The Leading Engine for Innovation and Entrepreneurship in Sustainable Energy

KIC InnoEnergy Roadmap Renewable Energy

Msc RENE Innovation Seminar 2015

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2. KIC InnoEnergy Renewable technology vision
3. Innovation assessment criteria
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- Roadmap:

Plan that matches future goals with specific technology solutions to help meet those goals.

- KIC InnoEnergy roadmap:
  - Definition of key technologies and innovations to address industry's challenges in the sustainable energy sector.
  - 5 years ahead
  - Updated every 2 years

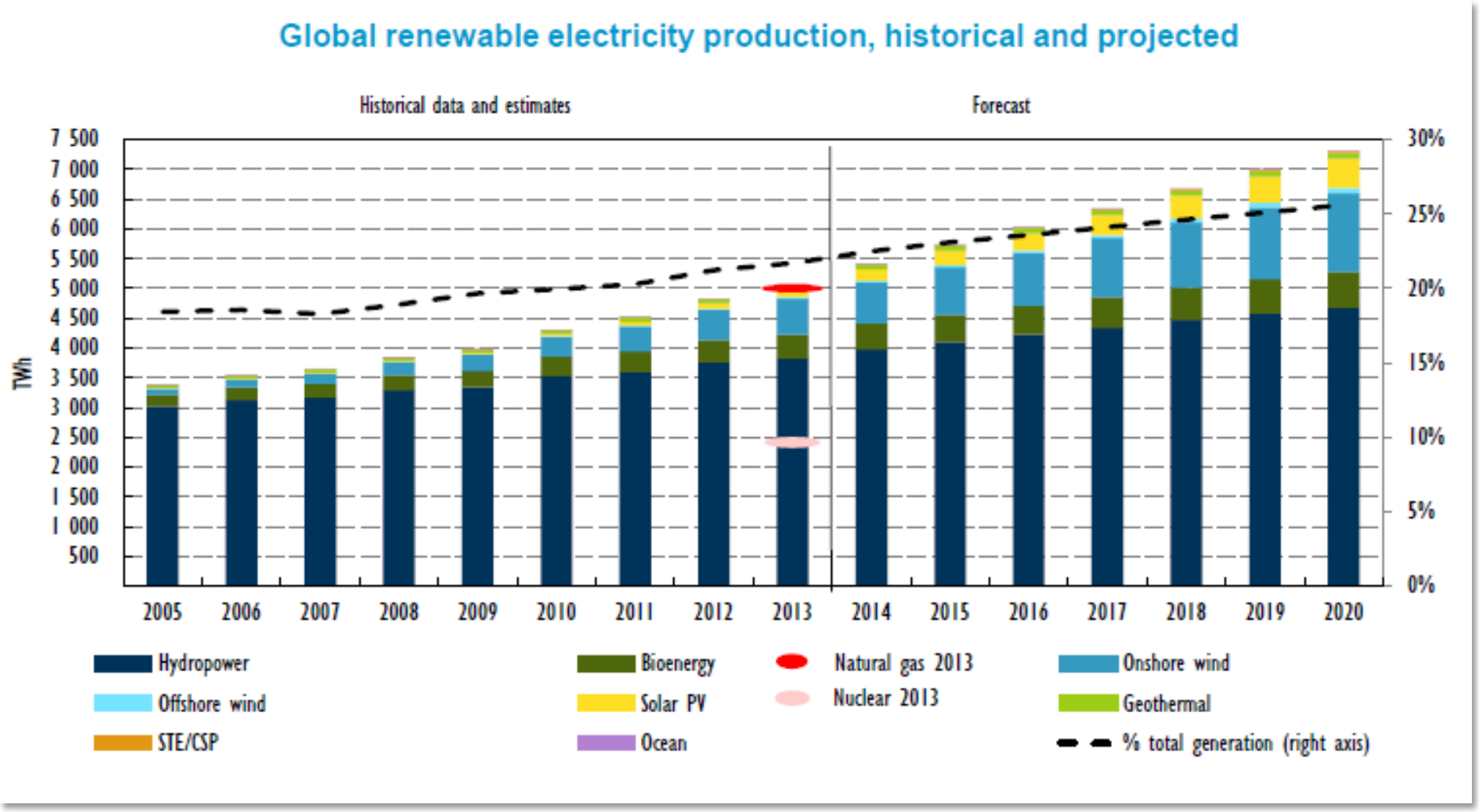
1- Some definitions

- Renewable energy (for KIC InnoEnergy):

Any technology that convert a renewable resource into electricity.

WIND	PV	STE	OCEAN
Onshore 	Utility scale 	Parabolic 	Wave 
Offshore 	Commercial 	Central Receiver 	Tidal 
	Residential 	Linear Fresnel 	

Strong momentum for renewable electricity

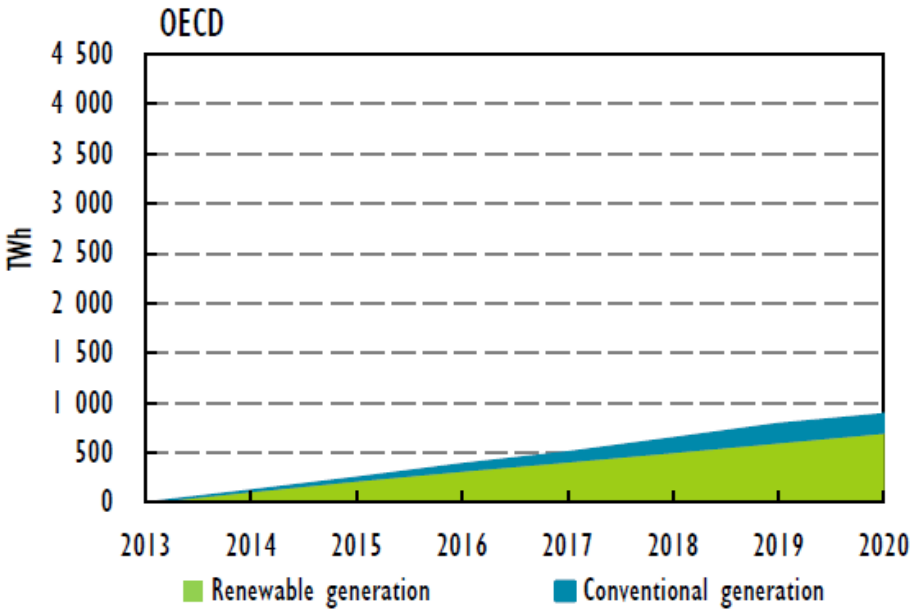


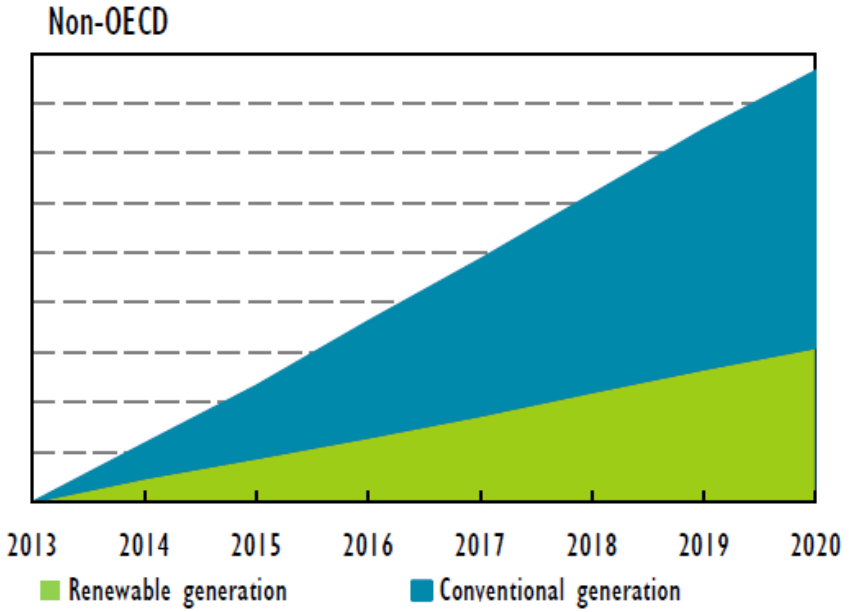
Market scale up by 45% from 2013 to 2020

