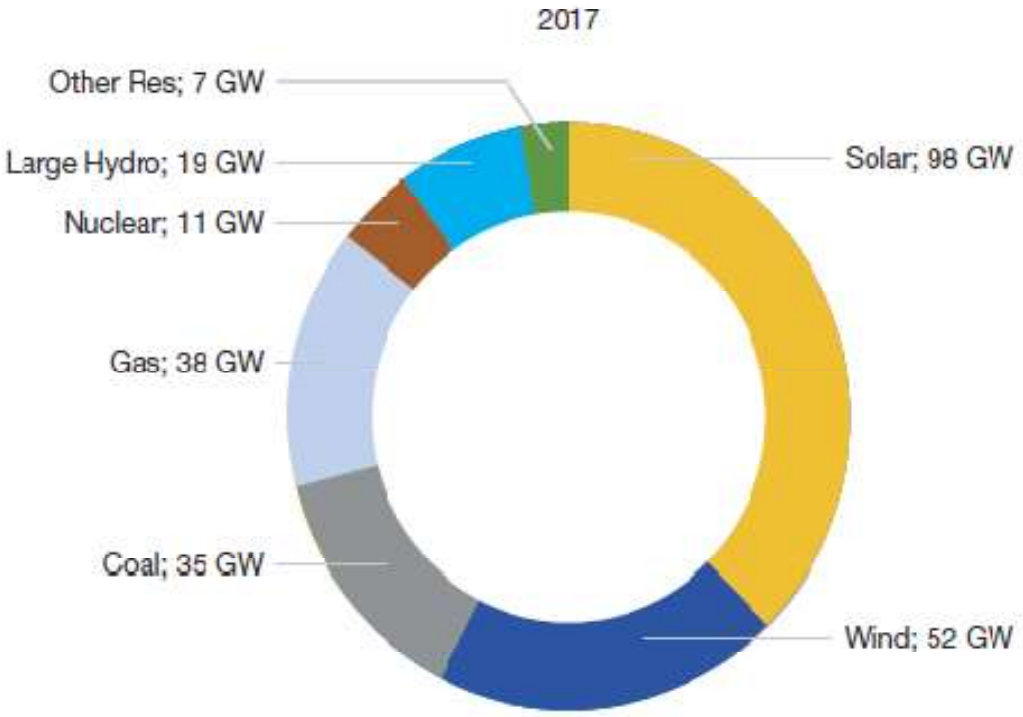
Introduction

- Photovoltaic system installations have grown rapidly over the last decade, with a total installed capacity of almost 500 GW by the end of 2018
- Applications range from small systems (a few hundred W) for low power applications, through residential systems of a few kW, to large utility systems (MW to GW level)
- There is also continuing technical development alongside reducing costs as the market increases
- However, there are still some challenges relating to integration into the electrical network, optimisation of system performance and financial support schemes
- We will discuss the current PV market and technologies

PV Markets

- Most of the market data being presented goes up to the end of 2017, because it takes some time to collate the figures – the two main sources used here are:
  - *Solar Power Europe – Global Market Outlook for Solar Power / 2018-2022*
  - *IEA Photovoltaic Power Systems Programme – Trends 2018 in Photovoltaic Applications*
- Just under 100 GW of PV systems were installed globally in 2017, leading to a cumulative installation of 403 GW
- The 2017 installed capacity represents a 30% growth on 2016 numbers
- More new solar capacity was installed in 2017 than for any other electricity generation technology

FIGURE 1 NET POWER GENERATING CAPACITY ADDED IN 2017 BY MAIN TECHNOLOGY



Source: Frankfurt School-UNEP Centre and BNEF (2018)

