Solar Power in Europe:

Market Trends and System Integration

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SolarPower Europe

What is SolarPower Europe?

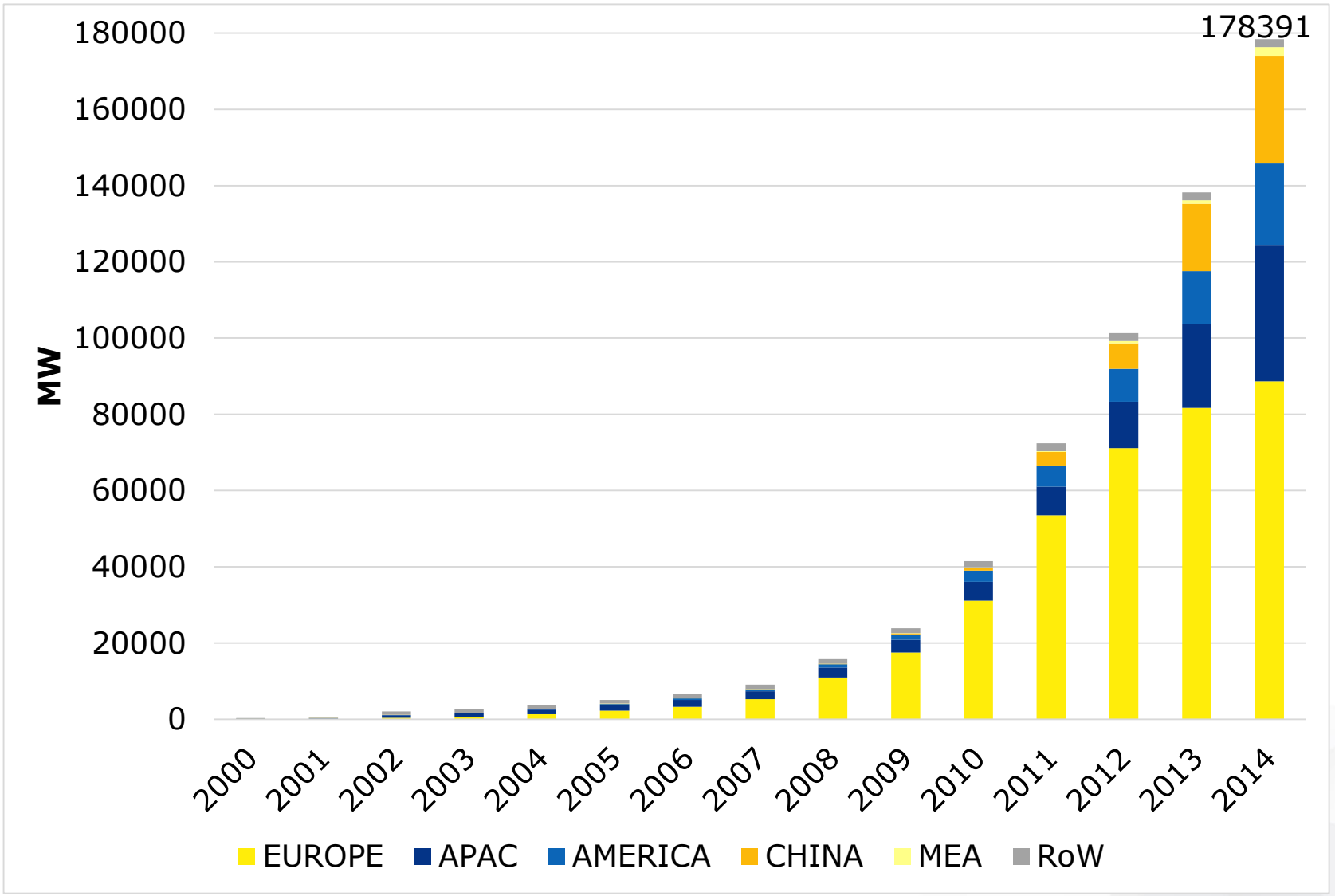
SolarPower Europe

- The new EPIA (European Photovoltaic Industry Association)
- A member led association representing organisations active along the whole value chain
- Shapes the regulatory environment and enhances business opportunities

Our members include the following leading companies

DUPONT, First Solar, SUNPOWER, WACKER, CanadianSolar, 3SUN, Enel Green Power, BayWa r.e. renewable energy, JA SOLAR, JinKO Solar, Building Your Trust in Solar, phoenix SOLAR, REXEL, ENERGIZING LIFE TOGETHER, REC, solarcentury, SunEdison simplifying solar, TOTAL COMMITTED TO BETTER ENERGY, Trinasolar Smart Energy Together, YINGLI SOLAR