Source: IEA Medium-term renewable energy market report 2014

Renewables vs conventional power

Cumulative change in gross power generation by source and region, 2013-20





Renewables account for 80% of new generation in OECD

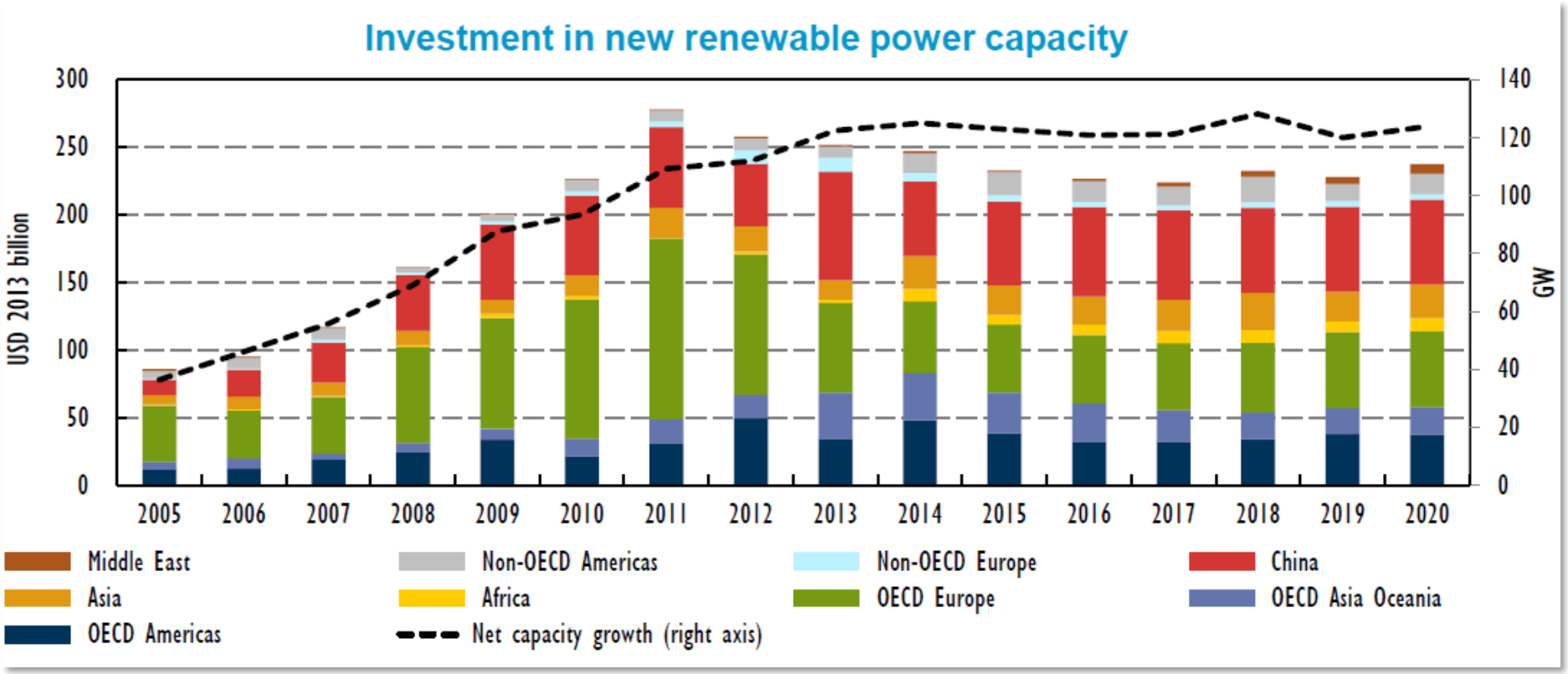
Limited growth in stable markets with slow demand increase & growing political risk

Renewables largely used in non-OECD but only 35% of growth

Large growth in dynamic markets with fast demand increase

Source: IEA Medium-term renewable energy market report 2014

Renewable investment has risen to high level



Peak investment in 2011, then steady around $ 250 billion:

→ slowing capacity growth?

