International Energy Agency
Secure
Sustainable
Together

EGRD workshop 14-15 June 2017

Blue sky research for energy technology

Disruptive innovation

Carrie Pottinger
Programme Manager, Technology R&D Networks
EGRD Secretary

www.iea.org

© OECD/IEA 2017

Overview

- IEA overview
- IEA efforts to facilitate innovation
- Disruptive innovation (DI) – some considerations

© OECD/IEA 2017

Overview of the IEA

- Energy, the economy and climate
- Energy security, economic growth, environmental protection
- Engagement worldwide

© OECD/IEA 2017

International Energy Agency

International Energy Agency
Secure Sustainable Together

- **IEA MEMBER COUNTRIES**
  - Asia-Pacific
  - Europe
  - North America

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

The 3 ‘E’s of sound energy policy

Energy security

- **Promote diversity, efficiency and flexibility** within the energy sectors of the IEA member countries.
- **Remain prepared collectively** to respond to energy emergencies.
- **Expand international cooperation** with all global players in the energy markets.

Environmental protection

- **Develop more environmentally acceptable energy options**.
- **Promote greenhouse gas emission abatement**, through energy efficiency and the use of low-carbon and cleaner fossil fuels.
- **Assess best options to address climate change**.

Economic growth

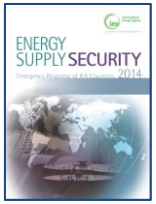
- Work to ensure the stable and affordable supply of energy and promote free markets in order to foster economic growth.
- **Promote access to modern energy services globally**.

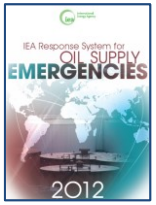
© OECD/IEA 2017

Energy security

Emergency response - coordinated actions

- Foundation of IEA mission
- In case of disruption, we take action
- Global co-operation plays an important role during oil supply disruption





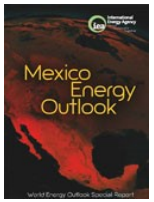
Evolving mandate

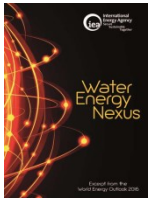
- Broaden oil security mandate to draw in more partner countries
- Strengthen capacity in global gas supply security
- Continue and deepen work on electricity security in context of the low-carbon transition

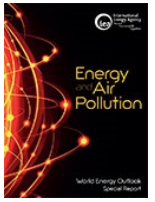
© OECD/IEA 2017

Economic growth

- ***World Energy Outlook (WEO)***
  - 450 ppm scenario
  - Regional focus: Mexico (2016), China (2017)
  - Special reports: Air Pollution (2016), Water-Energy Nexus (2017)

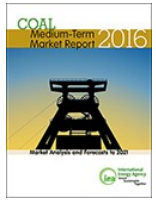


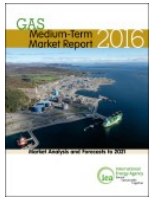


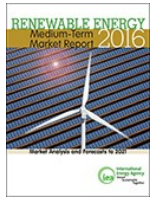


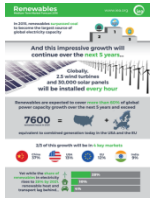
- ***World Energy Investment (WEI)***
  - Global levels of investment
  - Countries attracting the most capital
  - Technologies with highest investments
  - Effects of fuel prices on technology investments

- ***Market analysis***
  - Oil
  - Coal
  - Gas
  - Energy efficiency
  - Renewables









© OECD/IEA 2017

Environmental protection

Supporting diversity of energy supply

- Deployment of commercialised technologies
- Market trends
- Potentials of nascent technologies
- Roadmaps (21 technologies or sectors)

Reducing energy demand – the low hanging fruit

- Energy efficiency recommendations
- Energy efficiency policy pathways

Examining climate change policies

- Identify policy instructments for least-cost CO2 reductions
- Provide technical support to UN climate negotiations

© OECD/IEA 2017

Cross-cutting activities

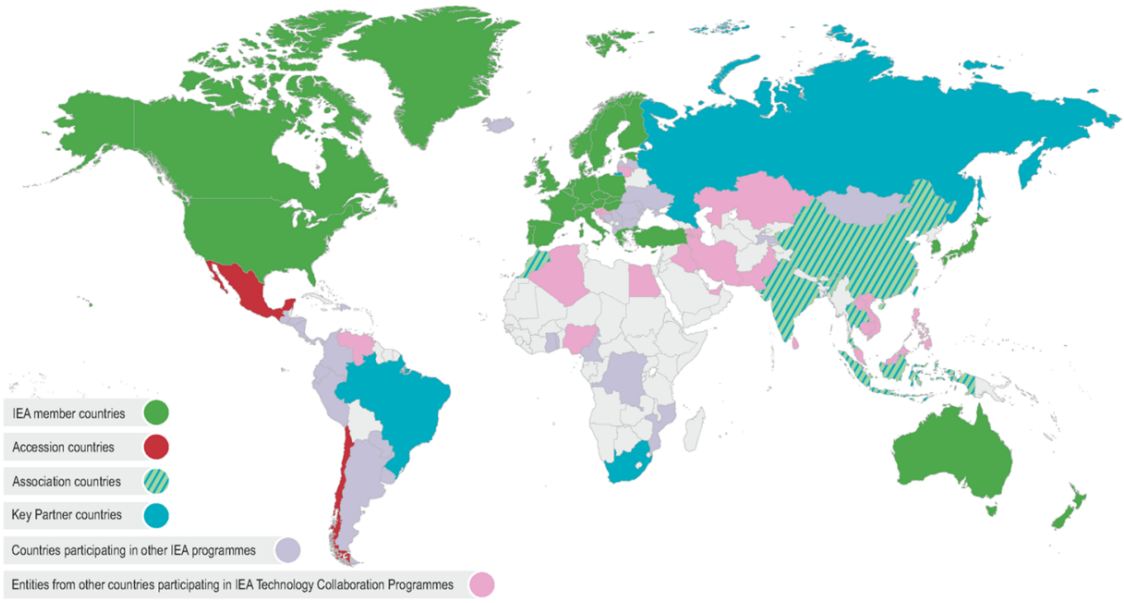
- **Policy analysis**
  - Member and selected partner countries
  - Policies and measures searchable online database

- **Statistics**
  - Online energy atlas and data queries
  - Mobile phone APP, CDROMs, publications

© OECD/IEA 2017

Engagement worldwide

- **Accession countries**
  - Chile, Mexico
- **Association countries**
  - China, India, Indonesia, Morocco, Singapore, Thailand
- **Other Partner countries**
- **Activities**
  - Energy policy reviews
  - Research projects
  - Data sharing
  - Participation in Technology Collaboration Programmes (TCPs)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