FIGURE 6 EVOLUTION OF GLOBAL TOTAL SOLAR PV INSTALLED CAPACITY 2000-2017

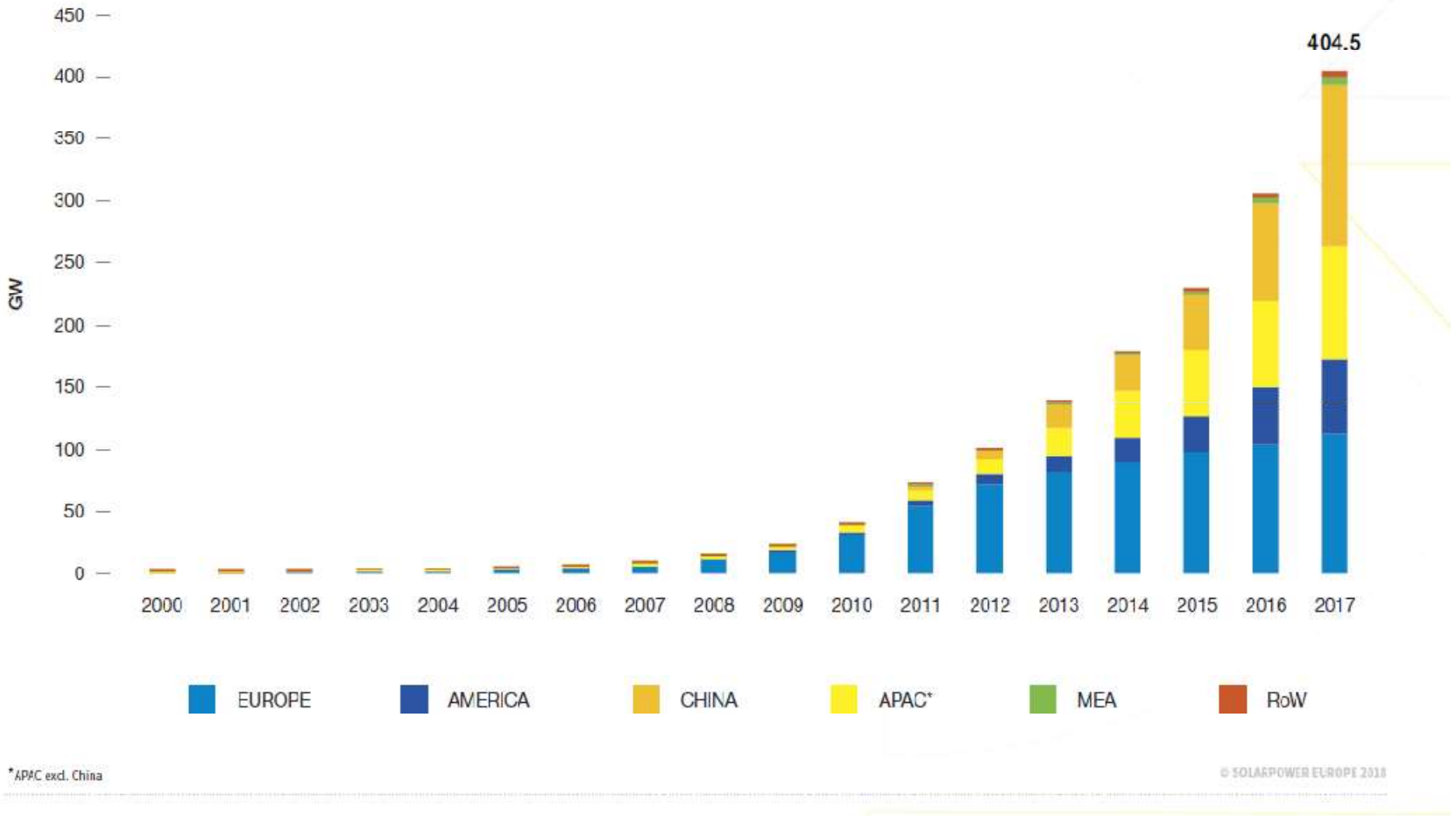
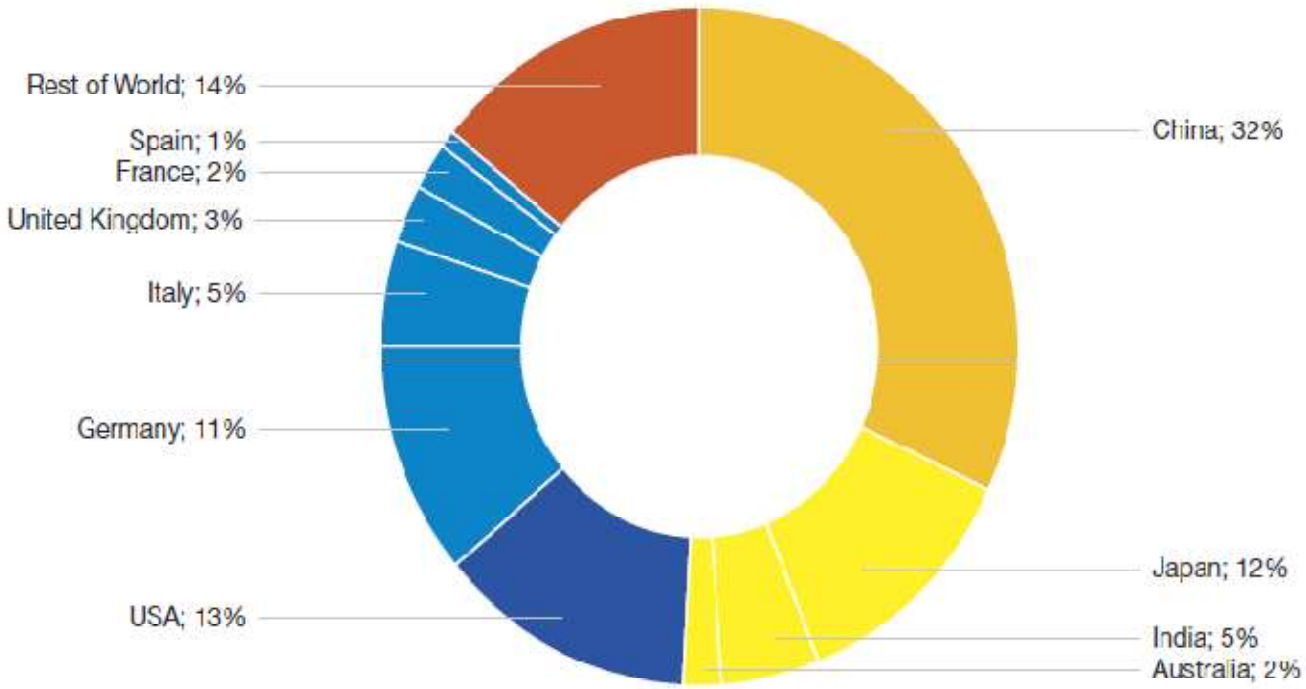


