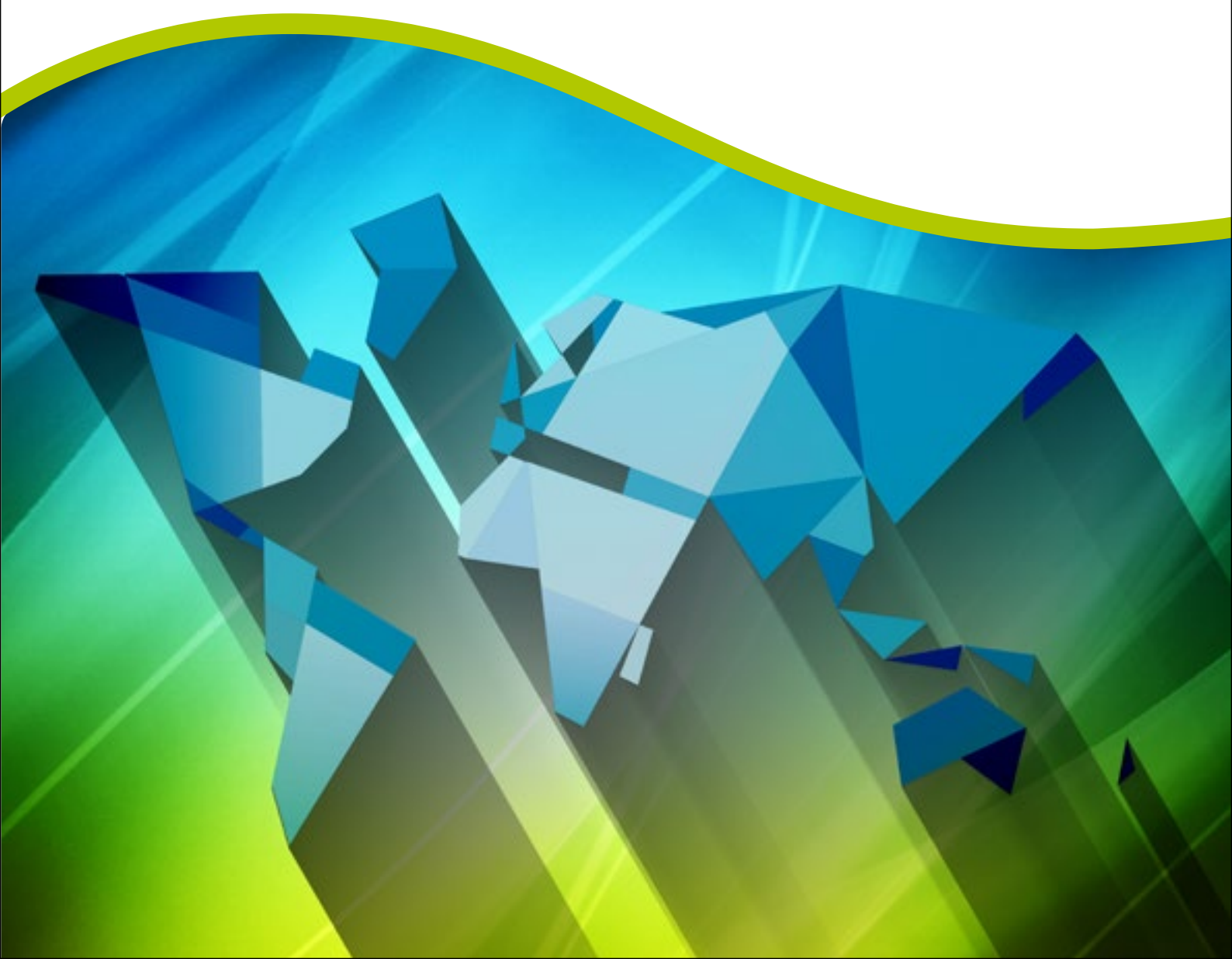




# Top 10 Energy Innovators in 100 Energy Priorities

**A unique report mapping industrial and academic players  
in global competition**



## About Questel Consulting

Questel provides a comprehensive suite of web-based services for productivity and collaboration dedicated to intellectual property. Covering the entire innovation cycle, from idea to product, Questel's offerings include:

- Competitive intelligence and technological landscape,
- Ideation management and innovation capture,
- Technology scouting and licensing-in,
- Invention management and prior-art searching,
- Portfolio management and pruning,
- Licensing-out and monetization.