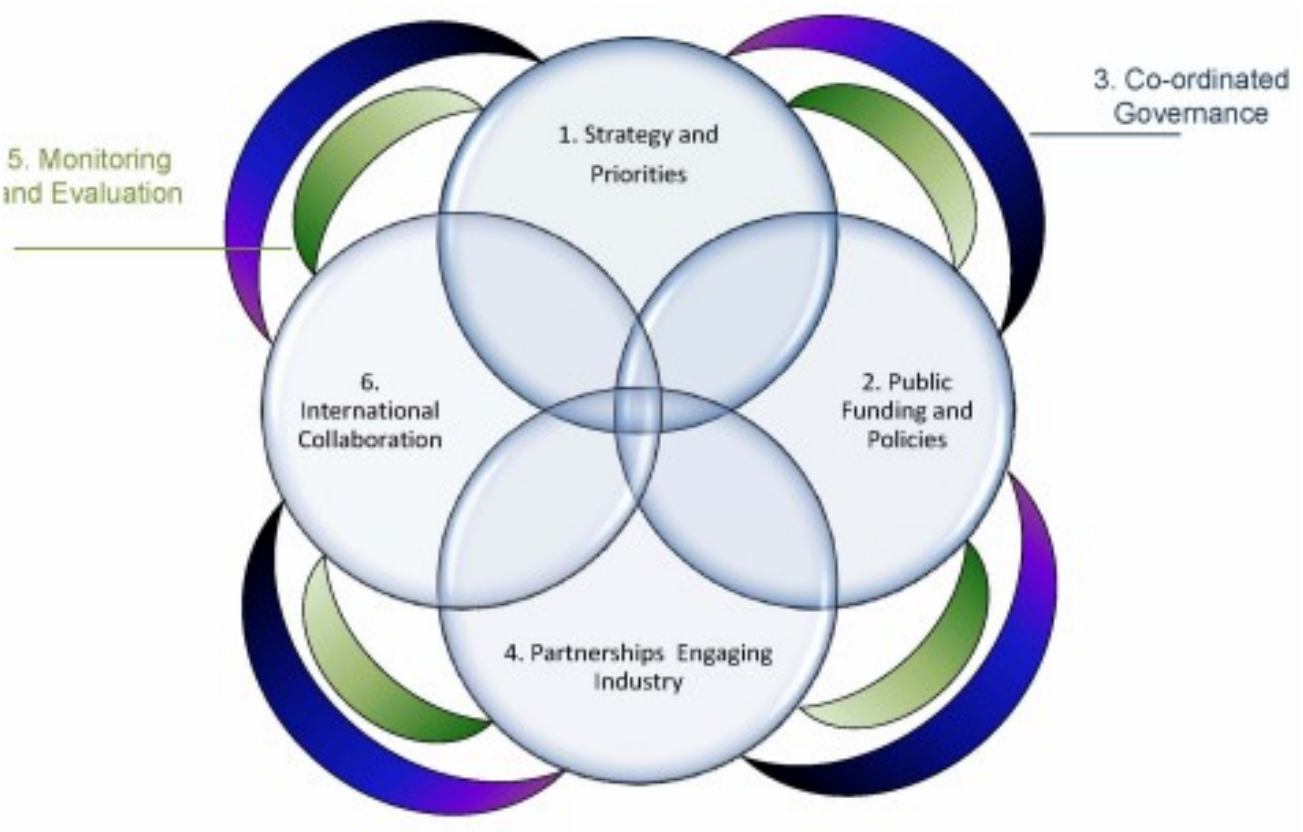
© OECD/IEA 2017

IEA efforts to facilitate innovation

- Essential elements to facilitate innovation
- Energy R&D strategies, priority-setting and policies
- Tracking energy technology progress
- Monitoring R&D investments
- Facilitating R&D through international co-operation

© OECD/IEA 2017

Essential elements to facilitate innovation



Source: IEA (2011), *Good Practice Policy Framework for Energy Technology Research, Development and Demonstration (RD&D)*.

© OECD/IEA 2017

Medium-term Strategy for Energy Research and Technology 2018-2022

- **Committee on Energy Research and Technology (CERT)**
  - **Vision**

    Energy technology research and innovation, ***supported by policy, sustained by public and private investment, and pursued through effective multi-lateral collaboration****, will* ***expand options, reduce costs, and serve as key enablers of a global energy transition*** *to enhanced energy security and access, economic growth, and environmental protection****.***
  - **Mission**
    - **Support policy makers:** Enhance the IEA's authoritative technology analysis and policy recommendations supported by energy data and market outlooks.
    - **Facilitate knowledge sharing:** Strengthen the IEA's position as a key global clean energy hub by coordinating efforts across the Energy Technology Network and with multilateral collaborations, partnerships and initiatives (e.g. CEM, MI, BEC, UNFCCC)
    - **Advance the global agenda for energy innovation and multilateral collaboration:** By supporting the IEA Technology Collaboration Programmes (TCPs) and consolidating the range of opportunities for strategic interactions among the CERT, the Working Parties (WPs), the TCPs and the Secretariat.

© OECD/IEA 2017

Medium-term Strategy for Energy Research and Technology 2018-2022 (2)

- **Objectives**
  - **Support research and innovation activities** as well as enhance and expand analysis to inform policy decisions, taking a whole-system perspective
  - **Further strengthen the Energy Technology Network** (the TCPs and Working Parties)
  - **Engage with Partner countries, the private sector, and relevant international partnerships and organisations**

© OECD/IEA 2017

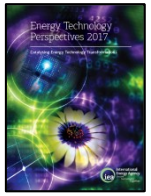
Experts' Group on R&D Priority-Setting and Evaluation (EGRD)

- **Examining analytical approaches to energy technologies, policies, and R&D**
- **Results and recommendations support the Committee on Energy Research and Technology (CERT) and feed into IEA analysis**
- **Snapshot of topics examined**
  - Life in the Fast Lane: evolving paradigms for mobility and transportation systems of the future (2016)
  - Space Cooling (2016)
  - Island Energy - Status and Perspectives (2015)
  - Will a Smarter Grid Lead to Smarter End Users - or Vice Versa (2015)
  - The Role of Storage in Energy System Flexibility (2014)

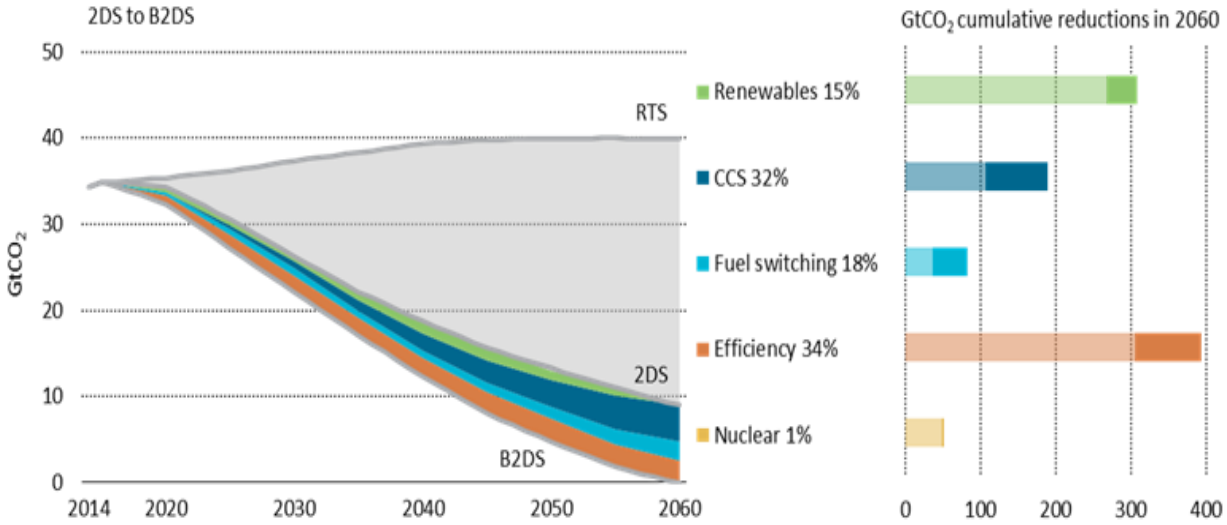
© OECD/IEA 2017

Tracking energy technology progress and future scenarios

- ***Energy Technology Perspectives 2017***
  - Scenarios to 2060



Global CO2 emissions reductions by technology area and scenario



RTS (Reference Technology Scenario); 2DS (- 2°C Scenario); B2DS (Beyond 2°C Scenario.

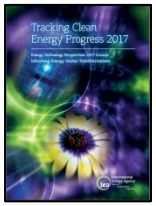
Source: IEA (2017), *Energy Technology Perspectives*. Paris.

Energy innovation has already started delivering, but more efforts are needed.