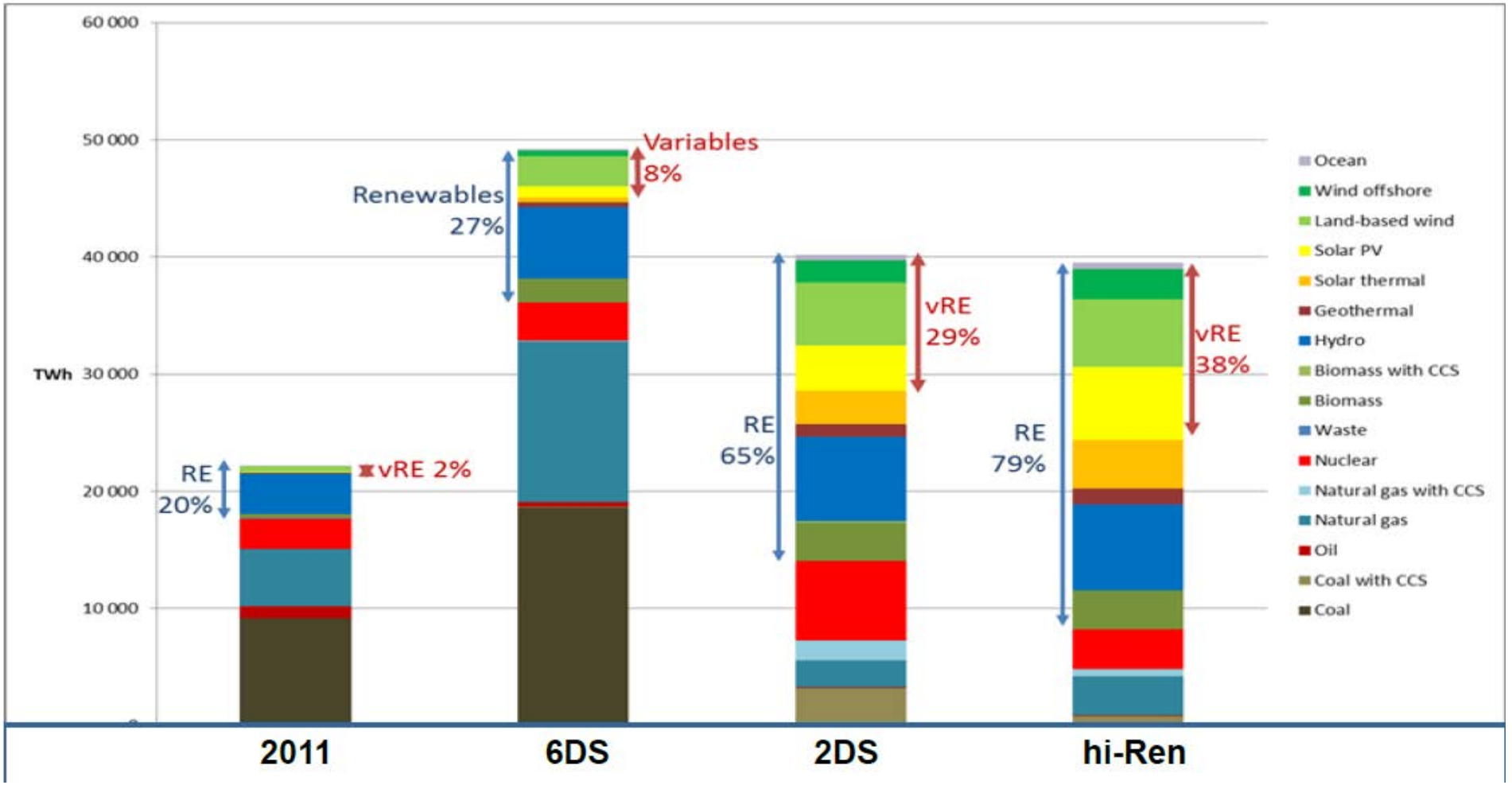
→ Falling cost curve

Source: IEA Medium-term renewable energy market report 2014

2- KIC InnoEnergy technology vision: general considerations

- Need for high shares of carbon free energy to run the economy by 2050.
- Renewable energies are not an option.
- All existing business models to be revised.
- Energy policy and regulation to become obsolete (or already is?).

An Energy revolution is needed



Generation today:

- Fossil fuels: 68%
- Renewables: 20%

Generation 2DS 2050:

- Fossil fuels: 7-20%
- Renewables: 65-79%

Source: IEA Medium-term renewable energy market report 2014

2- KIC InnoEnergy technology vision: Onshore wind energy

Past

- Local markets
- Technology driven by size increase and material improvement
- Model of integration
- Dependence on incentives
- Dispersion of players

Future

- Globalized markets
- Optimum size reached, R&D on optimization, limited track record left
- New capabilities for smooth grid management
- Towards competitiveness

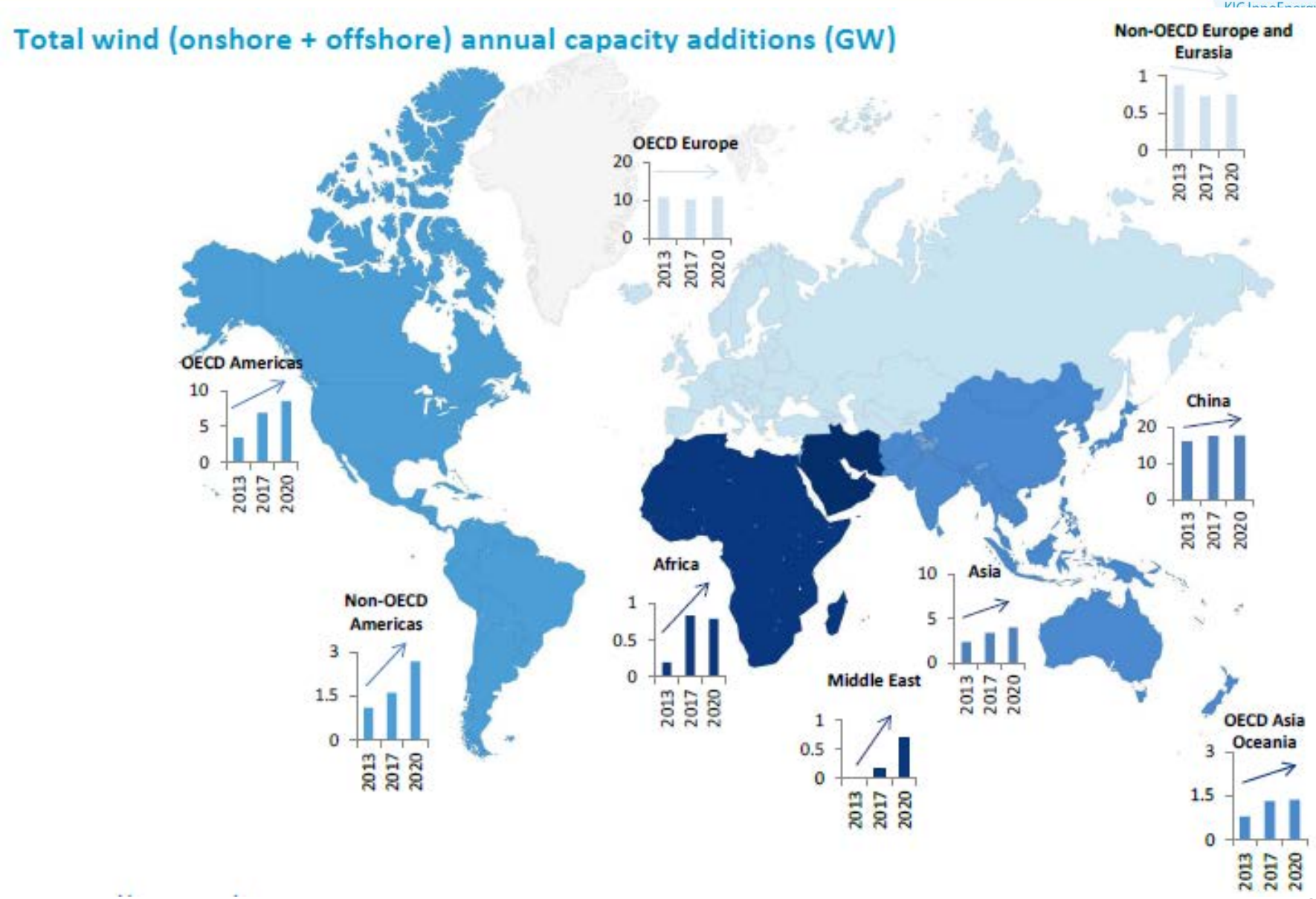
(Brazil, Chile, South Africa)

- M&A activity reducing the nº of players. Europe remains tech leader.

2- KIC InnoEnergy technology vision: Offshore wind energy

- Past
  - Niche markets / demo projects
  - Onshore equipment “marinisation”
  - “Onshore like” operation
  - Dependence on incentives
  - Global lack of knowledge and training
- Future
  - Local markets driven by specific sea conditions but global potential
  - Specific products including disruptive options
  - Distance to shore and size redefine the operation strategies
  - Need to demonstrate cost reduction capacity
  - Building a new sector