Questel Consulting team is the result of the fusion of Avenium in France (created in 2002 as a spin-off of the CEA) and the PatentPeople in the US (created in 2008). Questel Consulting team is specialized in management and strategy for intellectual property and technology.

### OUR CLIENTS & FIELDS OF EXPERTISE

Our customers are international groups, SME and start-ups as well as academic research centers.

Our diversified fields of expertise cover energy, micro-electronics, transportation, materials, chemistry, pharmaceuticals, life sciences, etc.

### OUR SERVICES

Assist our clients in building their industrial property strategy and enabling them to:

- sustain competitive advantage
- speed up R&D
- mitigate risks
- maximize profit

Assist our clients in portfolio valorisation and technology transfer for their patented inventions.

## KIC InnoEnergy

KIC InnoEnergy SE is the European company dedicated to promoting innovation, entrepreneurship and education in the sustainable energy field by bringing together academics, businesses and research institutes.

Our goal is to make a positive impact on sustainable energy in Europe. We do this by creating future game changers with a different mind-set, and bringing innovative products, services and successful companies to life.

KIC InnoEnergy is one of the first Knowledge and Innovation Communities (KICs) fostered by the European Institute of Innovation and Technology (EIT). We are a commercial company with 27 shareholders that include top ranking industries, research centres and universities, all of which are key players in the energy field. More than 150 additional partners contribute to our activities to form a first class and dynamic network that is always open to new entrants and furthers our pursuit of excellence. Although we are profit-oriented, we have a "not for dividend" financial strategy, reinvesting any profits we generate back into our activities.

With our headquarters in the Netherlands, we develop our activities across a network of offices located in Belgium, France, Germany, the Netherlands, Spain, Portugal, Poland and Sweden.

KIC InnoEnergy & Questel Consulting

# Top 10 Energy Innovators in 100 Energy Priorities

**A unique report mapping industrial and academic players  
in global competition**

January 2015

Authors at Questel Consulting

**Benoit Chevalier**

*Senior consultant*

**Gladys Corrons-Bouis**

*Senior consultant*

**Jonathan Dominici**

*Consultant*

**Nathalie Mantrand**

*Senior consultant*

**Cyril Mavré**

*Senior consultant / Associate director*

**Eugénie Mériegault**

*Senior consultant*

**Benjamin Morel**

*Consultant*

**Mathis Theillet**

*Consultant*

Coordination of the study

**Celine Jullien**

*Industry Program Management Officer, KIC-IE*

KIC InnoEnergy Thematic Leaders

**Lucienne Krosse**

*Intelligent Energy Efficient Building and Cities*

**Antoni Martinez**

*Renewable Energies*

**Bo Normark**

*Smart Grids and Electric Storage*

**Tomasz Szmuc**

*Clean Coal and Alternative Gas Technologies*

**Laurent Thibaudeau**

*Sustainable Nuclear and Renewable*

*Energy Convergence*

# Glossary

## Players acronyms

**AAU.** University of Aalborg  
**AIST.** National Institute of Advanced Industrial Science and Technology  
**BP.** British Petroleum  
**CAS.** Chinese Academy of Sciences  
**CEA.** Commissariat à l’Énergie Atomique et aux énergies alternatives  
**CEPRI.** China Electric Power Research Institute  
**CERTAM.** Centre d’Etude et de Recherche Technologique en Aérothermique et Moteurs  
**CIEMAT.** Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas  
**CIRAD.** Centre de coopération International en Recherche Agronomique pour le Développement  
**CNRS.** Centre National de la Recherche Scientifique  
**CRIEPI.** Central Research Institute of Electric Power Industry  
**CSIC.** Consejo Superior de Investigaciones Científicas  
**CSIR.** Council of Scientific Industrial Research  
**DLR.** Deutsches Zentrum für Luft- und Raumfahrt  
**DOE.** Department Of Energy  
**DTU.** Denmark Technology University  
**EDF.** Électricité de France  
**EPFL.** École Polytechnique Fédérale de Lausanne  
**EPRI.** Electric Power Research Institute  
**ETH.** Eidgenössische Technische Hochschule  
**ETRI.** Electronics and Telecommunications Research Institute  
**GE.** General Electric  
**IFP.** Institut Français du Pétrole  
**IMEC.** Interuniversity Microelectronics Centre  
**IREC.** Catalonia Institute for Energy Research  
**ITRI.** Industrial Technology Research Institute  
**JOGMEC.** Japan Oil, Gas and Metals National Corporation  
**KEPCO.** Korea Electric Power Corporation  
**KIER.** Korea Institute of Energy Research  
**KIST.** Korea Institute of Science and Technology  
**KTH.** Kungliga Tekniska högskolan  
**KU Leuven.** Katholieke Universiteit Leuven  
**MHI.** Mitsubishi Heavy Industries  
**MIT.** Massachusetts Institute of Technology  
**NIMS.** National Institute for Materials Science  
**NREL.** National Renewable Energy Laboratory  
**OWET.** Oregon Wave Energy Trust  
**TEPCO.** Tokyo Electric Power Company  
**TNO.** Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek  
**UPC.** Universitat Politècnica de Catalunya  
**UPM.** Universidad Politécnica de Madrid  
**ZAE.** Zentrum für Angewandte Energieforschung