© OECD/IEA 2017

Tracking Clean Energy Progress

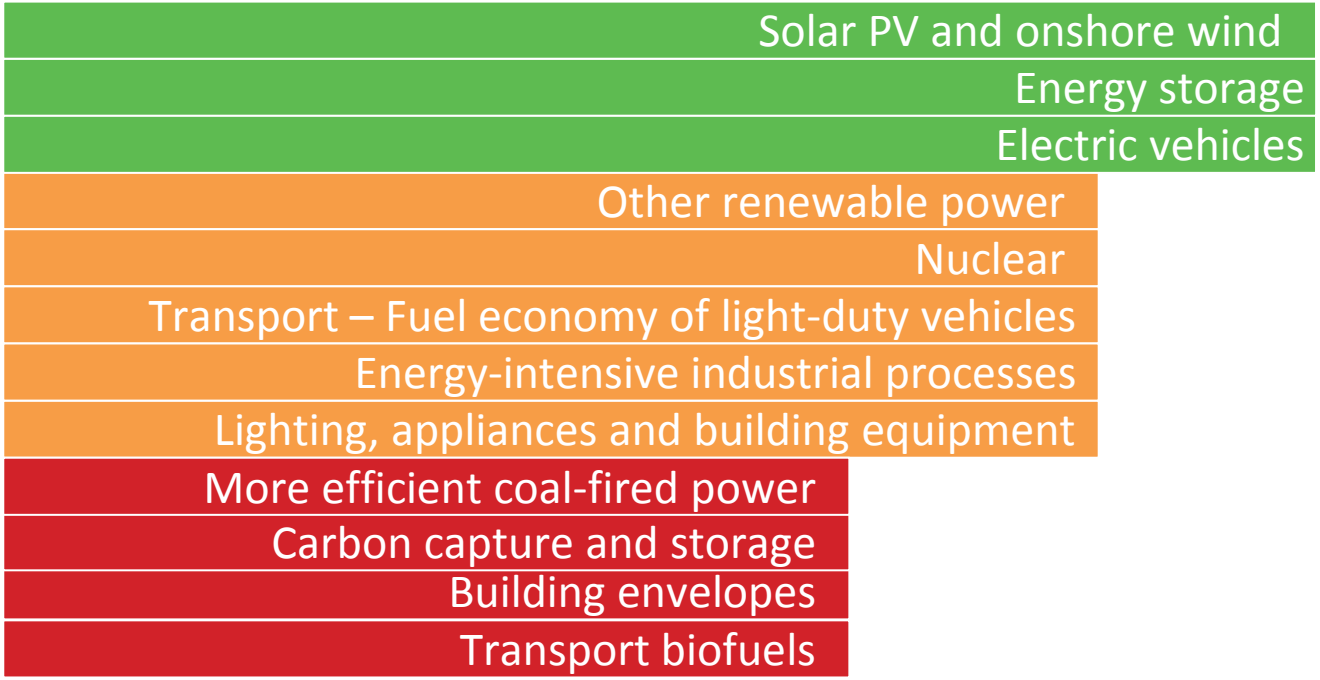
- **Energy technologies require support across all stages of R&D and innovation**
- **Tracking progress in the clean energy transition is essential to:**
  - Assess collective progress toward long-term goals
  - Aid countries to identify pathways to achieving ambitions
- **Where policies have provided clear signals on the value of the technology, innovations have made substantial progress**
  - Solar PV
  - Onshore wind
  - Electric vehicles
  - Energy storage



© OECD/IEA 2017

Tracking clean energy technology progress

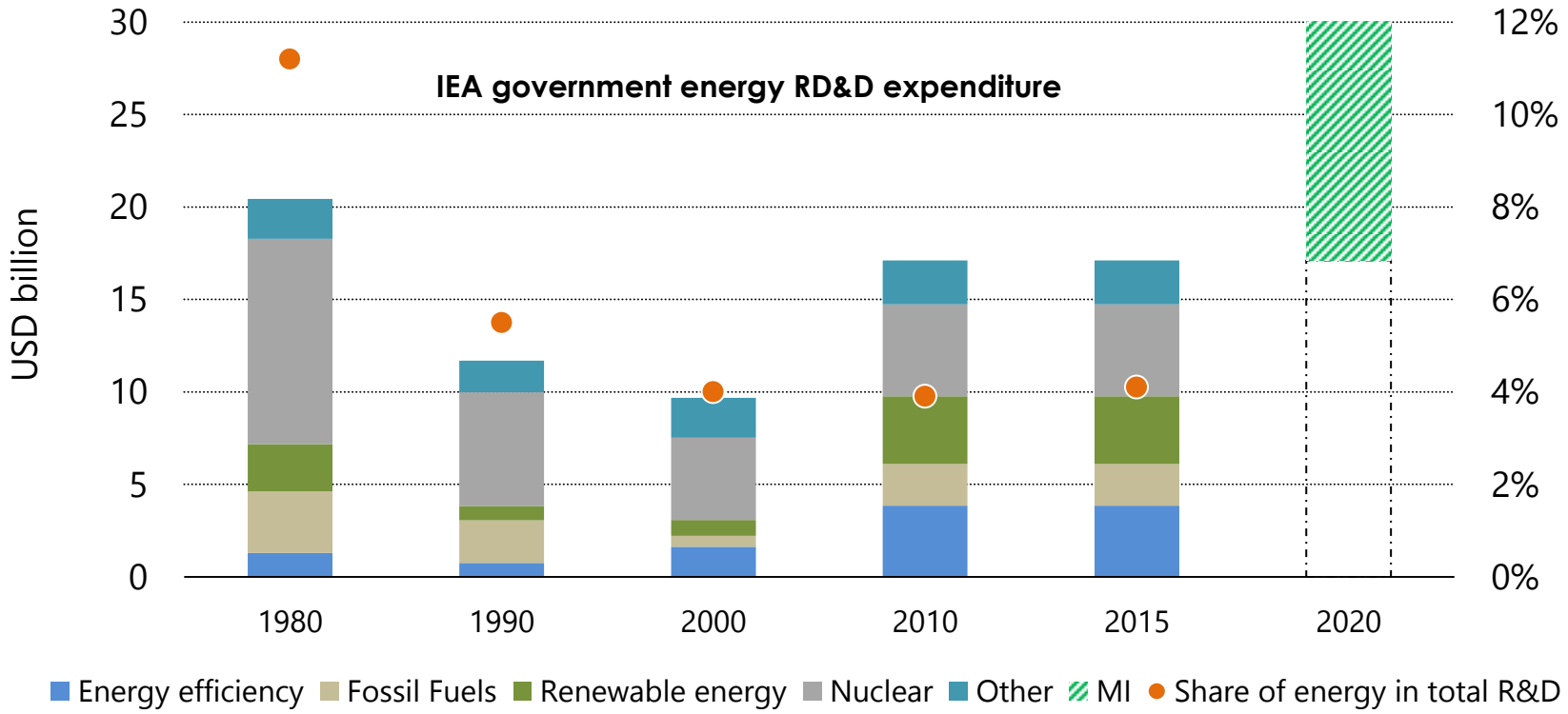
Progress on energy technologies compared with rate needed to meet ambitious climate targets



Recent progress in some clean energy areas is promising, but many technologies still need a strong push to achieve their full potential.

© OECD/IEA 2017

Energy RD&D funding targets the right issues but more is needed

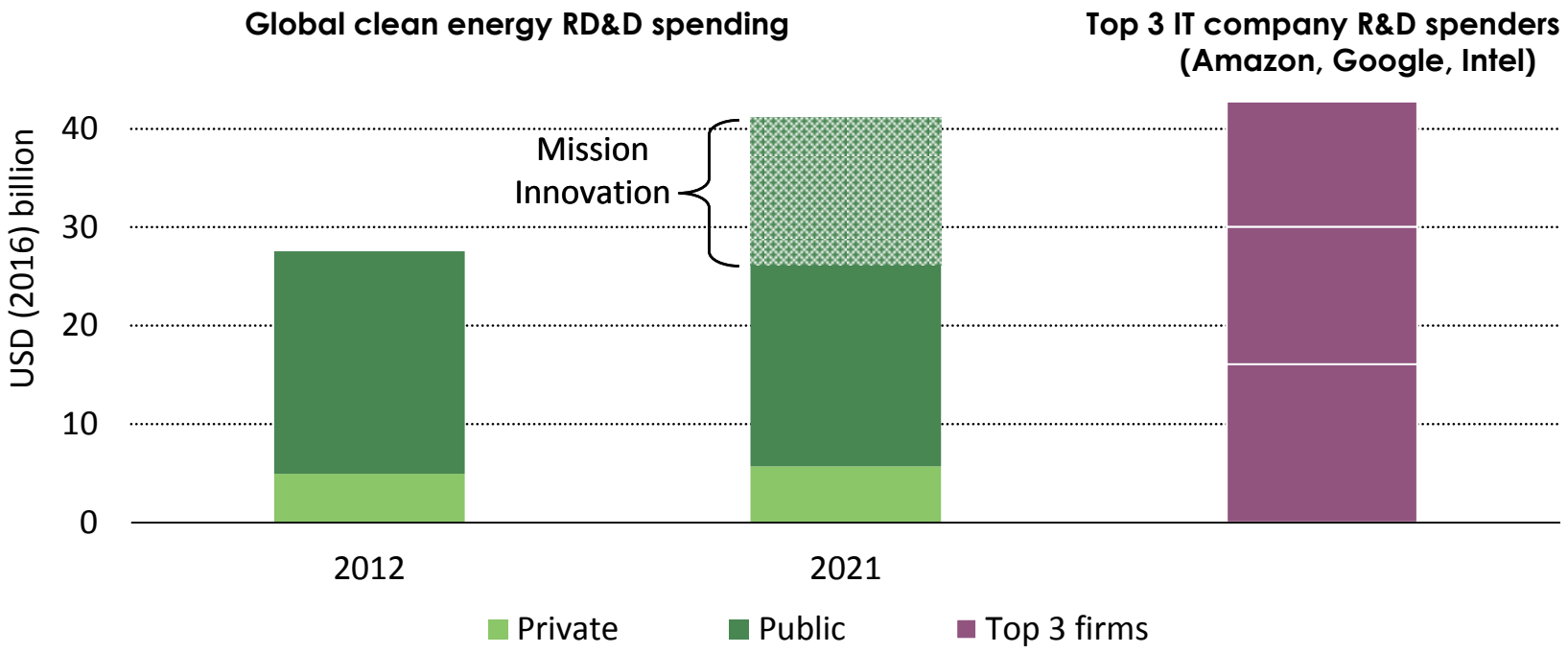


Source: IEA (2017), *Energy Technology Perspectives*. Paris.