Wind growth to strengthen in emerging markets

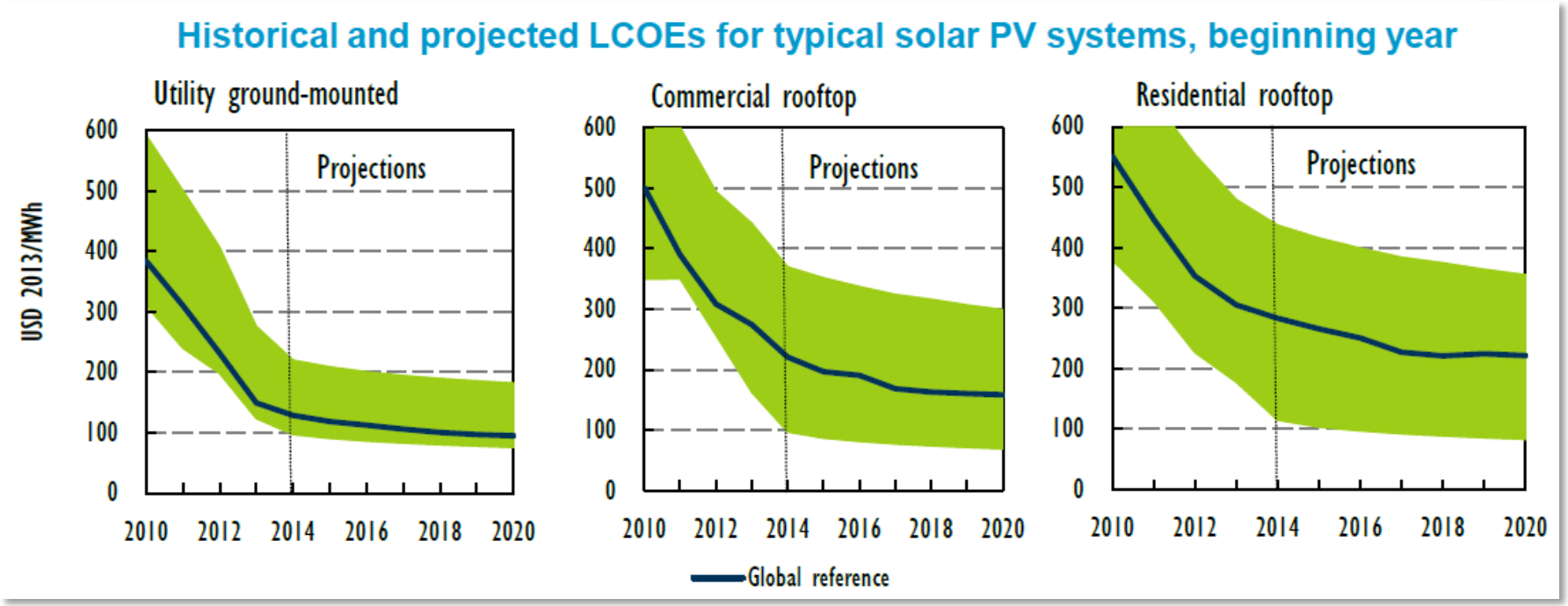


Source: IEA Medium-term renewable energy market report 2014

2- KIC InnoEnergy technology vision: photovoltaics

- Past
  - Technology driven developments
  - Dependence of incentives
  - Small energy production
  - Generation cost is the challenge
  - Europe as a world leader
- Future
  - Market driven developments
  - Self-sustained markets (cost reduction, grid parity, etc…)
  - Major player in the electricity mix
  - Integration is the challenge
  - Europe’s position challenged

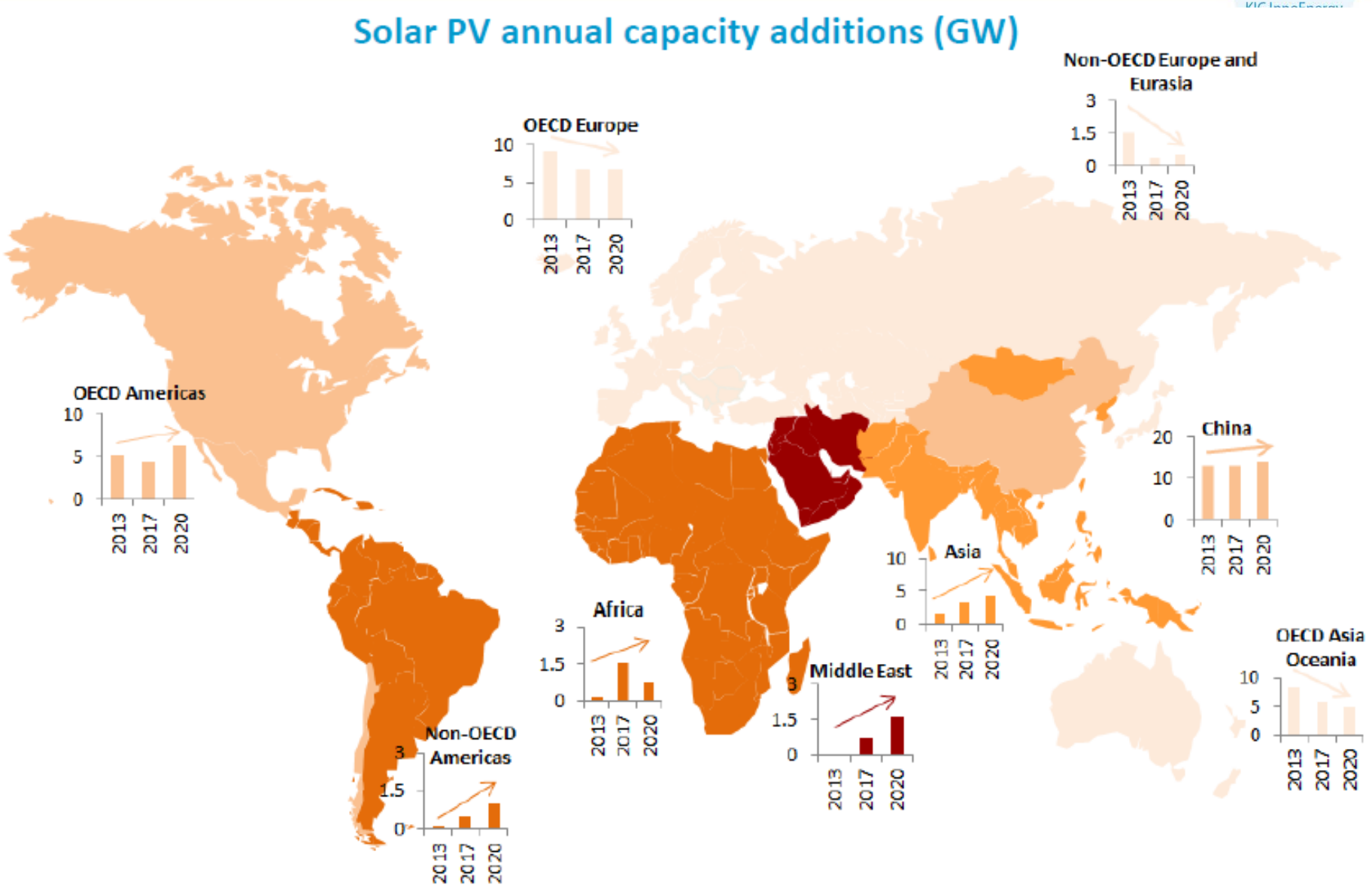
Generation cost for solar PV falling rapidly



- Utility scale → more and more competitive
- At present combination of low financing cost, low system prices and excellent resource available.
- Future cost reduction to be driven by technology improvement
- Policy debate over distributed PV