FIGURE 8 GLOBAL TOP 10 SOLAR PV MARKETS TOTAL INSTALLED SHARES BY END OF 2017



TRENDS IN PHOTOVOLTAIC APPLICATIONS // 2018

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME WWW.IEA-PVPS.ORG

TOTAL BUSINESS VALUE IN PV SECTOR IN 2017

$110 BILLION

TOP 5 PV MARKETS IN 2017

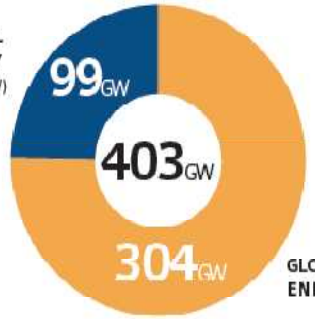
CHINA	53,1 GW
USA	10,7 GW
INDIA	9,1 GW
JAPAN	7,5 GW
TURKEY	2,6 GW

PV CONTRIBUTION TO ELECTRICITY DEMAND

2,5%

Share of PV in the global electricitiy demand in 2017

GLOBAL PV CAPACITY END OF 2017



CLIMATE CHANGE IMPACTS

247

millions of tons of CO_2 **saving** every year,

equivalent to taking

140

million cars off the road

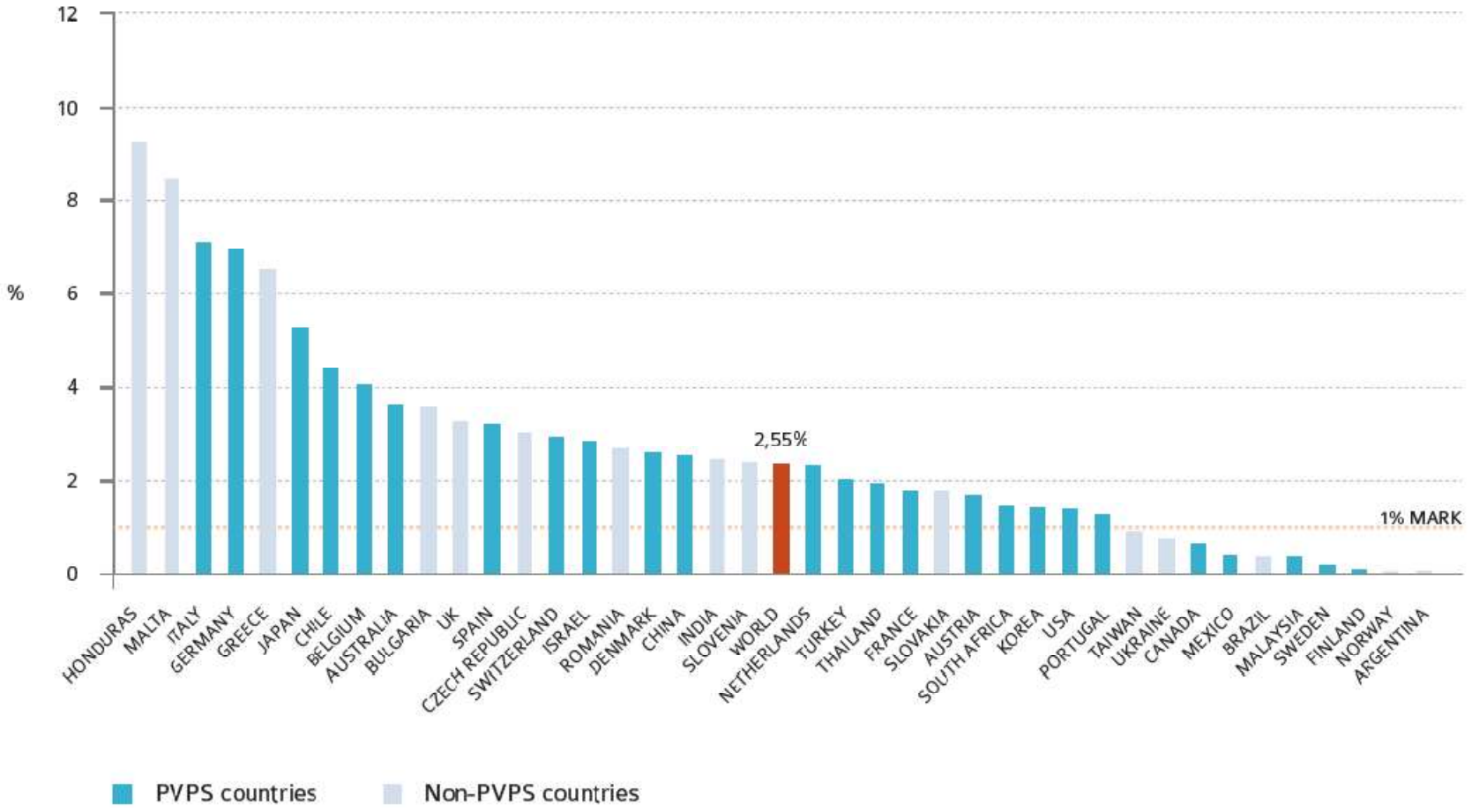
or planting

164

million trees each year

GLOBAL CUMULATIVE PHOTOVOLTAIC SOLAR POWER BY THE END OF 2017

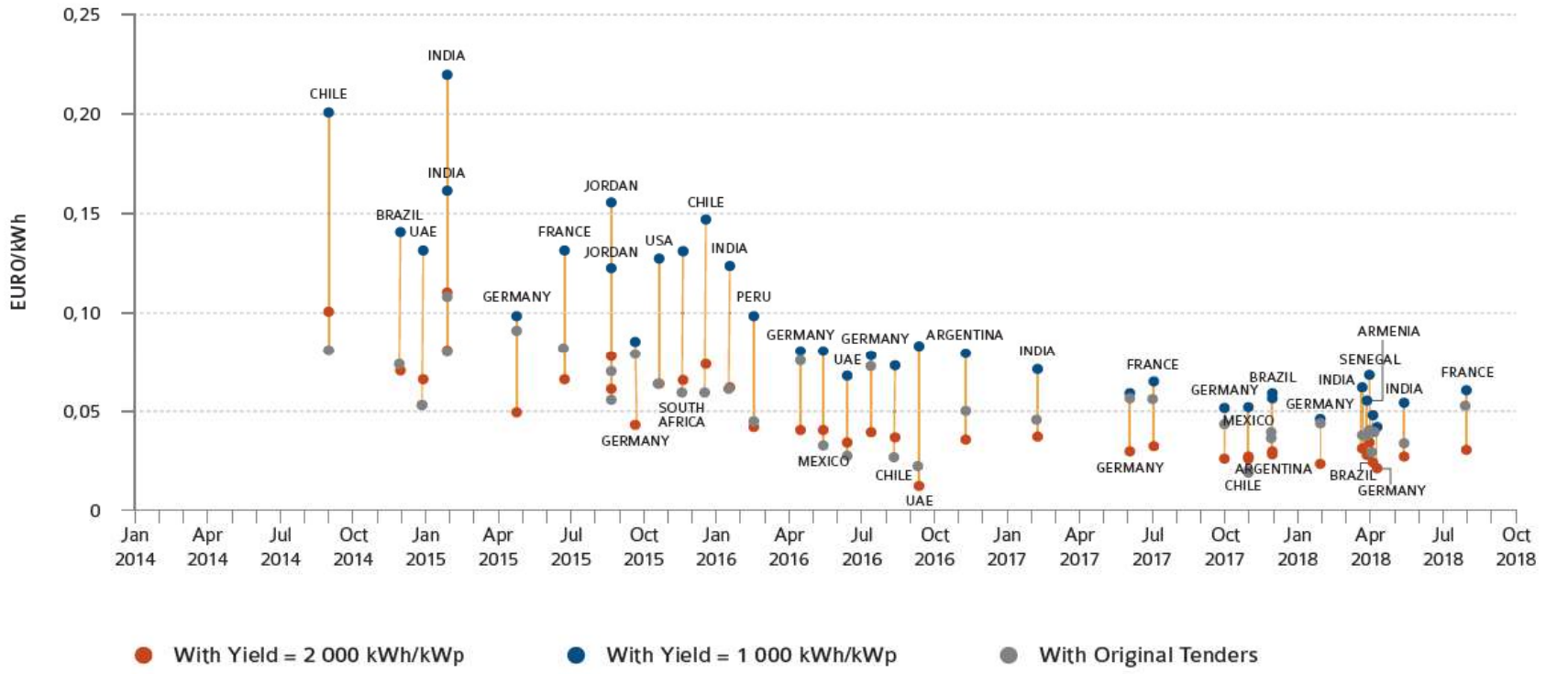
FIGURE 31: PV CONTRIBUTION TO THE ELECTRICITY DEMAND IN 2017