## Economic & business acronyms

**CAGR.** Compound Annual Growth Rate  
**IP.** Intellectual Property  
**JV.** Joint Venture  
**R&D.** Research and Development  
**RoW.** Rest of the World  
**SME.** Small and Medium Enterprises

## Technical acronyms

**BMS.** Battery Management System  
**CAES.** Compressed air energy storage  
**CCS.** Carbon Capture and Storage  
**CdTe.** Cadmium Telluride  
**CHP.** Combined Heat and Power  
**CIGS.** Copper indium gallium selenide  
**CIS .** Copper Indium Selenide  
**CO<sub>2</sub>.** Carbon Dioxide  
**CSP.** Concentrating Solar Power  
**CZTS.** Copper zinc tin sulfide  
**DC.** Direct Current  
**DRM.** Dry Reforming of Methane  
**EMS.** Energy Management Solution  
**ESCo.** Energy Service Company  
**FACTS.** Flexible AC Transmission System  
**GaN.** Gallium Nitride  
**H<sub>2</sub>.** Dihydrogen  
**Hg.** Mercury  
**HVAC.** Heating, Ventilating, and Air Conditioning  
**HVDC.** High Voltage Direct Current  
**ICT.** Information and Communication Technologies  
**IR.** InfraRed  
**KCl.** Potassium Chloride  
**Li.** Lithium  
**NaS.** Sodium Sulfur  
**NiMH.** Nickel Metal hydride  
**Nox.** Nitrogen oxide  
**O&M.** Operation and Maintenance  
**OCAS.** Obstacle Collision Avoidance System  
**PC.** Polycarbonate  
**PCM.** Phase Change Material  
**PEM.** Proton Exchange Membrane  
**PV.** Photovoltaic  
**ROV.** Remotely Operated Vehicles  
**SBM.** Single Buoy Mooring  
**SiC.** Silicon Carbide  
**Sox.** Sulphur oxide  
**T&D.** Transmission and Distribution  
**TCO.** Transparent Conductive Oxide  
**TFPV.** Thin Film Photovoltaic  
**UCG.** Underground Coal Gasification  
**UHV.** Ultra High Voltage  
**VSC.** Voltage Source Convertors  
**VSD.** Variable Speed Drive

# Table of contents

Introduction	4
Methodology	6
Global Results	8
Type of most Innovative Players	10
Innovative Players by frequency of appearance	12
<b>Wind Energy</b>	<b>14</b>
<b>Ocean Energy</b>	<b>40</b>
<b>Solar Photovoltaic System</b>	<b>58</b>
<b>Solar Thermal Electricity</b>	<b>92</b>
<b>Intelligent Energy Efficient Buildings and Cities</b>	<b>124</b>
<b>Smart Grids and Electric Storage</b>	<b>154</b>
<b>Renewable Energy Convergence</b>	<b>186</b>
<b>Clean Coal and Gas Technologies</b>	<b>232</b>
About KIC InnoEnergy	278

# Methodology

## 100 energy priorities

### A KIC InnoEnergy selection

This report provides an in-depth understanding of the global competitive energy landscape, identifying and ranking the top 10 industry and academic players according to their innovation competencies.

**The 100 energy priorities are KIC InnoEnergy priorities, defined in its Roadmaps in the following thematic fields**

(to be found at <http://cip2014.kic-innoenergy.com/thematic-roadmaps/>)

- Renewable Energies (Photovoltaic, Solar thermal, Ocean, Wind energies)
- Clean Coal and Gas Technologies
- Intelligent Energy-Efficient Buildings and Cities
- Smart Grids & Electric Storage
- Sustainable Nuclear & Renewable Energy Convergence
- Energy Efficiency in the industry

## Top 10 players

### A Questel Consulting-KIC InnoEnergy methodology

**The methodology combines 9 key performance indicators (KPI)**

and an adapted weighting and scoring method to make relative comparisons possible across thematic fields and by player type. The selected KPI and corresponding scores concern quantitative and qualitative measures of patents, scientific publications, strategic involvement in each topic, collaboration in R&D, and R&D commercialisation, all viewed as essential to defining innovation competencies.