Source: IEA Medium-term renewable energy market report 2014

Stronger outlook for solar PV



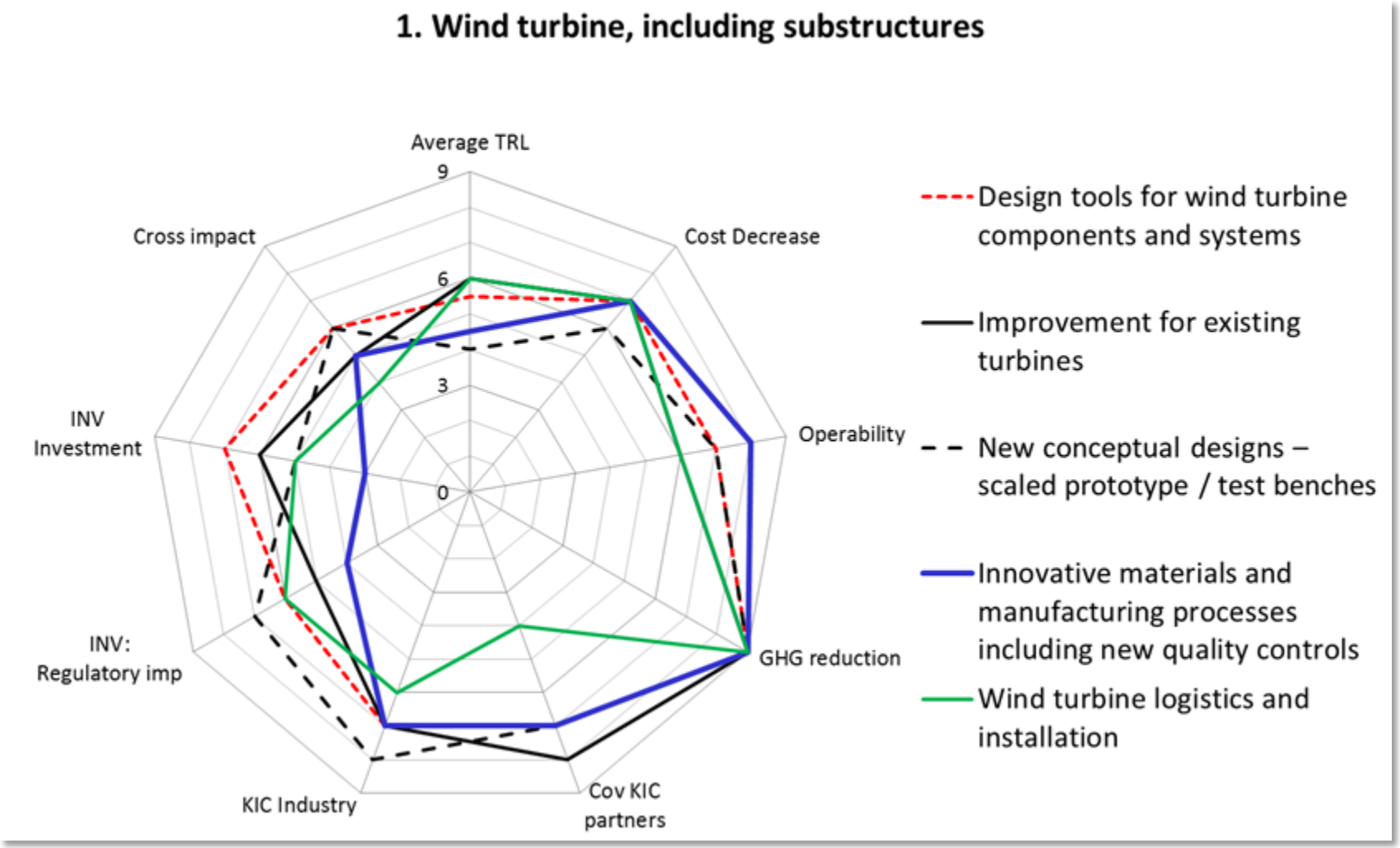
3- KIC InnoEnergy technology vision: solar-thermal electricity

- Past
  - Only demo projects (except Spain)
  - Early technology development to set up cost level
  - Coupling with thermal storage under development
  - Very low track record
- Future
  - Reduced number of active markets
  - Main cost decrease driver linked to upscaling of manufacturing processes
  - Storage → dispachable (high value for grid op.)
  - Limited perspectives

2- KIC InnoEnergy technology vision: Ocean Energy

- Past
  - 1st generation of inventors
  - Few designs
  - High risk financing
  - No market perspectives
  - Huge potential
- Future
  - 1st gen →dead / 2nd gen
  - Many designs
  - Scarce financing
  - Some national objectives
  - Huge potential

3- Innovation assessment criteria

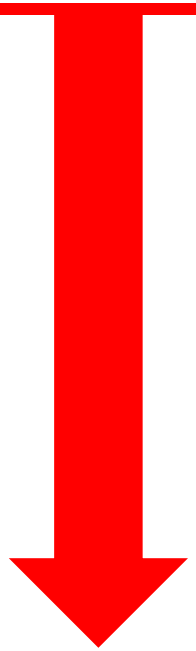


3- Innovation assessment criteria

- Time to market:
  - As short as possible
  - Ideally no more than 5 years from beginning of the product development.
  - In practice, we use the TRL (>4) & MRL

3- Innovation assessment criteria: TRL

TRL Levels
Level 1: Fundamental research
Level 2: Applied Research
Level 3: Research to prove feasibility
Level 4: Laboratory Demonstration
Level 5: Technology Development
Level 6: Field demonstration of whole system
Level 7: Industrial Prototype
Level 8: Product Industrialization
Level 9: Market Certification and Sales Authorization



TRL >4
Proof of concept done

3- Innovation assessment criteria: MRL

MRL Levels
Level 1: Unsatisfied needs identified
Level 2: Identification of the potential Business Opportunities
Level 4: Market research
Level 5: Targeting
Level 6: Industry analysis
Level 7: Competitors analysis and positioning
Level 8: Value proposition
Level 9: The product/service definition
Level 10: Business Model

No pre-defined MRL limits but the risk assessment is based on how disruptive the proposal is.

3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities:
  - Technology cost decrease (LCOE for example)
  - Increase operability & security
  - Decrease GHG emissions

3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities
- Leadership & competence of KIC IE Partners:
  - Identification of topic where KIC IE is strong
  - Identification of needs for partnerships