SOURCE SOURCE IEA PVPS & O

Costs

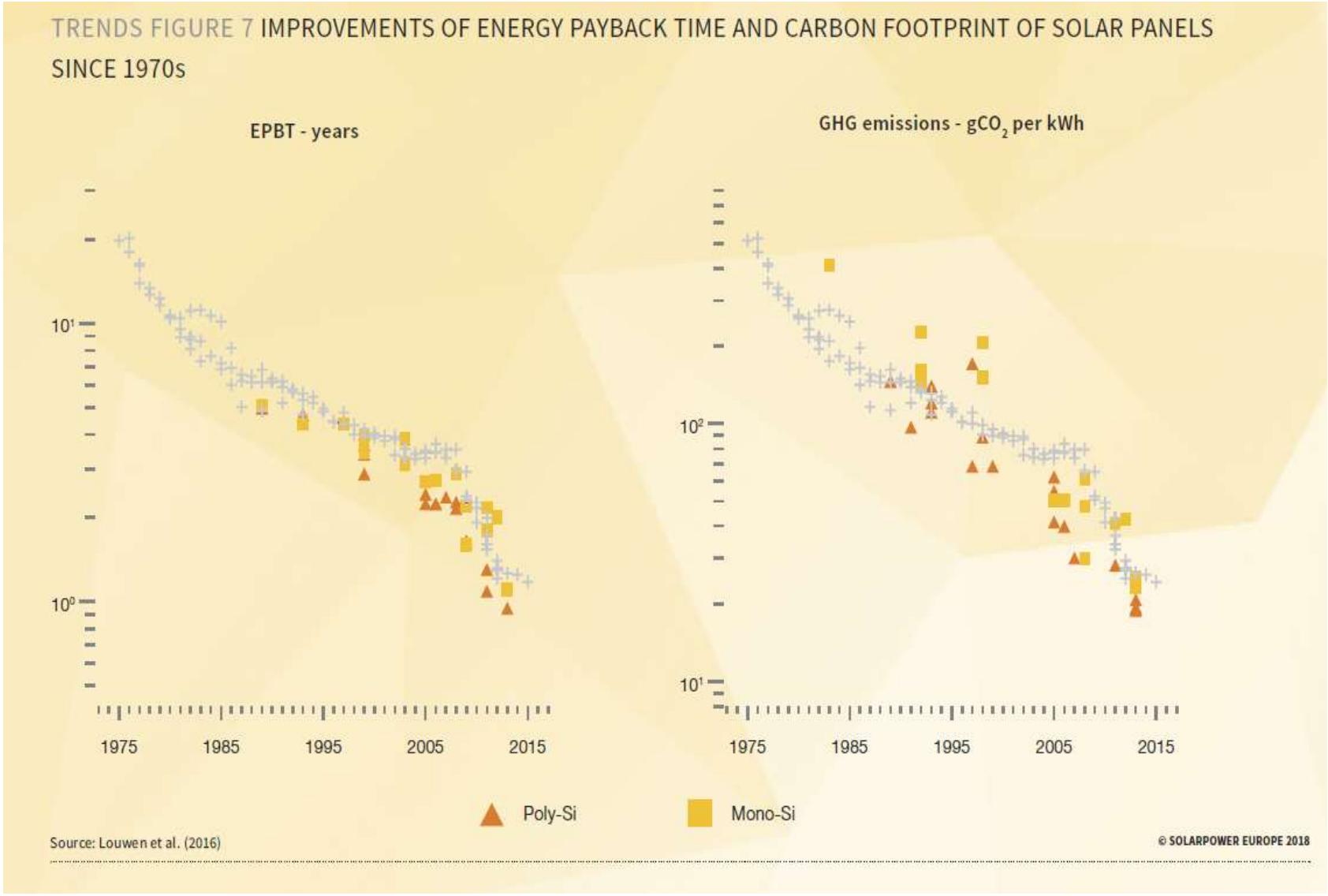
FIGURE 15: NORMALIZED LCOE FOR SOLAR PV BASED ON RECENT PPA PRICES 2014 - Q2 2018



SOURCE IEA PVPS, BECQUEREL INSTITUTE.

PV cell and module technology

- The majority of commercial PV modules are based on crystalline silicon, with multicrystalline having a somewhat larger share of the market than monocrystalline silicon
- Other commercial modules are based on thin film materials such as cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) and amorphous silicon
- Validated efficiencies of 24.4%, 19.9%, 18.6%, 15.7% and 12.3% have been achieved for modules over 0.7 m^2 in area (Green et al, 2018), although commonly available modules may be a little lower in efficiency
- One of the new cell types with a lot of interest is based on perovskite material – cell efficiencies over 20% have been measured for small areas cells and over 11% for small area modules, although the lifetime remains unproven
- In module development, there is a lot of interest in bifacial modules where electricity is generated by both sides of the module