Energy RD&D spending should reflect the importance of energy technology in meeting climate objectives: energy R&D investment represents only 4% of total investments in R&D.

© OECD/IEA 2017

Global clean energy RD&D spending needs a strong boost to match efforts in other sectors

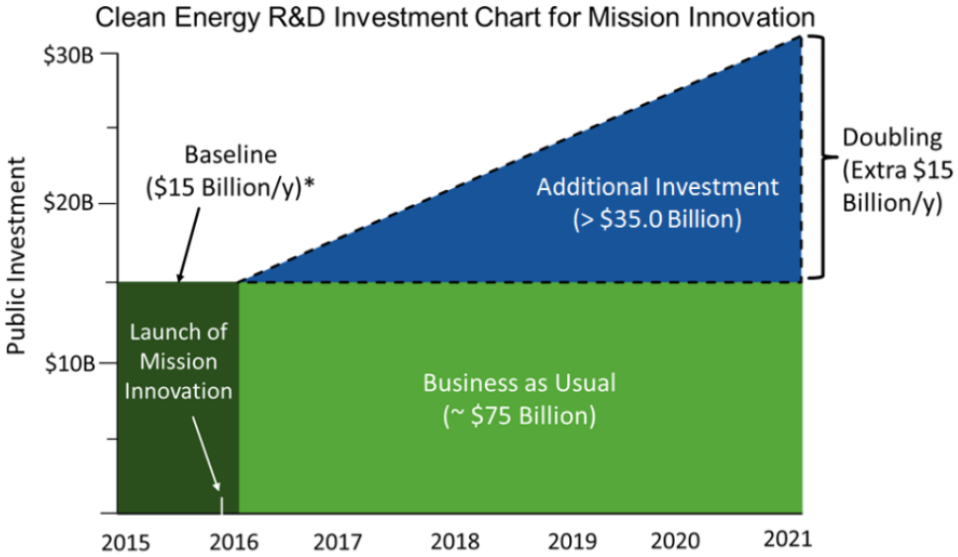


Global RD&D spending in efficiency, renewables, nuclear and CCS plateaued at $26 billion annually, coming mostly from governments.
Mission Innovation could provide a much needed boost.

© OECD/IEA 2017

Mission Innovation

- **Launched at COP21**
  - Commitment by 22 countries (14 IEA, 8 non-IEA) and the EC
  - Dramatically accelerate global clean energy innovation
  - Double spending on clean energy R&D investment over 5 years
  - Encourage greater levels of private sector investment
  - Make clean energy widely affordable



* MI Baseline of USD $15 billion per year in clean energy R&D is compiled from reports of 21 MI Members.

Source: www.mission-innovation.net

© OECD/IEA 2017

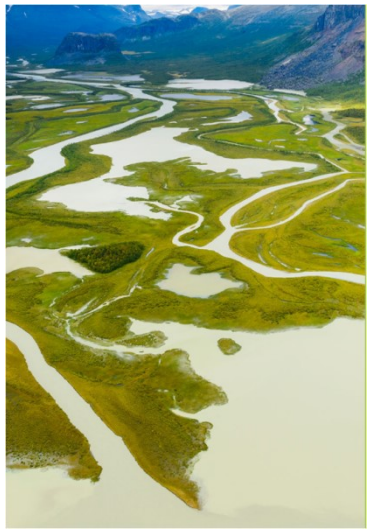
Mission Innovation – Innovation Challenges

- **Great scientific challenges in clean energy innovation**
  - 1. Smart Grids — *China, India, Italy*
  - 2. Off-Grid Access to Electricity — *France, India*
  - 3. Carbon Capture — *Saudi Arabia, United States*
  - 4. Sustainable Biofuels — *Brazil, Canada, China, India*
  - 5. Converting Sunlight (into fuels) — *EC, Germany*
  - 6. Clean Energy Materials — *Mexico, United States*
  - 7. Affordable Heating and Cooling of Buildings — *EC, UAE, United Kingdom*
- **Cross-cutting activities**
  - Information sharing
  - Analysis and joint research
  - Business and investor engagement

© OECD/IEA 2017

Breakthrough Energy Coalition

- **Launched at COP21**
  - A partnership of 30 private entities working with 20 countries
    - Amazon, Bill&Melinda Gates, Bloomberg, Facebook, HP, Prelude Ventures, Reliance….
  - Committed to helping accelerate the cycle of innovation through investment (USD1 billion), partnership, and thought leadership
- **Breakthrough landscape**
  - The board and management team explores the 'landscape of breakthrough innovations' to decide where to invest
  - Criteria
    - Climate impact
    - Other investments
    - Scientific possibility
    - Filling the gaps



© OECD/IEA 2017

Breakthrough Energy Coalition (2)

- **5 Grand Challenges that will inform 55 technical quests**
  - **Electricity:** Deliver reliable, affordable zero-carbon electricity worldwide
  - **Buildings:** Eliminate emissions from homes, offices, hospitals and schools
  - **Manufacturing:** Making everything we use without emitting GHG
  - **Transport:** Getting around our communities without emitting carbon
  - **Agriculture:** Feed the planet without contributing to climate change
- **Public investment**
- **Leading to new companies and products that bring innovations to market**

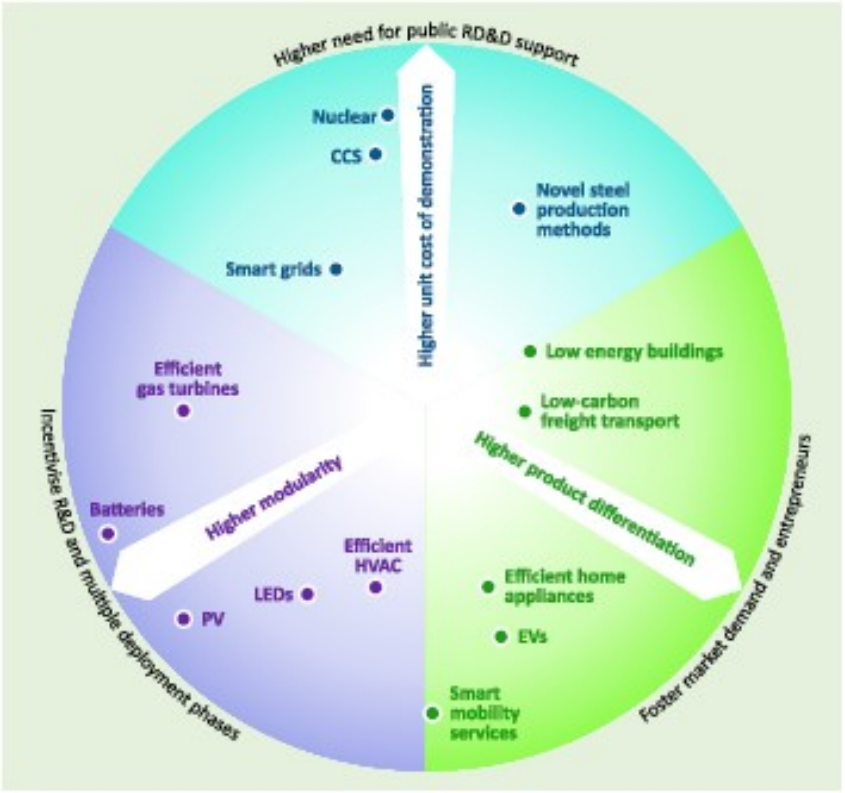
Source: www.b-t.energy

© OECD/IEA 2017

Technology characteristics influence relative needs for public innovation support

Governments play a crucial role in shaping and influencing the marketplace for technologies

Commercialisation
- Manufacturing improvements
- Competition
- Standards
- Consumer confidence



Greatest need for public support
- Highest risk
- Situational specificity
- Complexity
- Longer time to market / RoI