Evolution of global cumulative installed capacity



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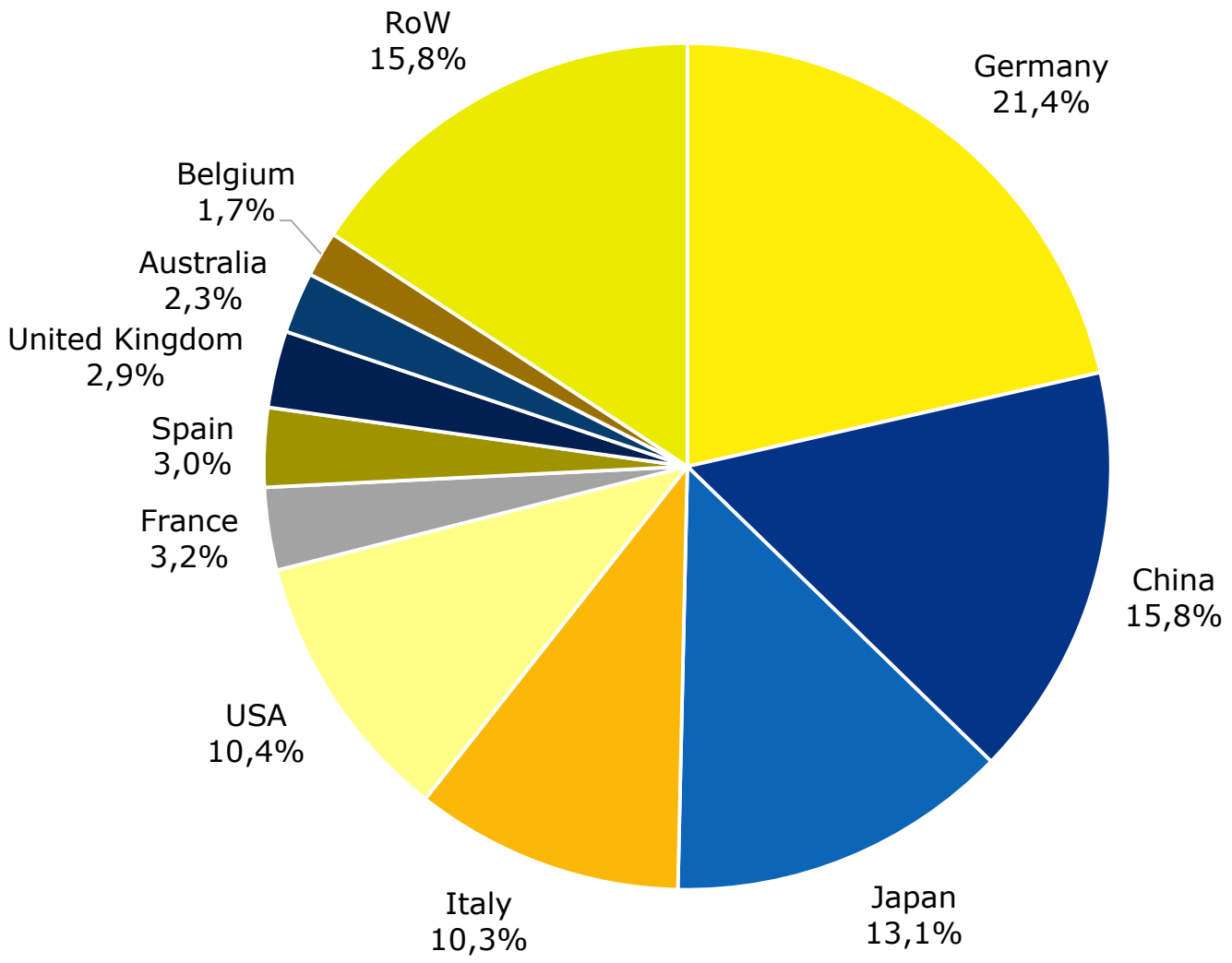
Global Solar PV cumulative capacity in 2014