3- Innovation assessment criteria: KIC IE partners

Mapping of the 27 KIC IE formal partners

Another approx. 30 associated partners also participate

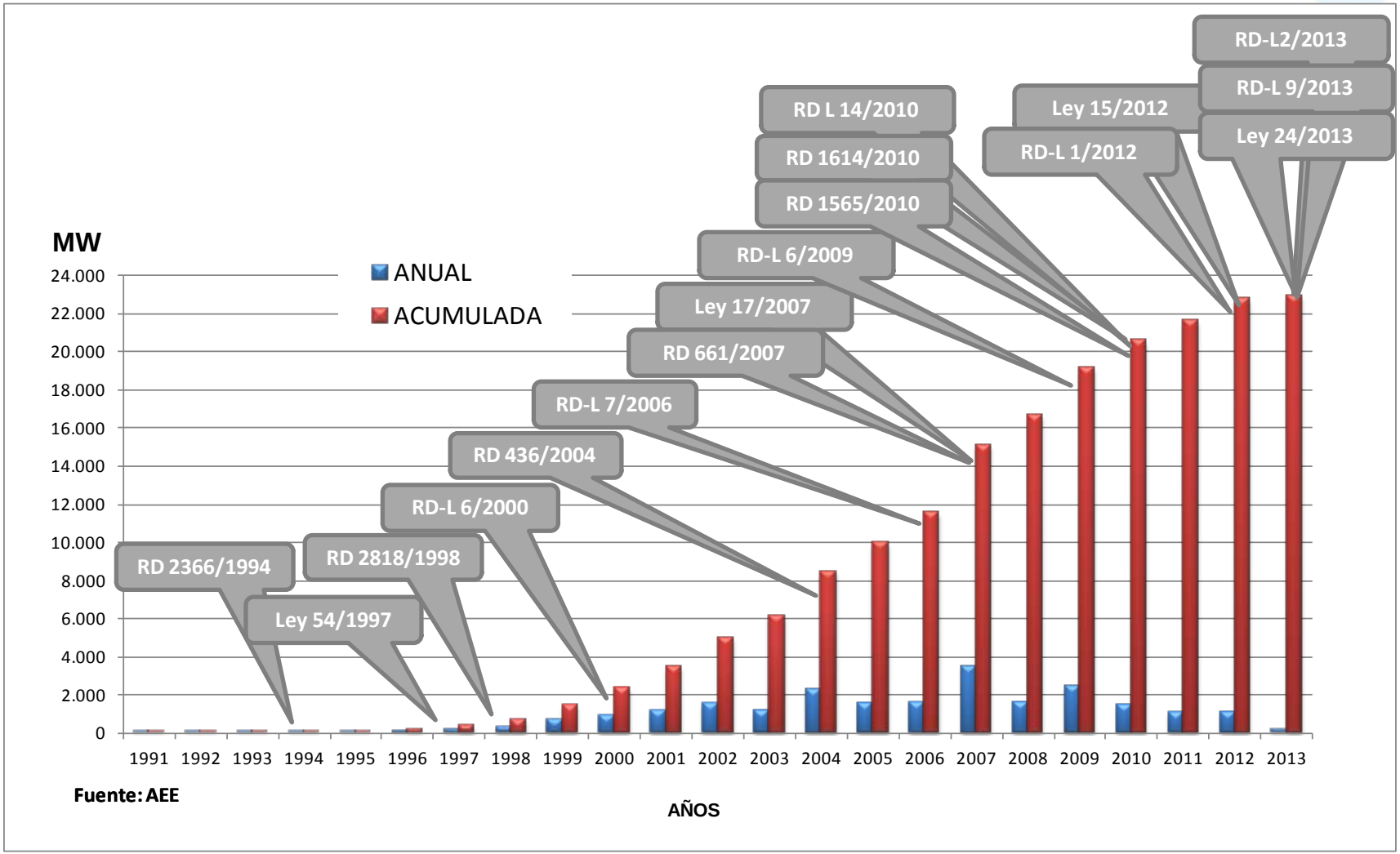
3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities
- Leadership & competence of KIC IE Partners
- KIC IE industry interest and commitment:
  - Outsourced & collaborative open-innovation strategy
  - Guarantee for KIC IE impact on the market

3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities
- Leadership & competence of KIC IE Partners
- KIC IE industry interest and commitment
- Foreseeable regulatory impact:
  - Dependence of technology deployment on regulatory issues (support schemes, grid access, etc…)
  - High regulatory volatility (for renewables)

3- Innovation assessment criteria: Spanish case study



Installed wind power in Spailn and the evolution of the regulatory framework

(source: AEE, the Spanish Wind Energy Association)

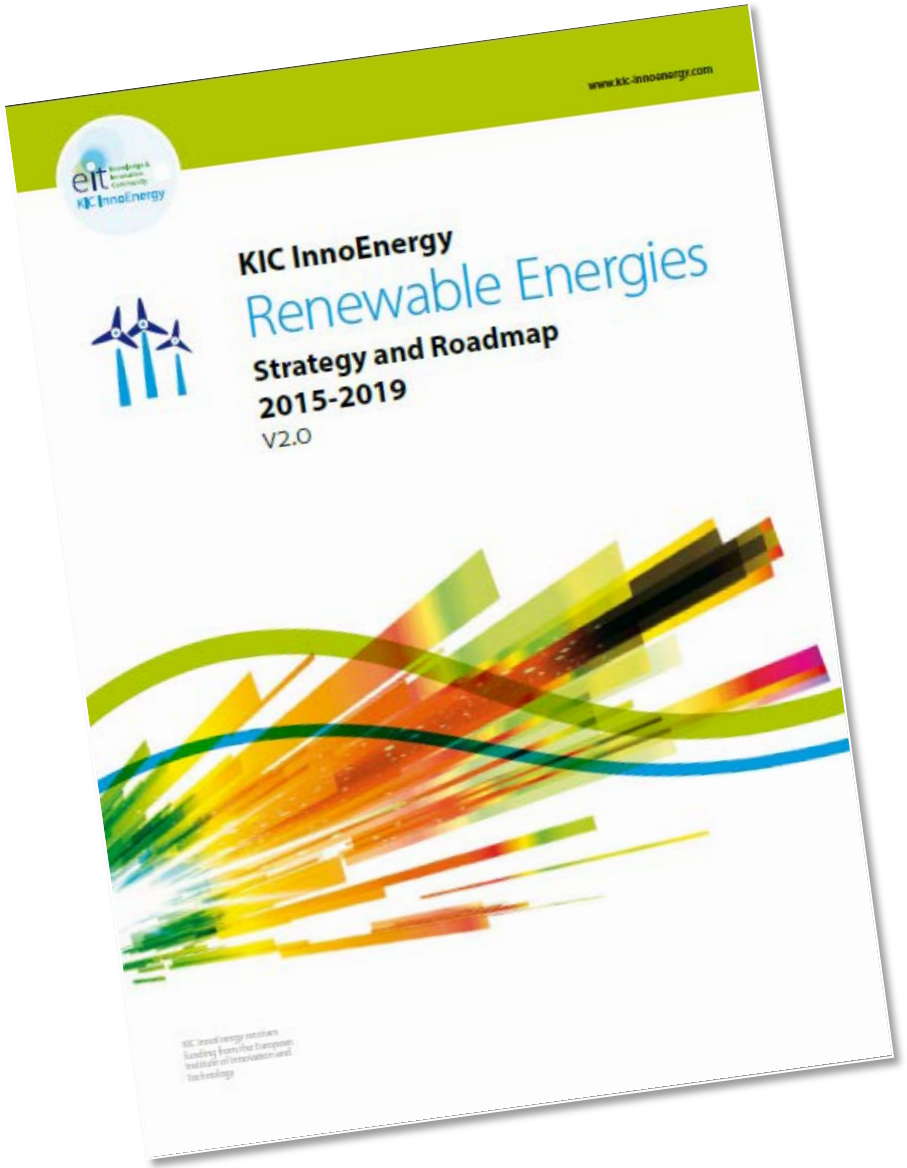
3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities
- Leadership & competence of KIC IE Partners
- KIC IE industry interest and commitment
- Foreseeable regulatory impact
- Required investment to develop the innovation:
  - Cost / Benefit analysis

3- Innovation assessment criteria

- Time to market
- Impact on KIC InnoEnergy 3 strategic priorities
- Leadership & competence of KIC IE Partners
- KIC IE industry interest and commitment
- Foreseeable regulatory impact
- Required investment
- Cross impact in several applications:
  - Products addressing other sectors' problems.