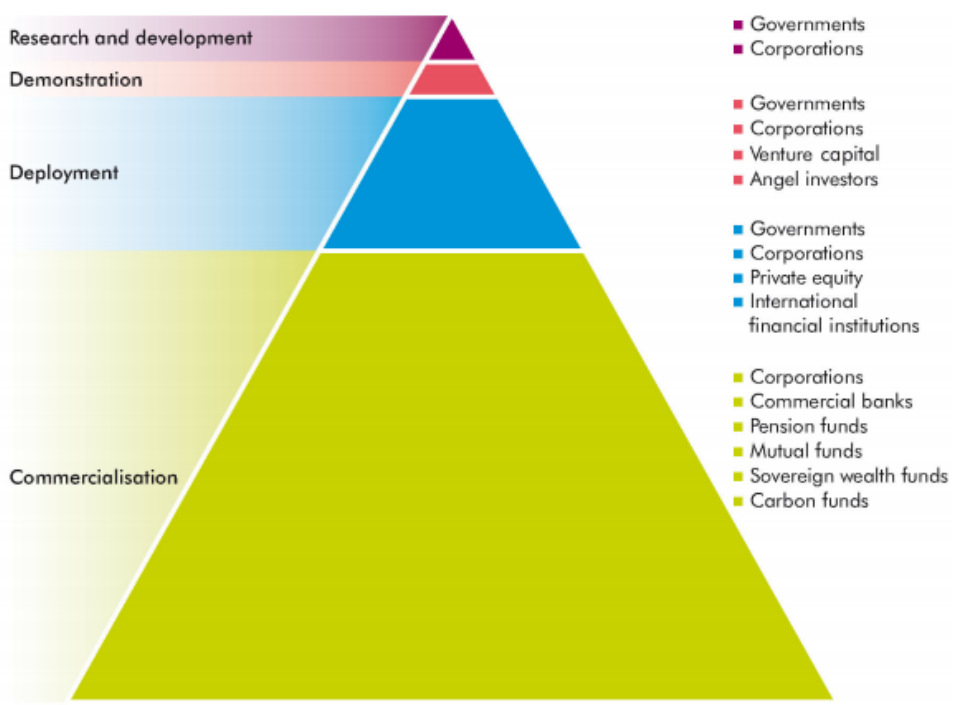
Reduced need for public support
- Reducing public support
- Early adopters
- Niche markets

Source: IEA (2017), *Tracking Clean Energy Progress*. Paris.

© OECD/IEA 2017

The role of public and private sector investment

- **Understanding RD&D investment patterns + targeted efforts by stakeholders results in accelerated deployment and innovation**
- **International collaboration can boost these efforts**



IEA (2010), *Global Gaps in Clean Energy R&D.*

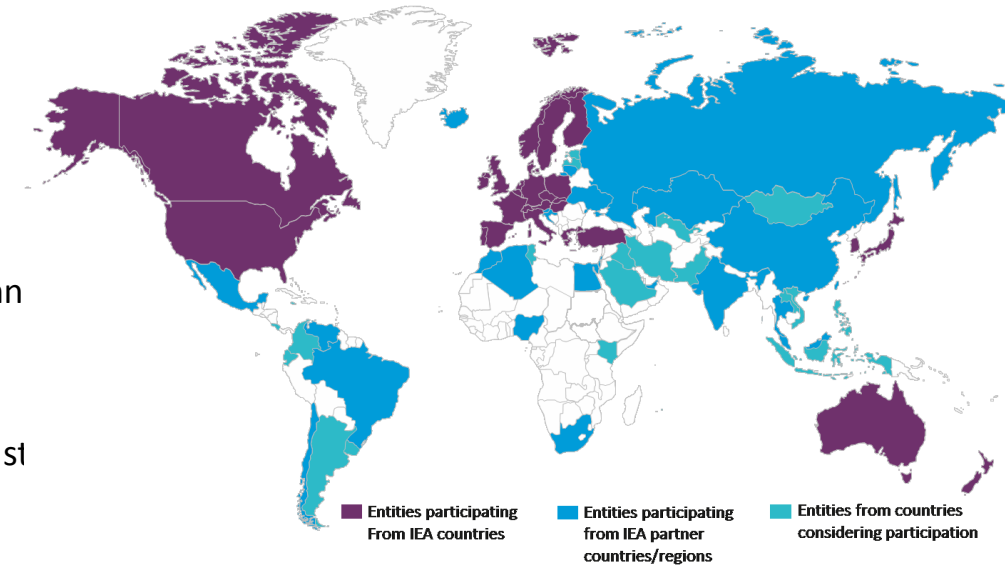
© OECD/IEA 2017

IEA Technology Collaboration Programmes (TCPs)

- **A time-proven, flexible mechanism**
- **Created or discontinued according to energy policy challenges**
- **Currently 38 TCPs**
  - Cross-cutting activities
  - Energy efficiency
  - Fossil fuels
  - Fusion power
  - Renewable energy and hydrogen
- **Focus of recent outcomes**
  - Understanding socio-economic aspects of techn
  - Reducing greenhouse gas emissions
  - Advancing science and technology
  - Contributing to benchmarks and international st
  - Facilitating deployment
  - Improving efficiency

iea Energy Technology Network
Technology Collaboration Programmes

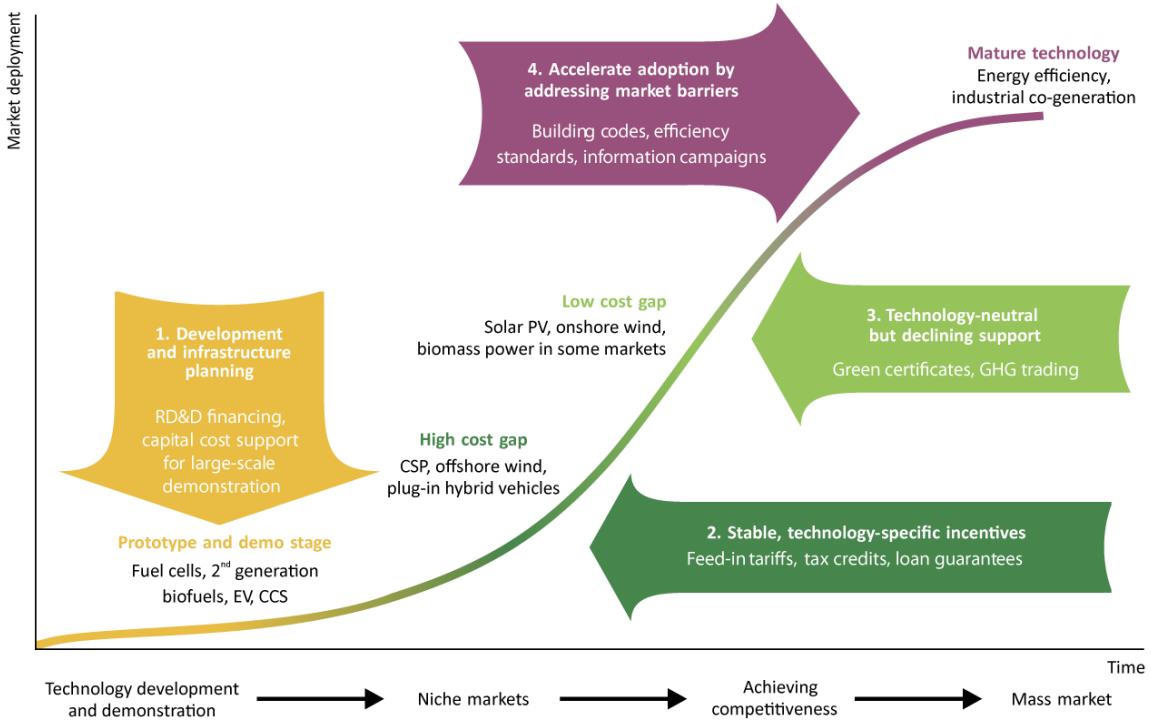
- Close to 6,000 experts
- More than 2,000 topics to date
- More than 300 public or private organisations
- 52 countries
- 38 IEA Technology Collaboration Programmes
- 5 intergovernmental organisations



This map is without prejudice to the status of sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