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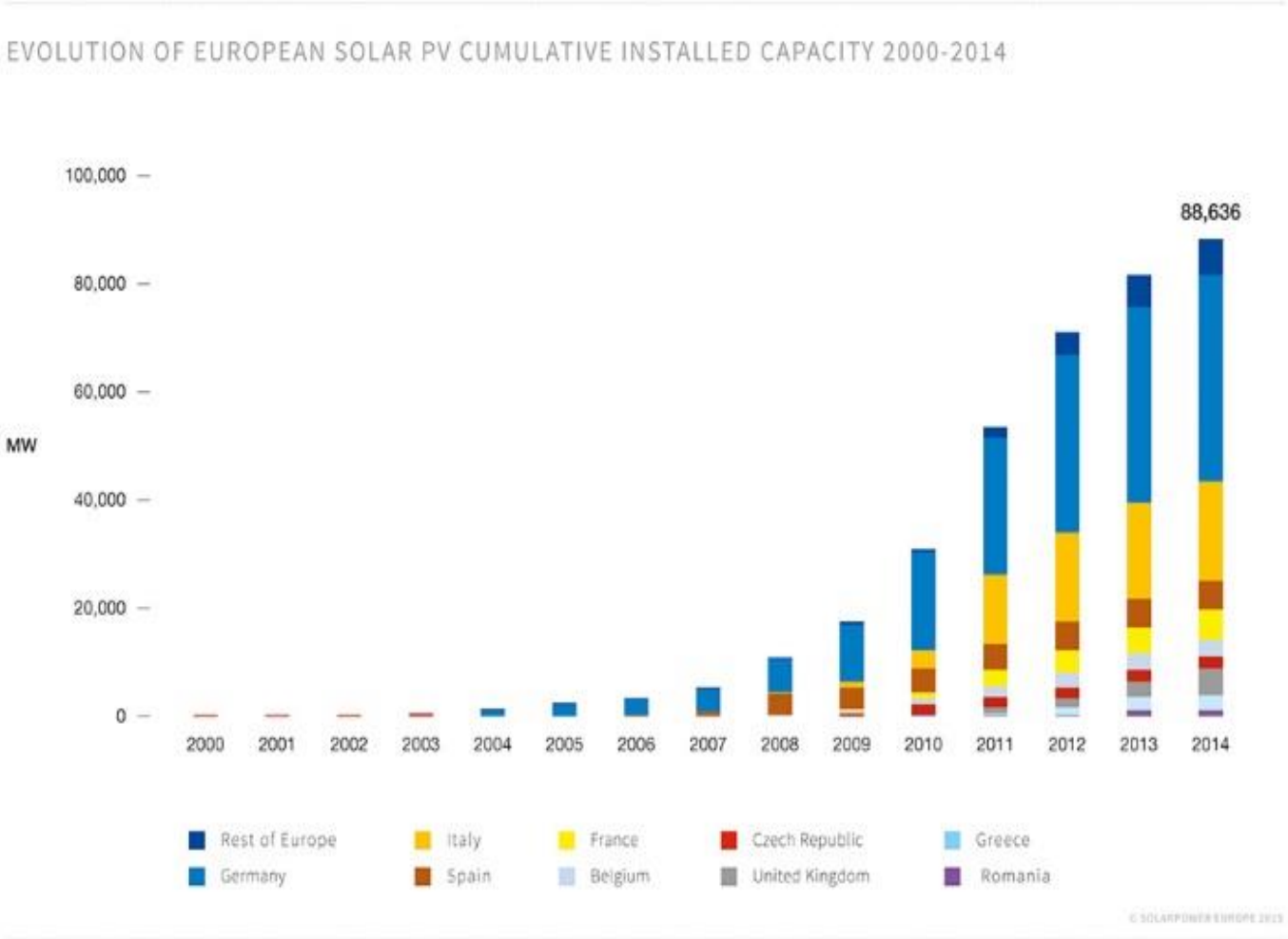
Europe: The cradle of Solar



89 GW

4 MILLION PV SYSTEMS

3,5%

power needs of 30 million EU households

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MESSAGE #1:

Long-term signals are needed

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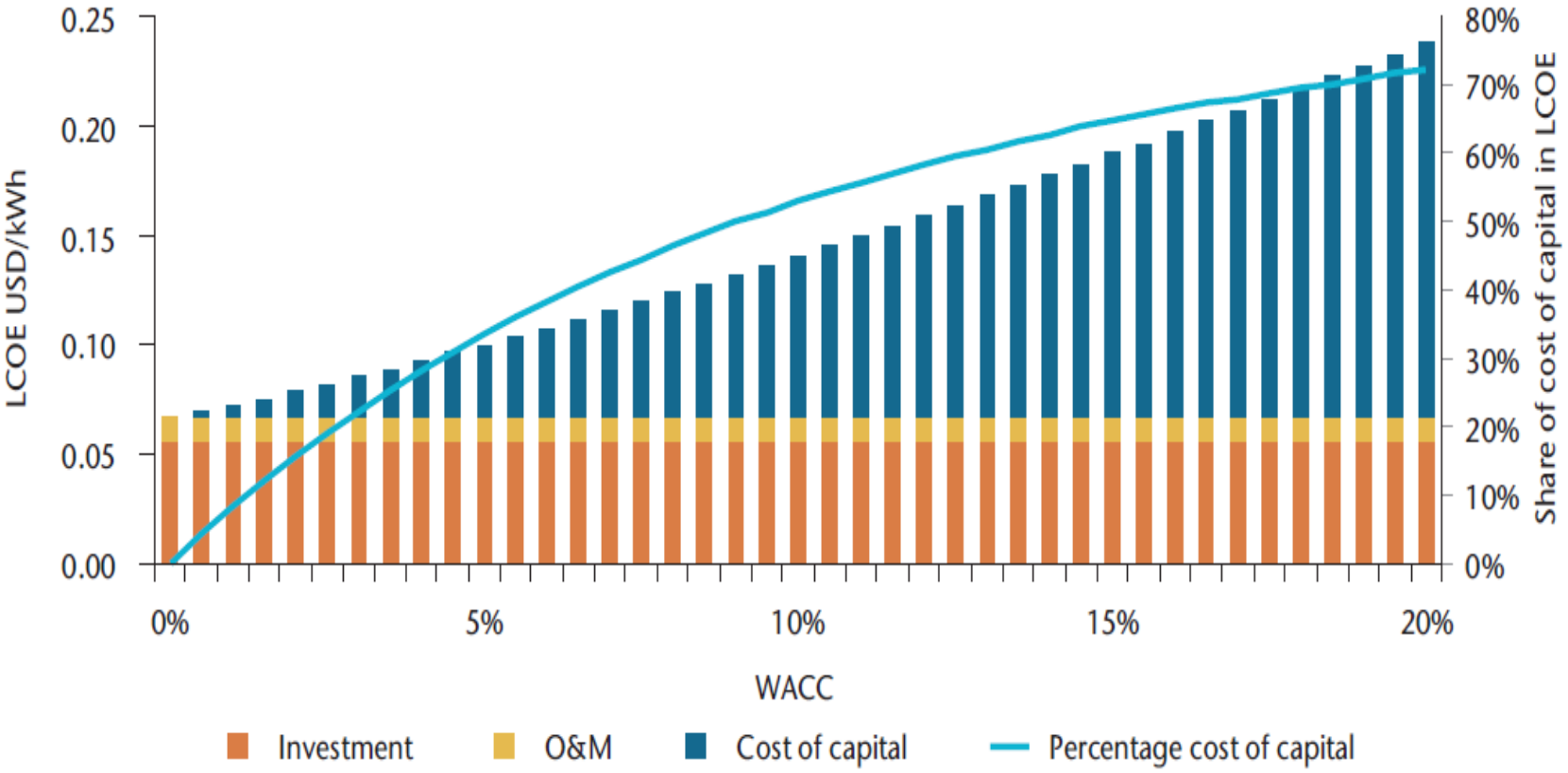
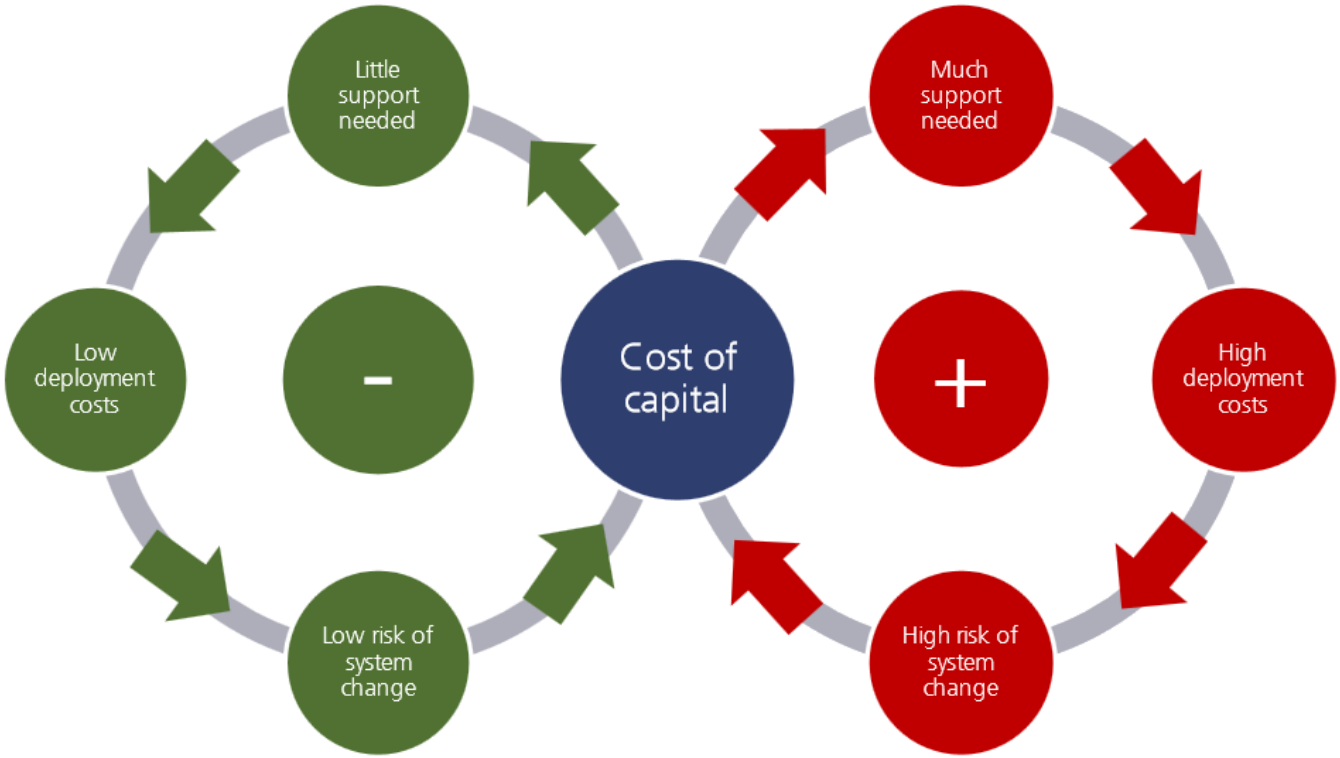
Cost of capital has a major impact on the cost of solar

When cost of capital reaches 9%, it makes up 50% of the LCOE



Source: International Energy Agency, Technology Roadmap Solar Photovoltaic Energy, 2014

Reduce cost of capital via long-term signals



De-risking (CAPEX intensive) investments will make the energy transition cheaper

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Source: DIA-CORE project

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MESSAGE #2:

It’s not just about financial support

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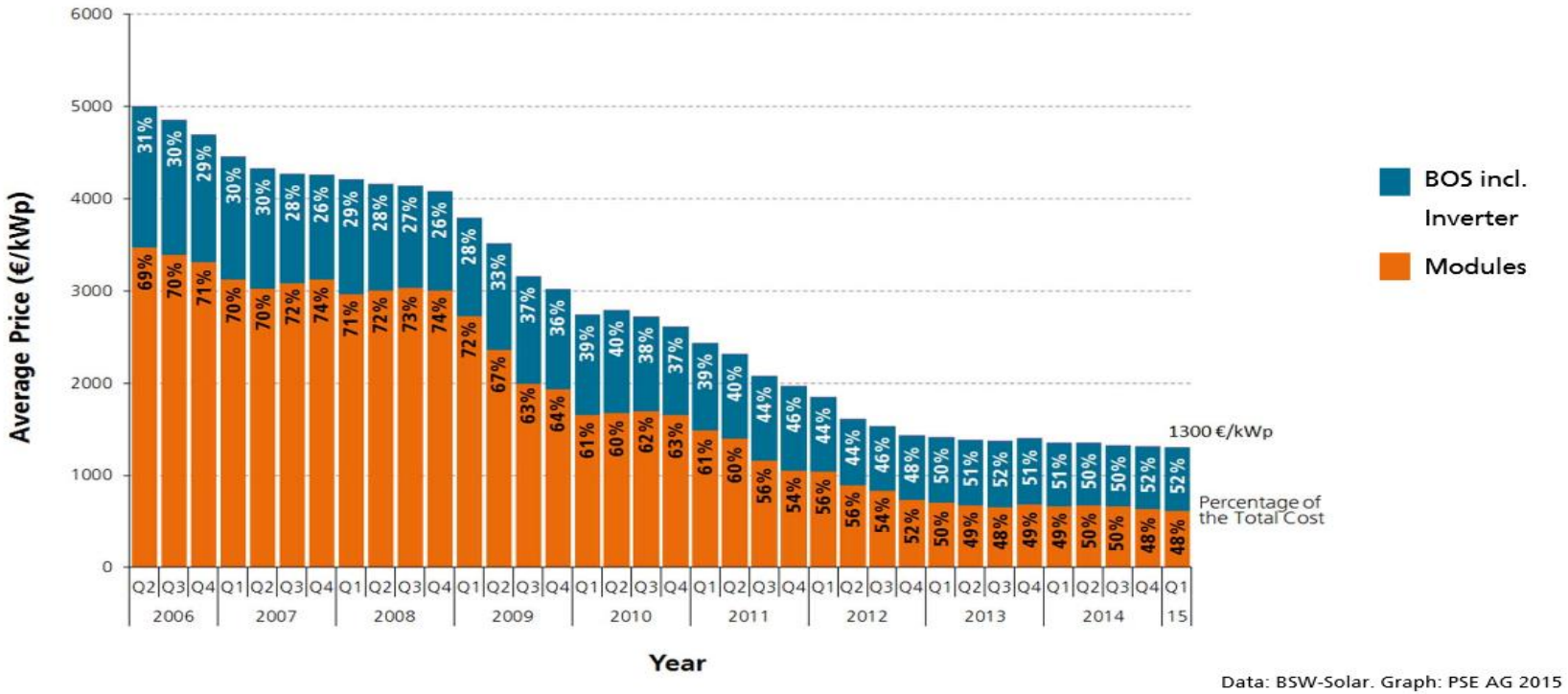
Relative importance of soft costs is increasing

Streamlined administrative procedures and simplified grid connection processes are key to further drive down costs

Average Price for PV Rooftop Systems in Germany (10kWp - 100kWp)



Data: BSW-Solar. Graph: PSE AG 2015

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MESSAGE #3:

Grid operation and market design need to be adjusted

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Where we have come from

Promotion of solar has been based on direct financial support:

- Feed-in-tariff
- Net-metering

→ TSOs act(ed) as balance responsible parties (BRPs)

Not the end of the story

Solar PV Uptake:

- Support schemes delivered impressive cost reductions
- Generation cost competes with conventional generation
- Favourable cost developments at retail level

	March 2015	2021	2026
Installed Capacity	90 GW	≈170 GW	≈ 250 GW
Ability to cover EU electricity demand	3.5 %	7%	10%

- **Provision of grid services to TSOs and DSOs to become mandatory in several countries**
- **Market and system integration need to be adjusted for further European PV deployment**
- **Example: managing the eclipse in March 2015 was the first real stress test for the European grid**

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Key ingredients of a reliable power grid

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Solar PV capabilities

	PV	PV and Battery
Reactive Power	√	√
Negative balancing	√	√
Positive balancing	X	√
Self-regulated consumption	X	√

		Solar PV System Size					
		Small scale		Large scale		Aggregation	
		Tech.	Procedures	Tech.	Procedures	Tech.	Procedures
Frequency	FCR						
	FRR						
	RR						
	FFR						
	RM						
Voltage	SSVC						
	FRCI						