4- Technology roadmaps: Renewable Energy



4- Technology roadmaps: Wind

WIND ENERGY

2020 Challenges

- Reduction of the LCOE through Wind Farm and O&M improvements, risks mitigation
- Adapt turbine design to Northern Africa specific conditions, including innovative concepts and materials of the components
- Better accuracy of the wind assessment for design improvement, siting & layout and production forecast
- Adapted production processes and logistics: manufacturing, transport and installation solutions
- Improving grid integration for increasing wind energy deployment, including energy storage and low to mid voltage applications
- Develop the use of small and mid-scale wind turbines

Products & Services

Wind Turbine and Substructures

- 1.1 Design tools for wind turbine components and systems
- 1.2 Improvement for existing turbines
- 1.3 New conceptual designs – scaled prototype / test benches
- 1.4 Innovative materials and manufacturing processes including new quality controls
- 1.5 Wind turbine logistics and installation

Wind Farm

- 2.1 Design of the global control of the wind farm for optimizing the AEP
- 2.2 WF layout: Optimization of the layout under multiple constraints to reduce WF LCOE
- 2.3 Optimization of floating wind farm LCOE
- 2.4 Wind farm installation cost optimization

Operation & Maintenance

- 3.1 Condition monitoring
- 3.2 Enhanced operation & maintenance
- 3.3 Design of the Mid-term Wind and Sea State Assessment Chain
- 3.4 Near-free maintenance

Grid and Power Transmission

- 4.1 Grid and power transmission adaptation on extreme climate
- 4.2 Energy storage
- 4.3 Improve grid transmission, especially for long distance by new technologies, incl. offshore substations
- 4.4 Optimization of global wind energy contribution by looking on grid level, including ancillary services and inertia

2014 2016 2018 2020

Target

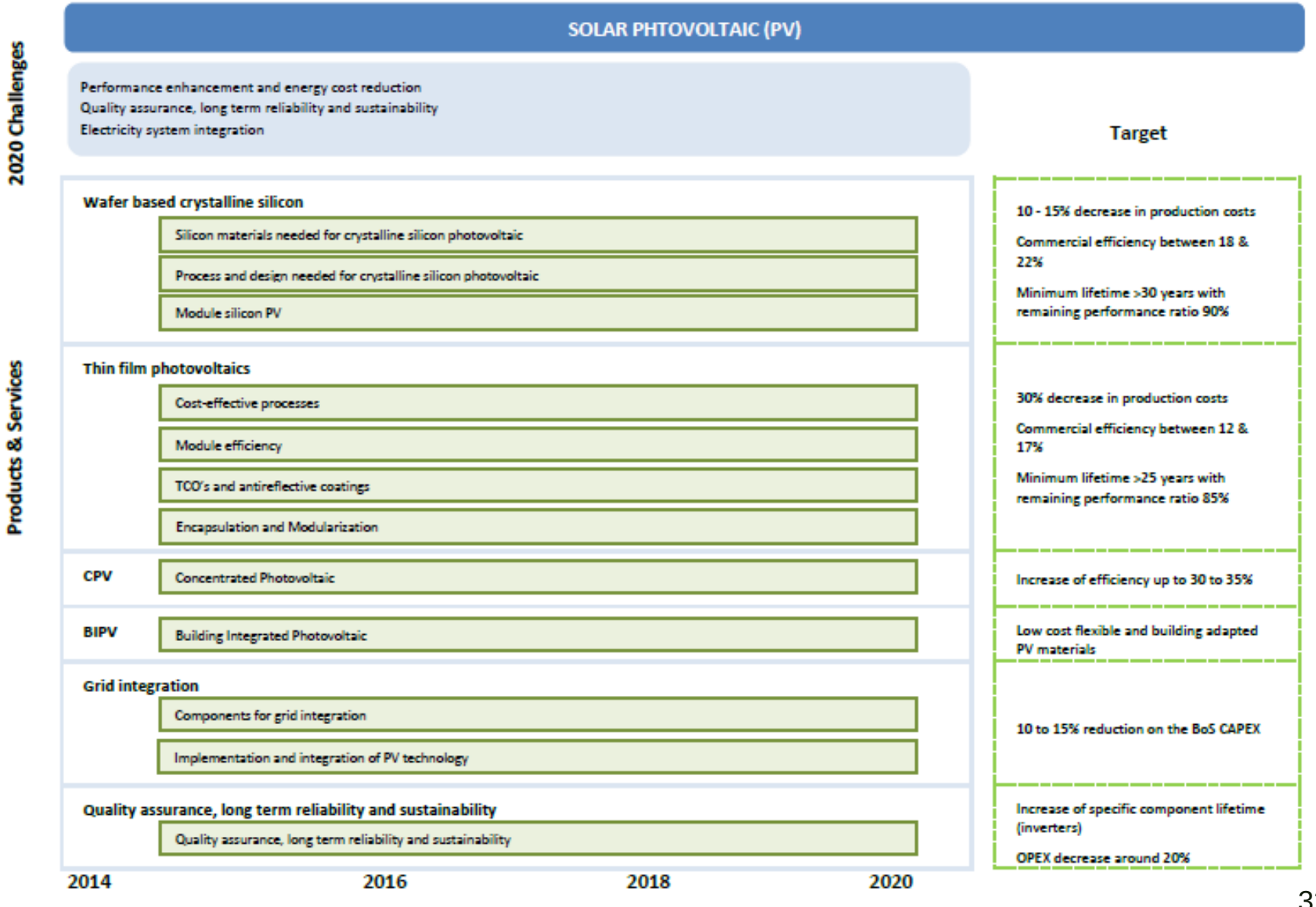
CAPEX reduction, lifetime increase and higher reliability.
Higher energy yield
Potential LCOE reduction:
Offshore: 9%
Onshore: 3%

CAPEX and OPEX reduction and energy yield by a global approach on wind farm optimization
Potential LCOE reduction:
Offshore: 6%
Onshore: 3%

OPEX cost reduction and higher reliability, possible lifetime extension
Potential LCOE reduction:
Offshore: 4%
Onshore: 3%

Higher reliability and less power losses for LCOE reduction. Potential LCOE reduction:
Offshore: 4%
Onshore: 1%
Enabling higher penetration in electrical grid by ancillary services and energy storage

4- Technology roadmaps: PV



4- Technology roadmaps: STE

SOLAR THERMAL ELECTRICITY (STE)

2020 Challenges

- Increasing competitiveness of STE plants and reduce land requirement
- Lowering investment and O&M costs in order to reduce LCOE
- Better dispatchability and grid integration allow a higher market penetration
- Finding solutions for countries with specific constraints (scarce water, sand storms)

Products & Services

Higher plant efficiency

- Plant monitoring, control, and continuous on-site quality control of solar equipment
- Improved selective coatings; more effective designs for CRs
- New working fluids and/or receiver conditions for higher temperatures
- Software development at component and system level

Lower investment and O&M costs

- Improved solar concentrators designs & more cost-effective sun tracking systems.
- Improved durability of key components & lower water consumption for cleaning mirrors

Better dispatchability

- Improved sensible heat storage concepts
- Tools for solar radiation forecasting and nowcasting

Development of markets with specific constraints (scarce water, sand storms)

- Advanced dry-cooling systems
- Methodology to analyse degradation and predict lifetime of key components.

Target

- LCOE reduction between 24,1% (PTC) and 21,5% (LFR) is possible on midterm.
- LCOE reduction between 8% (CR) and 4,4% (LFR)is possible on midterm.
- LCOE reduction between 3,6% (PTC) and 1% (LFR)is possible on midterm.
- In order to achieve lower environmental influences even an increase on the LCOE of 2,3% is accepted.