© OECD/IEA 2017

Supporting energy innovation: the right policy at the right time

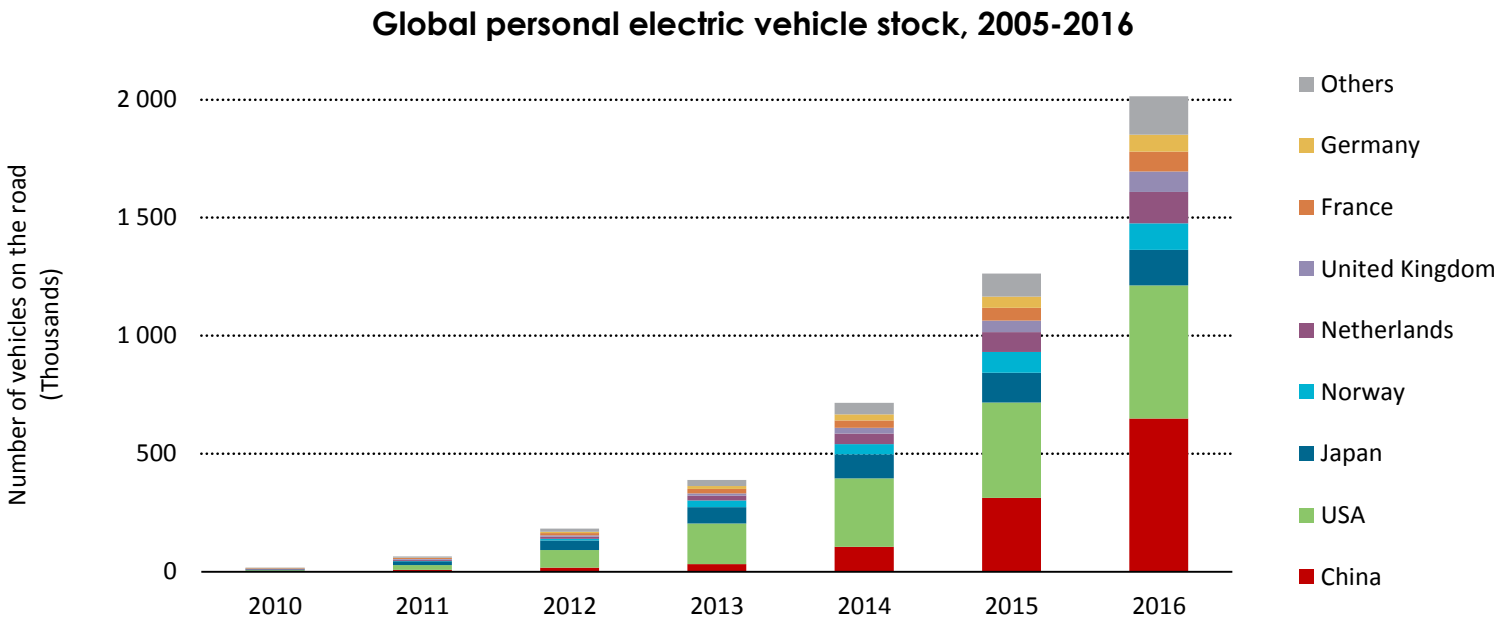


Source: IEA (2015), *Energy Technology Perspectives*. Paris.

The right support depends on the maturity of the technology and the rate and degree of market uptake.

© OECD/IEA 2017

Electric mobility is breaking records, but policy support remains crucial to maintaining the momentum



The global EV car stock reached 2 million units in circulation last year, but sales growth dropped from 70% to 40% in 2017, suggesting an increasing risk of diverging from agreed goals.

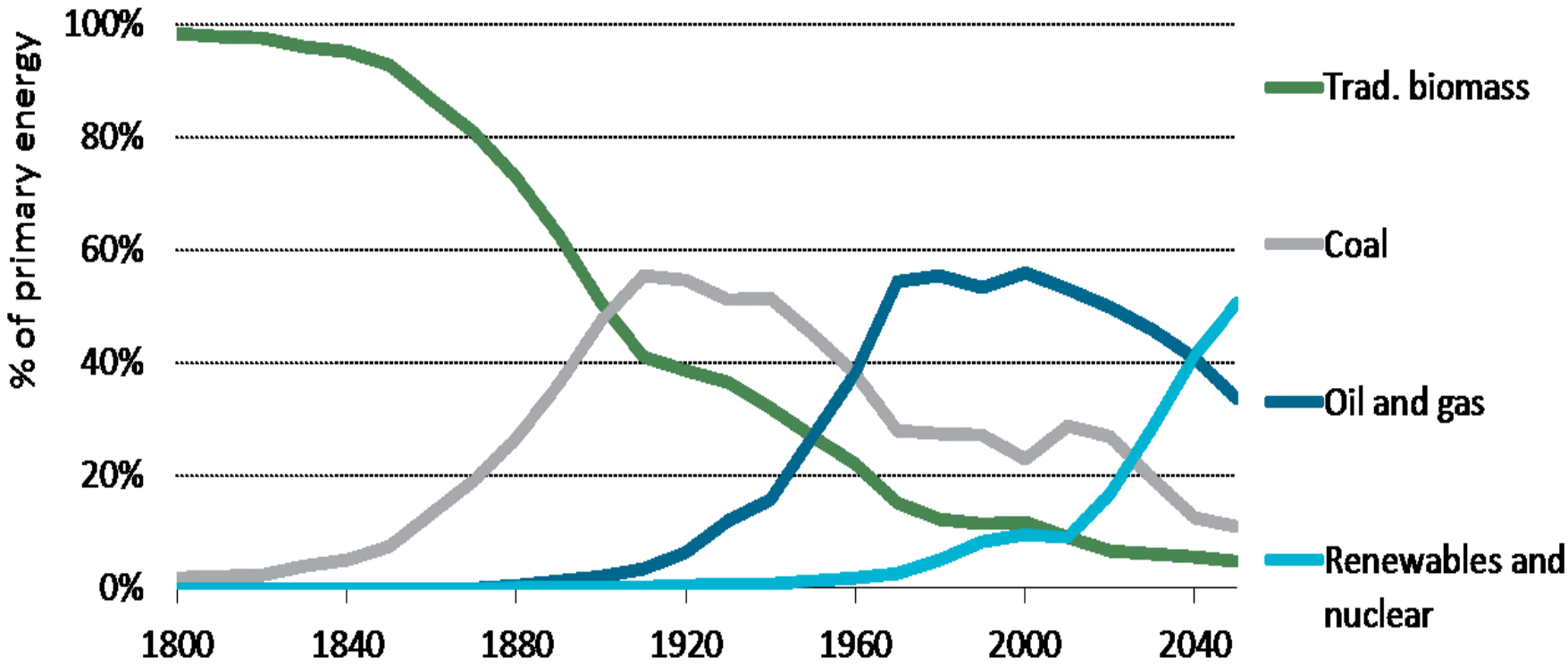
© OECD/IEA 2017

Disruptive innovation (DI) – some considerations

- The energy sector develops slowly
- What is innovation?
- Illustrating non-linear innovation
- Types of innovation
- Innovative approaches and processes
- Disruptive innovation – some considerations
- Positive and negative? A question of perspective
- Horizon scanning for DI