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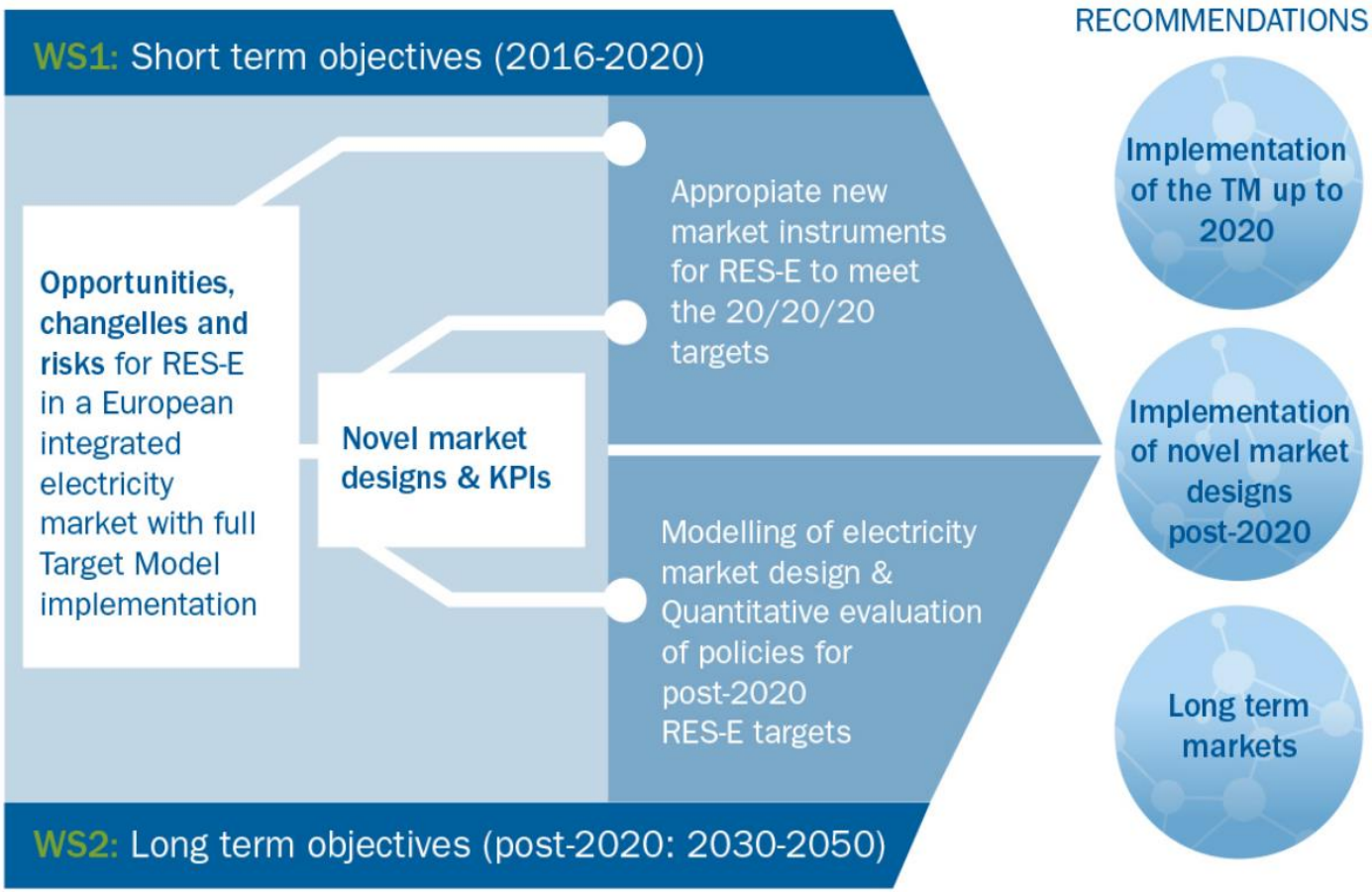
Sources: ise.fraunhofer & REservices

Market4RES: two work streams



Market RES

Design options and specific assessment criteria for short-term effects of RES support

- Design options assessed:
  - ✓ Net metering of demand and generation per network user for computation of regulated charges
  - ✓ Long-term clean energy auctions
  - ✓ Long term clean capacity auctions
  - ✓ Feed-In Tariffs (with Regulated Prices and with Auction)
  - ✓ Feed-In Premiums regulated (with/without price cap and floors)
  - ✓ Feed-In Premiums resulting from an auction (with/without price cap and floors)
  - ✓ Certificate Schemes with Quota
  - ✓ Support conditioned to the provision of grid support services
  - ✓ No support scheme (conventional market remuneration)
- Specific assessment criteria
  - ✓ Efficiency (Cost reflectivity, Liquidity, Cost Causality)
  - ✓ Robustness
  - ✓ Implementability (Cost Efficiency, Barriers to RES participation in markets)
  - ✓ Fairness

Most promising RES support schemes regarding their short term effects

Assessment Criteria	Design Options
Very High Grades	✓ LT clean capacity auction ✓ No support scheme (1)
High Grades	✓ LT clean energy auction
Average Grades	✓ Certificates ✓ FIP (auction)
Low Grades	✓ FIT ✓ FIP (regulated) ✓ Net Metering

(1) Although with overall strong grades in the assessment criteria hereby considered, we would discard this design option since it performs very poorly under the Effectiveness criterion and, therefore, cannot comply with the policy objectives set for RES targets in the Long-term.