#### Sources of information

- Professional databases: Orbit®, Thomson Innovation®, Web of Knowledge®, OneSource®.
- Public information: players' press releases, technology transfer offices' websites, financing institutions' websites (Cordis, enGrant Scientific), thematic fields' websites (news, associations), and players' annual reports.
- KIC InnoEnergy survey: to partners and to 850 top industry and academic players worldwide.

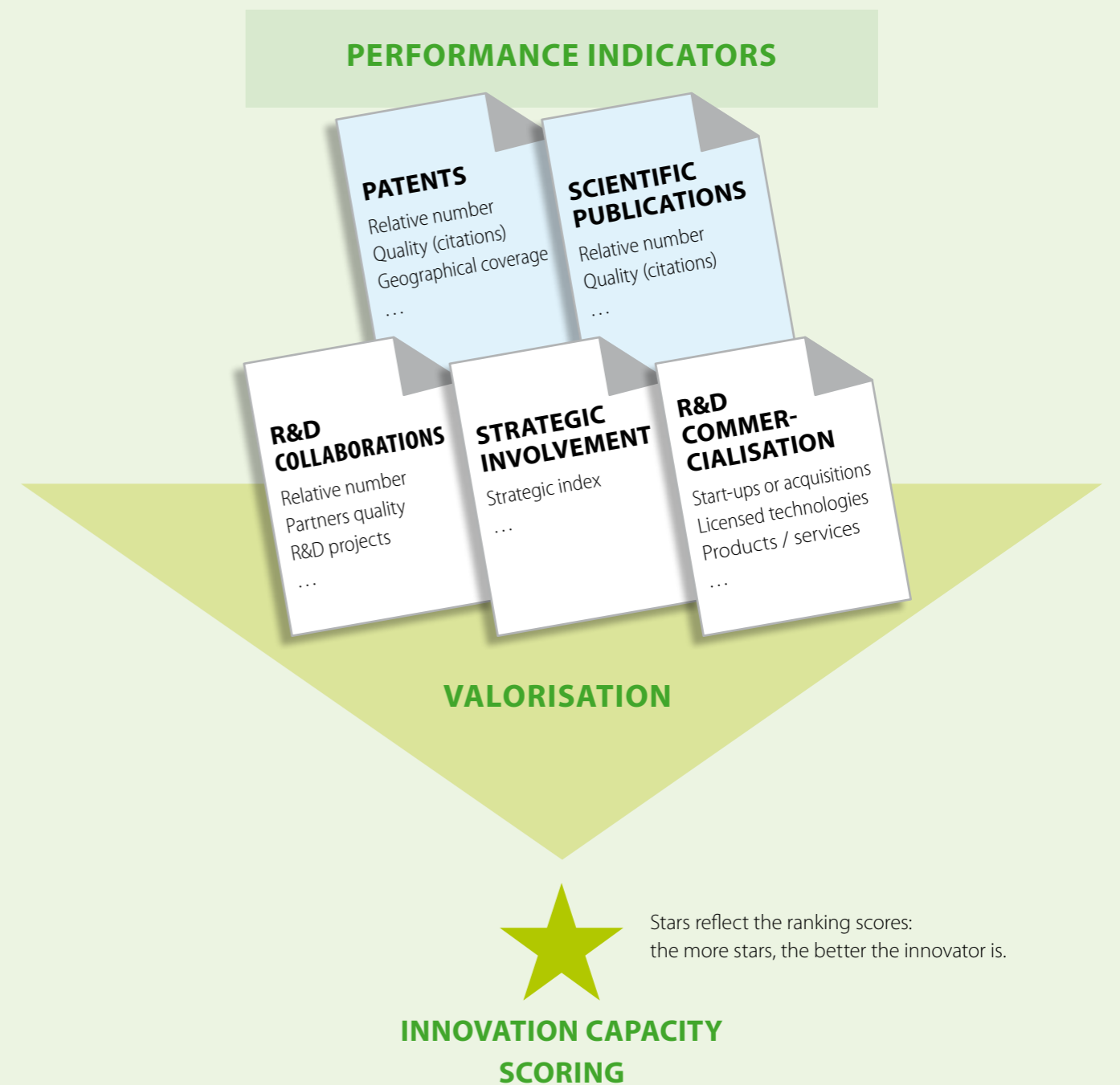
#### Report summary in figures

- ~150,000 Patents
- ~180,000 Scientific Publications
- 1,890 identified R&D collaborations
- 340 identified acquisitions /created start-ups
- 1,227 identified products /services and licenses
- 2,000 identified and ranked top 10 industry and academic players