2014 2016 2018 2020

4- Technology roadmaps: Ocean

OCEAN ENERGY

2020 Challenges

- Improve reliability and performance, energy yield and costs
- Better understand the resource and how to harness it.
- Improve installation and O&M techniques.
- Demonstrate reliable full-scale prototypes of 1-2MW machines.
- Develop game changer wave and tidal technologies.

Products & Services

Enabling technologies for wave and tidal

- Subsea electrical infrastructure
- Foundations & moorings
- Power Take-off and BOP components
- O&M: smart condition monitoring systems
- Materials: innovative materials and coatings

Wave and tidal converters

- Demonstration of innovative concepts at TRL 7
- Development of disruptive concepts at TRL 5

2014 2016 2018 2020

Target

High reliable and low cost submarine electrical components, wet mates and cables
CAPEX and OPEX reduction and life time increase
Better balance of power and more efficient and reliable PTO
Lower cost fixed foundations for tidal and bottom fixed wave converters

Demonstration of full-scale, single device the ability to deliver a significant reduction of LCOE.
Development of game changer solutions for wave and tidal energy.

KIC InnoEnergy projects answering the roadmaps

Kastrion


Current & vibration analysis for preventive & predictive condition based maintenance in offshore wind farms.

MicroLubGear


Automatic lubrication device for pitch and yaw gears

2020 Chall...

- ...the energy prediction
- ...installation costs, especially in Offshore
- ...ncepts and materials of the components for Onshore ar... ...wind Turbines, incl...
- ...the power transmission and grid integration for incre... ...wind farms deployment, in...

Neptune


A floating LIDAR solution to the current challenges of wind measuring for offshore wind farms.

Products & Services

Wi... ...arm and O&M improvements

- Monitoring systems
- Wind & weather forecast. Energy accurate prediction
- Installation and deployment. Logistics (offshore)

...increase. Monitoring brings up reliability...

MDWind


Robotic submarine Geotechnical site investigation for offshore wind

...energy.

Wind Turbine design – Including substructures (priority offshore)

- Design tools for wind turbine components
- New conceptual designs. Scaled prototypes (wind turbines and substructures)
- Improvement for existing turbines
- Innovative materials and manufacturing...

AFOSP


Alternative floating offshore substructures for offshore wind farms

...For innovative materials: automated...

RETRO-FIT DEICE


De-Icing of existing wind turbines using microwave technology

Wind Turbine and Wind Farm control

- Advanced sensors to control, to reduce loads and environmental risks, and to improve effi...

Offwindtech


To enable the future deep water offshore wind energy technology

Power transmission and integration

- Power transmission systems: electrical infrastructure a... ...tatio...

...fficiency of storage system. >70%

OTS


Offshore Test Station
Offshore Renewables enabling products and services

2012 2014 2016

How can we measure the impact of technology innovation?

Why?

→need to know the impact of:

- Our strategy
- Our projects → products/services
- Our ventures

Analysis to retro-feed our strategy, validate or change our decisions.

Impact analysis in several dimensions and according to our objectives:

- Cost
- GHG emissions
- Security of supply

…but not only:

- Employment
- Industrial leadership
- Macroeconomics (GDP, import/export balance, etc.)

5- Impact Analysis: cost reduction potential (LCOE analysis)

- **Deliverables**:

www.kic-innoenergy/reports

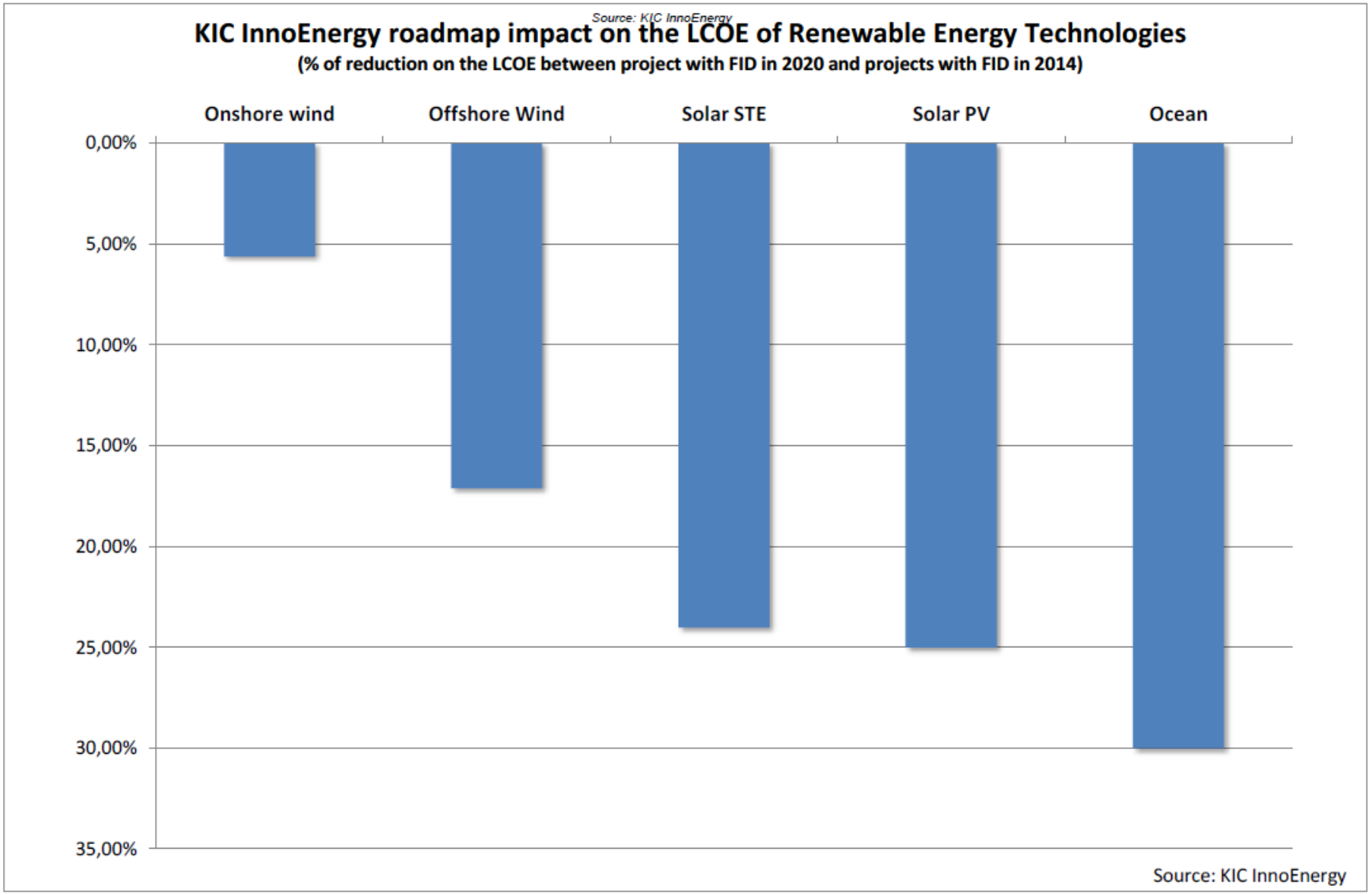
Online, access free cost tool

DELPHOS

(end 02/2015)

Series of report:
"Future renewable energy cost"
→Onshore wind
→Offshore wind
→STE
→PV (1st semester 2015)

5- Impact analysis: LCOE method applied to our roadmaps



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