© OECD/IEA 2017

The energy sector innovates slowly

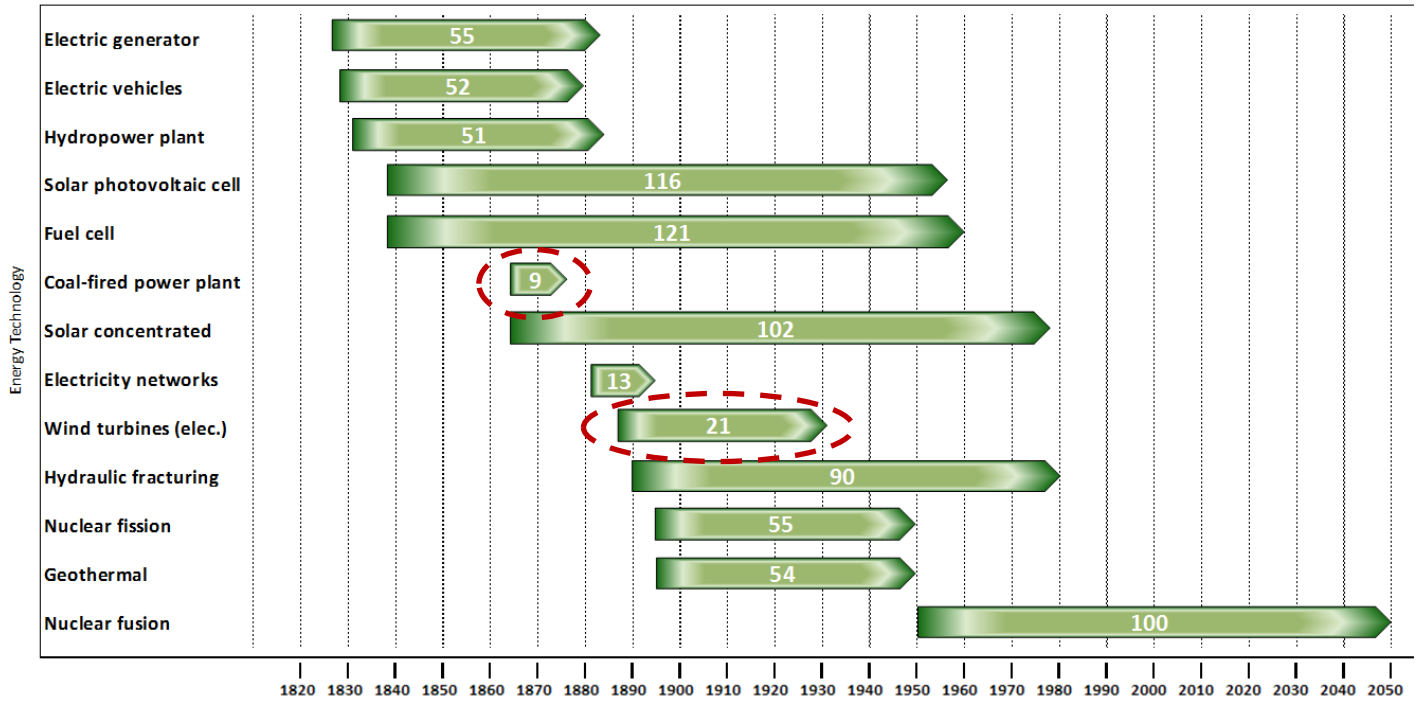


Source: Smil (2010) and IEA (2017), *Energy Technology Perspectives*. Paris.

© OECD/IEA 2017

Timeline of energy R&D

- **From proof of concept to commercialisation**



Both incremental and radical innovations are needed to decarbonise the global energy system; government support across all phases of RDD&D can facilitate both.

© OECD/IEA 2017

What exactly is innovation?

- **Implementation of a new or significantly improved product, process, marketing or organisational method**
- **May be the result of R&D within one area or cross-fertilisation across R&D areas**
- **A departure from incremental R&D (not synonymous)**
- **A non-linear, iterative process, where progress or problems at each stage affect previous phases and further developments**
  - Continuous vs. discontinuous (Michael Porter)
  - Incremental vs. breakthrough (Tushman, Anderson)
  - Conservative vs. radical (Abernathy, Clark)
  - Sustaining vs. disruptive (Christensen)
- **It must have been Introduced on the market or brought into use**

Sources: OECD (2015), *Oslo Manual* and the (2010& OECD Innovation Policy Portal Platform accessed 10 June 2017.

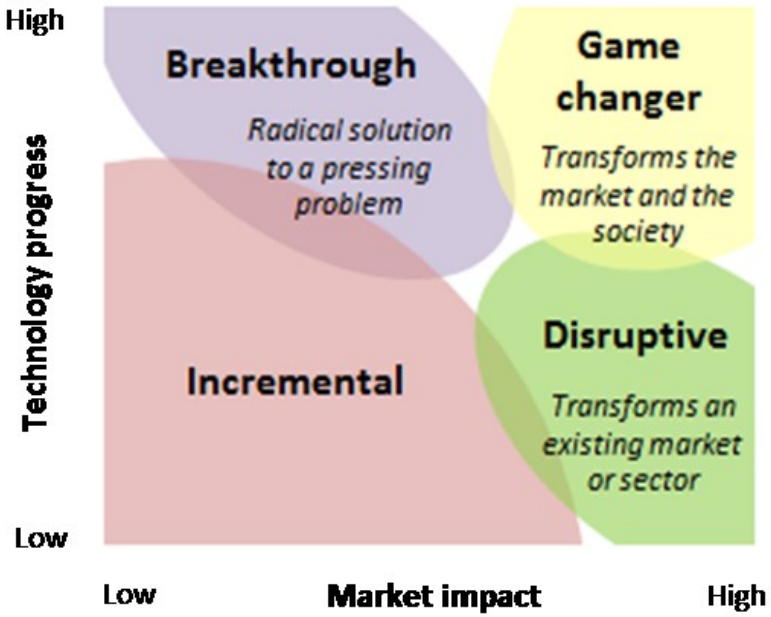
© OECD/IEA 2017

Types of innovation

- **Terms that are not interchangeable**

Steam generation

Electric vehicles
Fuel cells
Solar concentrating



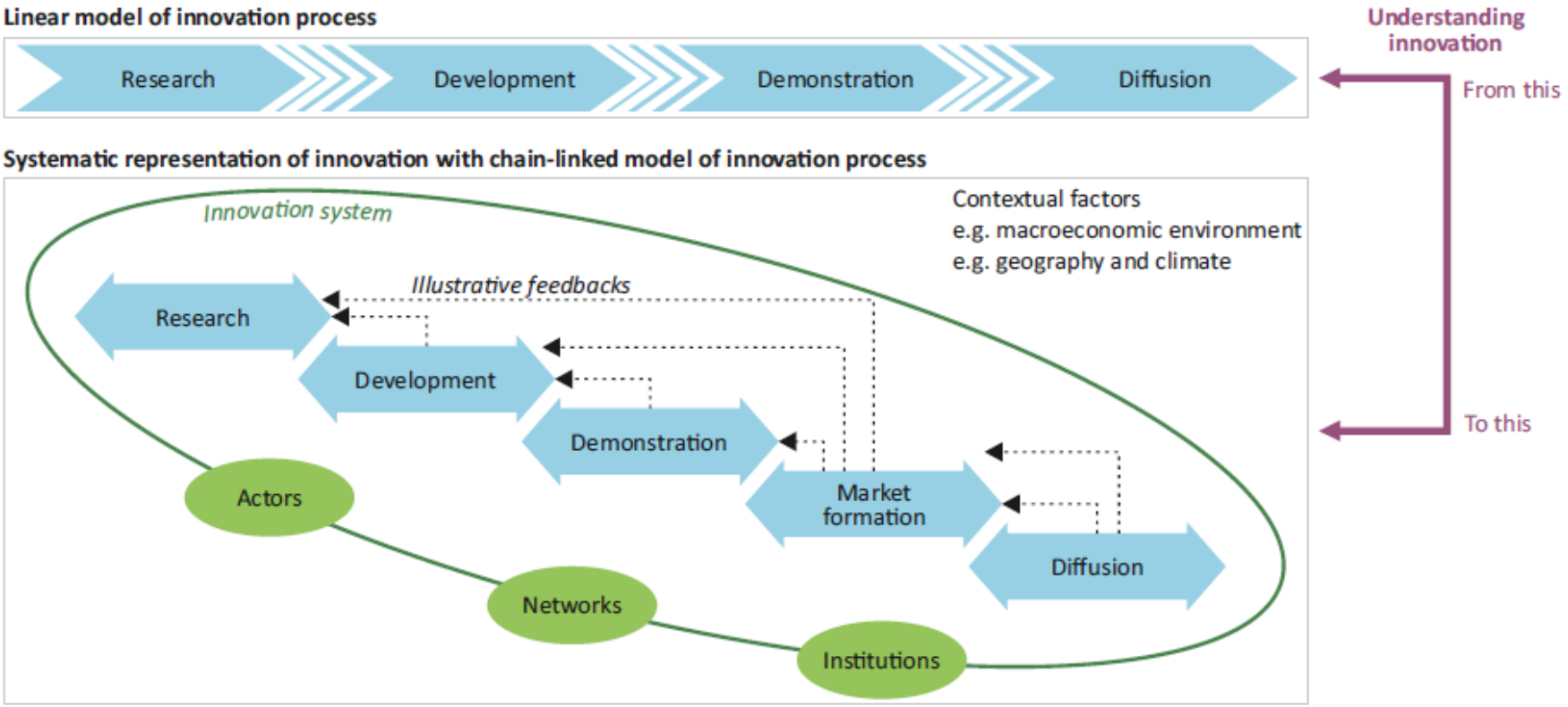
Automobile
Internet and ICT
Electricity networks

Digital photography
Solar PV
Onshore wind

Source: Adapted from Kalbach, J. (2012), *Experiencing Information*.