Market RES

Most promising RES support schemes regarding their long term effects

Assessment Criteria	Design Options
High Grades	✓ FIP resulting from auction ✓ FIT with auction ✓ Long-term clean energy or capacity auction ✓ No support scheme [1]
Average Grades	✓ Certificate Schemes with Quota ✓ FIP regulated
Low Grades	✓ Net metering of Demand and Generation ✓ Provision of grid support services ✓ FIT with regulated prices

[1] Although with overall strong grades in the assessment criteria hereby considered, we would discard this design option since it performs very poorly under the Effectiveness criterion and, therefore, cannot comply with the policy objectives set for RES targets in the Long-term.

Market RES

Pathway to open up opportunities

Steps for a reliable system integration

FAIR MARKET ACCESS FOR ALL PLAYERS

- Liquid and integrated short-term markets
- Shorter trading blocks and gate closures
- Re-definition of products and access criteria

THINKING BEYOND CAPACITY MECHANISMS

- Market to send signals
- Avoid lock-in

PROVIDING FRAMEWORK TO INVEST IN RES

- Strict implementation of 2020 framework
- (Smart) self-consumption
- Target-umbrella for 2030
- RES-legislation beyond 2020

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SolarPower Europe: Preparing tomorrow

metaPV

International Energy Agency

GIVAR III

GRID4EU

INNOVATION FOR ENERGY NETWORKS

REserviceS

ECONOMIC GRID SUPPORT FROM VARIABLE RENEWABLES

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GridTECH.EU

evolvDSO

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PVPARITY

PV GRID

Make it smart!

IEA PVPS Task 14

GREENGrid

HIGHWAY 2050

THANK YOU

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More information on: http://market4res.eu/

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  - ✓ Feed-In Premiums regulated (with/without price cap and floors)
  - ✓ Feed-In Premiums resulting from an auction (with/without price cap and floors)
  - ✓ Certificate Schemes with Quota
  - ✓ Support conditioned to the provision of grid support services
  - ✓ No support scheme (conventional market remuneration)
- Specific assessment criteria
  - ✓ Efficiency (Cost reflectivity, Liquidity, Diversity of products traded in the market and Market transparency)
  - ✓ Effectiveness
  - ✓ Robustness
  - ✓ Implementability (Simplicity of the market, Experience with the implementation in other systems and Applicability to other time frames and contexts)

Most promising RES support schemes for each criterion: Long-term effects

	Weakest Design Options	In-between Design Options	Strongest Design Options
Efficiency Criterion	✓ FIT with regulated prices ✓ Net metering of D and G ✓ Grid support services	✓ FIT with auction ✓ FIP regulated	✓ LT clean energy or capacity auctions ✓ FIP resulting from auction ✓ Certificate schemes ✓ No support scheme
Effectiveness Criterion	✓ Grid support services ✓ No support scheme ✓ Net metering of D and G	✓ FIT with regulated prices ✓ FIP regulated	✓ LT clean energy or capacity auctions ✓ FIT with auction ✓ FIP resulting from auction ✓ Certificate schemes
Robustness Criterion	✓ FIT with regulated prices	✓ FIP regulated ✓ Certificate schemes ✓ Grid support services	✓ No support scheme ✓ LT clean energy or capacity auctions ✓ Net metering of D and G ✓ FIP resulting from auction ✓ FIT with auction
Implementability Criterion	✓ LT clean energy or capacity auctions ✓ Certificate schemes ✓ Grid support services ✓ FIP resulting from auction	✓ FIP regulated ✓ FIT with auction ✓ Net metering	✓ No support scheme ✓ FIT with regulated prices

Most promising RES support schemes regarding their long-term effects: arguments

Design Options	Weak points (-)	Strong points (+)
✓ FIP resulting from auction ✓ FIT with auction ✓ Long-term clean energy or capacity auction ✓ Certificate Schemes with Quota	• LT clean energy auction: Less easy to extend to wide areas and to a wide range of overall market designs since it probably requires a central buyer • FIT with auction: Poor liquidity – No need to trade as revenue is unrelated to spot market prices • FIP resulting from auction & Certificate schemes: Increased project risk dependent on spot market prices may raise difficulties to finance new projects	• Tend to reveal the LT marginal cost of RES capacity in procurement schemes for new projects • Tend to foster liquidity as revenues (partially) depend on spot market prices (except for FIT with auction) • Effective to meet LT RES targets • Resilient to LT political intervention • Simple to understand by all stakeholders • Easy access to information • Implemented throughout several EU countries
✓ FIP regulated ✓ Net metering of Demand and Generation ✓ Provision of grid support services ✓ FIT with regulated prices	• May not reflect long term marginal cost of capacity for new RES projects in LT (may be set too high or too low) • Does not foster liquidity in LT, or ST • Difficulty to access information (discrimination may exist) • Fail to meet LT RES targets • Less resilient to LT political intervention (except for Net Metering)	• Implemented throughout several EU countries • Easily extendable to wide areas and to a wide range of overall market designs