#### 9 key performance indicators

- Relative number of patents
- Quality of patents (citations, geographical coverage...)
- Relative number of scientific publications
- Quality of scientific publications (citations)
- Relative number of industrial and academic collaborations (R&D projects)
- R&D Project Partners quality
- Strategic index (relevance of the priority for the player)
- Existing Spin-offs, new branches or subsidiaries, or acquired companies
- Commercialised products/services, licensed technologies

## Key Players identification process



#	ASSIGNEE	COUNTRY	SCORING		
			IP	PUBLICATION	VALORISATION
1	Company / Institution	Headquarters	★	★★	★★★

# Type of most Innovative Players

## INDUSTRY PLAYERS

This classification shows the Top 30 innovative industrial players in all 100 energy priorities. If they are the best in one thematic field they are labelled *Pure players*, in more than one thematic field, *Multi-positioned players*, or in many thematic fields, *Widely positioned players*.

It shows by thematic field (ocean, wind...) the type of innovative top 30 players.

The top 30 industrial innovative players are mostly pure players, with the exception of ABB as a top innovator in 6 out of the 8 thematic fields.

One third of the top 30 are in the ocean energy field.

None of the top 30 innovative players are active in the wind and smart grids fields (except ABB).

### Pure Players

#### Ocean Energies

Curtiss Wright Flow Control Corp  
Atlantis Resources Corp Pte  
Hydra Tidal Energy Technology  
Artemis Intelligent Power Limited  
Hywind AS  
Global Marine Systems Ltd  
Power-One Renewable Energy Solutions Llc  
Neptune Wave Power Llc  
Technip  
Rosemount Inc  
Subsea 7 Ltd

#### Smart and Intelligent Cities and Buildings

Philips  
Flex Energy  
Micro Turbine Technology  
Energetix Genlec Limited

#### Renewable Energy Convergence

Chlorine Eng Corp Ltd  
Shanghai Municipal Elec Power  
Dresser-Rand  
Shanghai Electric Sodium Sulfur Batteries  
Valeo  
NGK Insulators  
Beacon Power

#### Clean Coal Technologies

Halliburton  
Andritz  
Newmarket Corp  
Schlumberger

#### Solar Thermal Electricity

Brightsource Energy Inc

#### Solar Pv

First Solar

#### Wind Energy

#### Smart Grid And Storage

### Multi-Positioned Players

Baker Hughes

### Widely Positioned Players

ABB

## ACADEMIC PLAYERS

This classification shows the Top 30 innovative academic players overall the 100 energy priorities, sorting out if they are the best in one thematic field, as *Pure players*, in more than one thematic field as *Multi-positioned players*, or in many as *Widely positioned players*.

It shows per thematic fields (Ocean, Wind...) the type of Top 30 innovative players.

3 thematic fields regroup 70% of the top 30 players: clean coal technologies, renewable energy convergence and solar PV.

None of the top 30 innovative players are in wind energy.

The Chinese Academy of Science is the only top 30 player well positioned in all 8 thematic fields.

### Pure Players

#### Ocean Energies

IFREMER

#### Smart and Intelligent Cities and Buildings

#### Renewable Energy Convergence

Japan Nucl Cycle Dev Inst  
JAEA - Japan Atomic Energy Agency  
NIMS (Japan) - National Institute for Materials Science  
Kyoto University  
Univ Gyeongsang  
GKSS-Forschungszentrum Geesthacht  
Florida State University System

#### Clean Coal Technologies

Centre Coop. Int. Rech. Agronomique pour le Developpement (CIRAD)  
University of Wyoming  
Korea Research Institute of Chemical Technology  
China University of Petroleum  
China University of Geosciences  
CAS - Chinese Academy of Sciences  
Univ Washington State  
China University of Mining & Technology

#### Solar Thermal Electricity

University of Queensland

#### Solar Pv

Universität Konstanz  
University of Princeton  
Helmholtz Zentrum  
The University of Toledo  
IMEC  
Florida University  
Univ Leland Stanford Junior

#### Wind Energy

#### Smart Grid And Storage

Yonsei University

### Multi-Positioned Players

Consejo Superior de Investigaciones Cientificas (CSIC)  
Wisconsin University  
German Aerospace Center (DLR)  
Tokyo University  
National University of Singapore  
Huazhong University of Science & Technology

### Widely Positioned Players

CAS - Chinese Academy of Sciences

# Micro-Combined Heat and Power (CHP) for small non-residential buildings

This cluster corresponds to microturbines related to heat and power systems. No specific restriction has been applied on non-residential building applications.