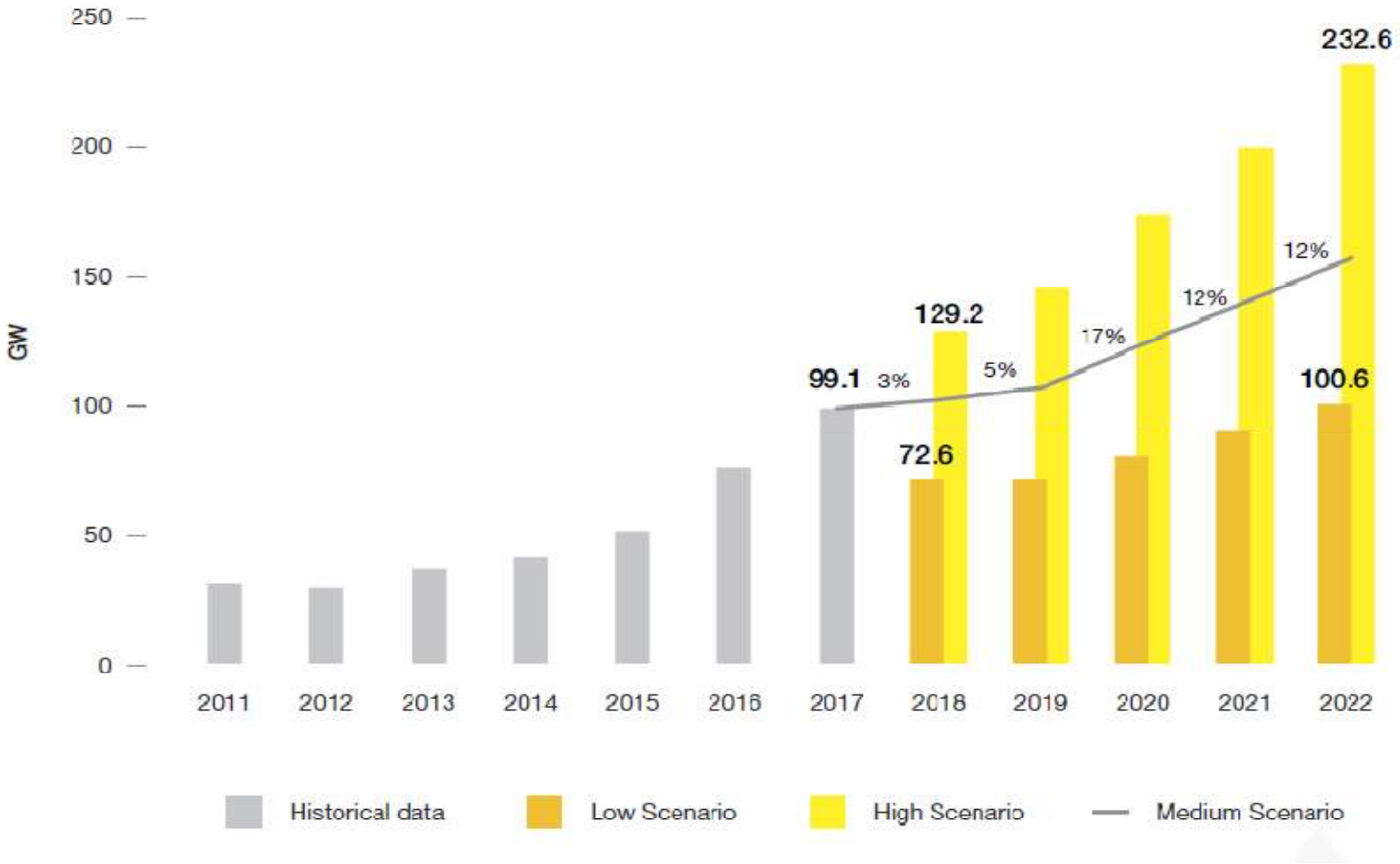

TRENDS FIGURE 7 IMPROVEMENTS OF ENERGY PAYBACK TIME AND CARBON FOOTPRINT OF SOLAR PANELS SINCE 1970s
EPBT - years
GHG emissions - gCO2 per kWh
10¹
10⁰
10²
10¹
1975
1985
1995
2005
2015
Poly-Si
Mono-Si
Source: Louwen et al. (2016)
© SOLARPOWER EUROPE 2018

PV Systems

- PV systems vary widely in size and applications, although they are all fairly simple in concept and reliable in operation
- Some “hot topics” for research and development include:
  - *Network integration*
  - *Storage*
  - *Performance optimisation by reduction of losses, operation and maintenance procedures – including moving to higher voltages for utility systems*
  - *Solar forecasting*
- There are also some interesting new implementation ideas, such as floating systems

Floating PV Systems
(QE II Reservoir, London, 6 MW)

FIGURE 9 WORLD ANNUAL SOLAR PV MARKET SCENARIOS 2018 - 2022



Some questions about the future

- How much of the electricity demand could be met with solar and storage?
- Do we need further substantial cost reductions?
- How do we handle the transition from financial support systems to free market?
- What technology developments are required?

Photograph courtesy of Phoenix Solar Greece