Most promising design options (overall high grades)

Discarded design options (overall low grades)

Market RES

Design options and specific assessment criteria for short-term effects of RES support

- Design options assessed:
  - ✓ Net metering of demand and generation per network user for computation of regulated charges
  - ✓ Long-term clean energy auctions
  - ✓ Long term clean capacity auctions
  - ✓ Feed-In Tariffs (with Regulated Prices and with Auction)
  - ✓ Feed-In Premiums regulated (with/without price cap and floors)
  - ✓ Feed-In Premiums resulting from an auction (with/without price cap and floors)
  - ✓ Certificate Schemes with Quota
  - ✓ Support conditioned to the provision of grid support services
  - ✓ No support scheme (conventional market remuneration)
- Specific assessment criteria
  - ✓ Efficiency (Cost reflectivity, Liquidity, Cost Causality)
  - ✓ Robustness
  - ✓ Implementability (Cost Efficiency, Barriers to RES participation in markets)
  - ✓ Fairness (Difficulty to change support retroactively)

Most promising RES support schemes for each criterion: Short-term effects

	Weakest Design Options	In-between Design Options	Strongest Design Options
Efficiency Criterion	✓ FIT ✓ Net Metering	✓ FIP (+without caps) ✓ LT clean energy auction	✓ LT clean capacity auction ✓ Certificates ✓ No support
Robustness Criterion	✓ FIT (regulated) ✓ FIP (regulated)	✓ FIT and FIP (auction) ✓ Certificates ✓ Net metering ✓ LT clean energy auction	✓ LT clean capacity auction ✓ No support
Implementability Criterion	✓ FIT ✓ FIP (regulated)	✓ LT lean energy and capacity auction ✓ Certificates ✓ FIP (auction, no caps)	✓ Net metering ✓ FIP (caps and auction) ✓ No support
Fairness Criterion	✓ FIT (regulated) ✓ FIP (regulated)	✓ FIT and FIP (auction) ✓ LT clean energy and capacity auction ✓ Certificates	✓ No support

Market RES

Most promising RES support schemes regarding their short-term effects: arguments

Design Options	Weak points (-)	Strong points (+)
✓ Long term clean capacity auction ✓ Long-term clean energy auction ✓ Certificates ✓ FIP (auction)	• FIP (auction), Certificates, and energy auction create non-negligible distortion of short term prices • Distortions created by FIP (auction), Certificates, and energy auction are not stable • Relevant amount of support provided • Create some barriers to RES participation in markets	• Limited distortion of efficient short term signals (negligible for LT clean capacity auction) • Tend to foster liquidity as revenues (partially) depend on spot market prices • Certificates promote Cost Causality • Resilient to political intervention
✓ FIP regulated ✓ Net metering ✓ FIT ✓ Support conditioned to the provision of grid support	• All create relevant distortion of short term prices (FIT-largest, FIP regulated-relevant, Net Metering-localized) • FITs, Net Metering, and Voltage condition reduce liquidity in short term markets • Prone to political intervention • Large support for regulated FIT and FIP • Create some barriers to RES participation in markets	• FIP regulated promotes liquidity in short term markets • Low overall support involved in Net Metering • Grid support condition reduces the amount of support mobilized

Most promising design options (overall strong grades)

Discarded design options (overall weak grades)

Market RES

Most promising RES support schemes from a global perspective

Design Options	Weak points (-)	Strong points (+)
✓ Long-term clean capacity auction ✓ Long-term clean energy auction ✓ Certificates ✓ FIP (auction)	• FIP (auction) and Certificates imply some project risk • FIP, Certificates, and energy auction distort short term prices to some extent, and this distortion depends on system conditions • LT clean auction difficult to extend to other markets (involves central buyer) • Relevant amount of support provided • Create some barriers to RES participation in markets	• Tend to reveal the marginal cost of RE capacity in LT procurement schemes for new projects • Effective to meet LT RES targets • Limited distortion of efficient short term signals • Tend to foster both LT and ST liquidity • Certificates promote Cost Causality • Resilient to political intervention
✓ FIP regulated ✓ Net metering ✓ FIT ✓ Support conditioned to the provision of grid support	• May not reflect marginal cost of RES capacity for new projects • Fail to meet LT RES targets • All create relevant distortions of short term prices (FIT-largest, FIP regulated-relevant, Net Metering-localized) • FITs, Net Metering and , and Voltage condition reduce liquidity in short term markets • Prone to political intervention • Regulated FIP and FIT: Large support	• FIP regulated promotes liquidity in short term markets • Low overall support involved in Net Metering • Grid support condition reduces the amount of support mobilized • Experience within the EU • Can be extended to other systems

Most promising design options (overall strong grades)

Discarded design options (overall weak grades)

Market RES