## INDUSTRY PLAYERS

184

Patent Families

8.2

% CAGR 2000-2011

Inventive activity is very low in this area, mainly because the thematic field is very limited and because local energy production is an emerging market. We observe that pure players, Energetix Genlec, Micro Turbine Technology and Flex Energy, lead this priority in terms of innovation capacity, as they acquired companies and/or have produced spin-off entities. Flex Energy acquired Ingersoll in 2011 and created the Ener-Core spin-off in 2012 and they also offer quite significant product portfolios. A lot of SMEs are among these top 10 leaders along with just a few conglomerates, General Electric and Panasonic. For example, Energetix Genlec, a small UK-based company specialised in micro-CHP; Ormat Technologies, an Israel-based company specialised in recovered energy generation, and Efficient Energy, a German company specialised in heating and cooling systems, are all well positioned. Hiflux and Microgen Engine, two UK-based companies the technologies of which have applications in a micro-CHP system, are both interesting players involved in this field.

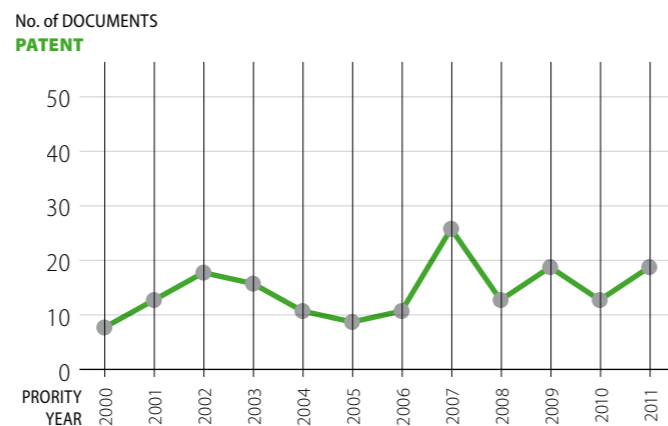
### Top 10 reference Companies

#	ASSIGNEE	COUNTRY	SCORING	
			IP	VALORISATION
1	Energetix GENLEC	United Kingdom	★★★	★★
2	Micro Turbine Technology	The Netherlands	★★	★★
3	Flex Energy	United States	★★	★★
4	Korea District Heating Corp	South Korea	★★	★
5	General Electric	United States	★★	★
6	Matsushita - Panasonic - Sanyo	Japan	★★	★
7	Efficient Energy	Germany	★★	
8	VAST Power Portfolio	United States	★★	
9	TMA Power	United States	★★	★
10	ORMAT Technologies	United States	★★	★



Geographical distribution of priority countries (%)

### Evolution of patent filings



## ACADEMIC PLAYERS

22

Patent Families

11.6

% CAGR 2000-2011

Academic players seem much less involved than industrial and pure players, with few patents and industrial collaborations. Even though scientific publication activity is higher, no clear academic leader emerges. The Polytechnic University of Milan is one of the innovation landscape leaders in this area, with high-quality scientific publications and participation in two European R&D collaborations. The skills of German Aerospace Center and VITO can also be highlighted as they appear among the top 10 innovators in this area.

### Top 10 reference Research Institutions

#	ASSIGNEE	COUNTRY	SCORING		
			IP	PUBLICATION	VALORISATION
1	AIST (Japan)	Japan	★★★	★★	
2	North China Electric Power University	China	★★	★★	
3	Polytechnic University of Milan	Italy		★★★★	
4	German Aerospace Center	Germany	★★	★	
5	Kyushu Institute of Technology	Japan	★★	★	
6	Korea Institute of Science and Technology (KIST)	South Korea	★★★★		★
7	Battelle Memorial Institute	United States	★★		★
8	US DOE - Department of Energy	United States		★★	
9	VITO	Belgium	★★		
10	Oregon State University	United States	★★	★	



Geographical distribution of priority countries (%)

### Evolution of patent filings and article publications