© OECD/IEA 2017

A better understanding of innovation can increase confidence in its outcomes

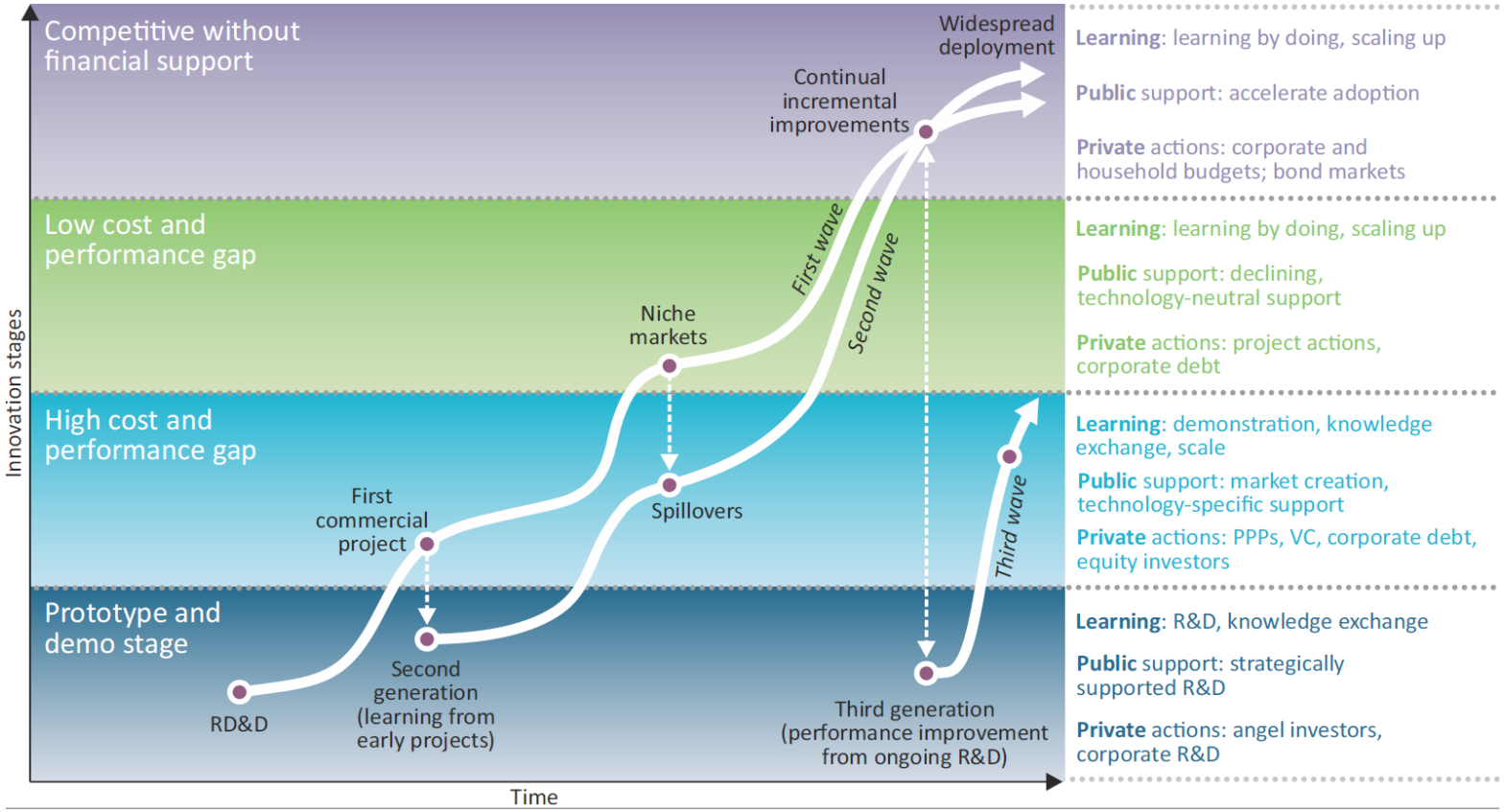


Source: IEA (2015), *Energy Technology Perspectives*. Paris.

In order to accelerate technological progress in low-carbon technologies, innovation policies should be systemic.

© OECD/IEA 2017

Non-linearity of innovation: solar PV

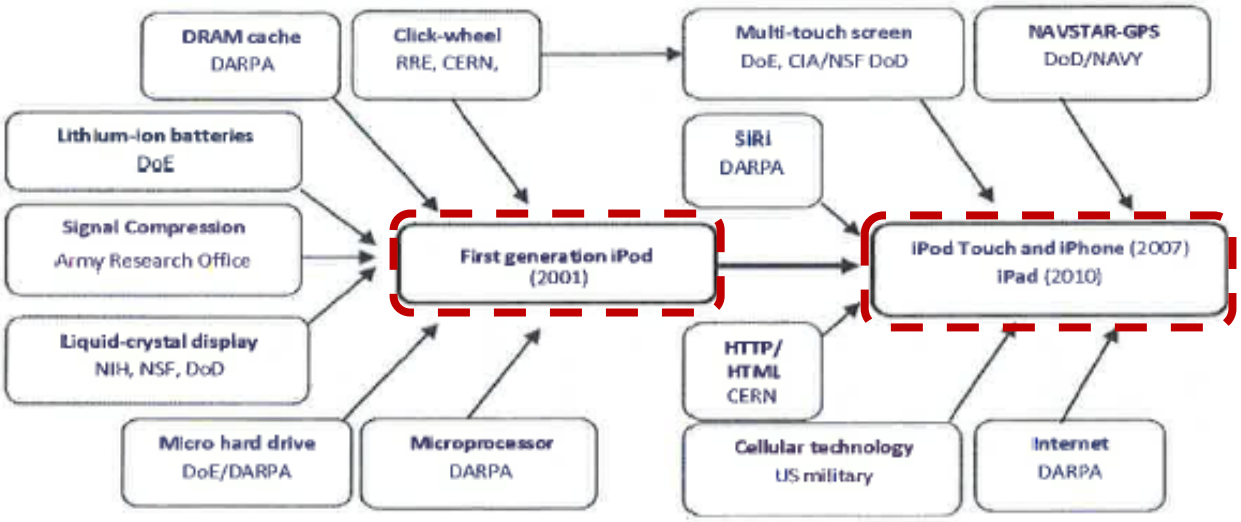


Source: IEA (2017), *Tracking Clean Energy Progress*. Paris.

© OECD/IEA 2017

Non-linearity of innovation: iPod and iPad

The publicly-funded technology behind 'smart phones'

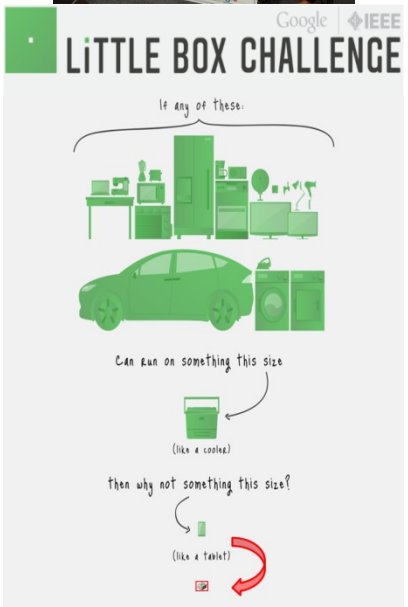


Source: Mazzucato (2013), *The Entrepreneurial State: debunking private vs. public sector myths*, Anthem Press, London, UK.

© OECD/IEA 2017

Innovative approaches and processes

- **Approaches**
  - Intellectual property
    - Open source, open science
  - Breaking the status quo (commerce, services industry)
    - E.g. Uber, Airbnb, Crowd-funding
- **Processes**
  - Involving multiple sectors or disciplines
  - Aimed at improving socio-economic conditions ('grand challenges')
  - Borrowing processes from social media



© OECD/IEA 2017

Disruptive innovation – some considerations

- When an innovation transforms an existing market or sector
- Introduces simplicity, convenience, accessibility, and affordability where complication and high cost are the status quo
- Initially a niche market that may appear unattractive or inconsequential to industry incumbents
- Eventually the new product or idea completely redefines the industry

© OECD/IEA 2017

Disruptive innovation – some considerations (2)

- **Enabling technology**
  - Invention or innovation that makes a product more affordable and accessible to a wider population
- **Innovative business model**
  - Targets non-consumers (new customers who previously did not buy products or services in a given market) or low-end consumers (the least profitable customers)
  - Most easily accomplished by new entrants (not locked into existing business models)
- **Coherent value network**
  - Where upstream and downstream suppliers, partners, distributors, and customers benefit from the success of the disruptive technology

© OECD/IEA 2017

Positive or negative? It's a question of perspective

- **Positive**
  - Makes life easier
  - Creates new markets
  - Advances scientific understanding

  ➡ Portable electronics, GPS, space, carbon fiber materials

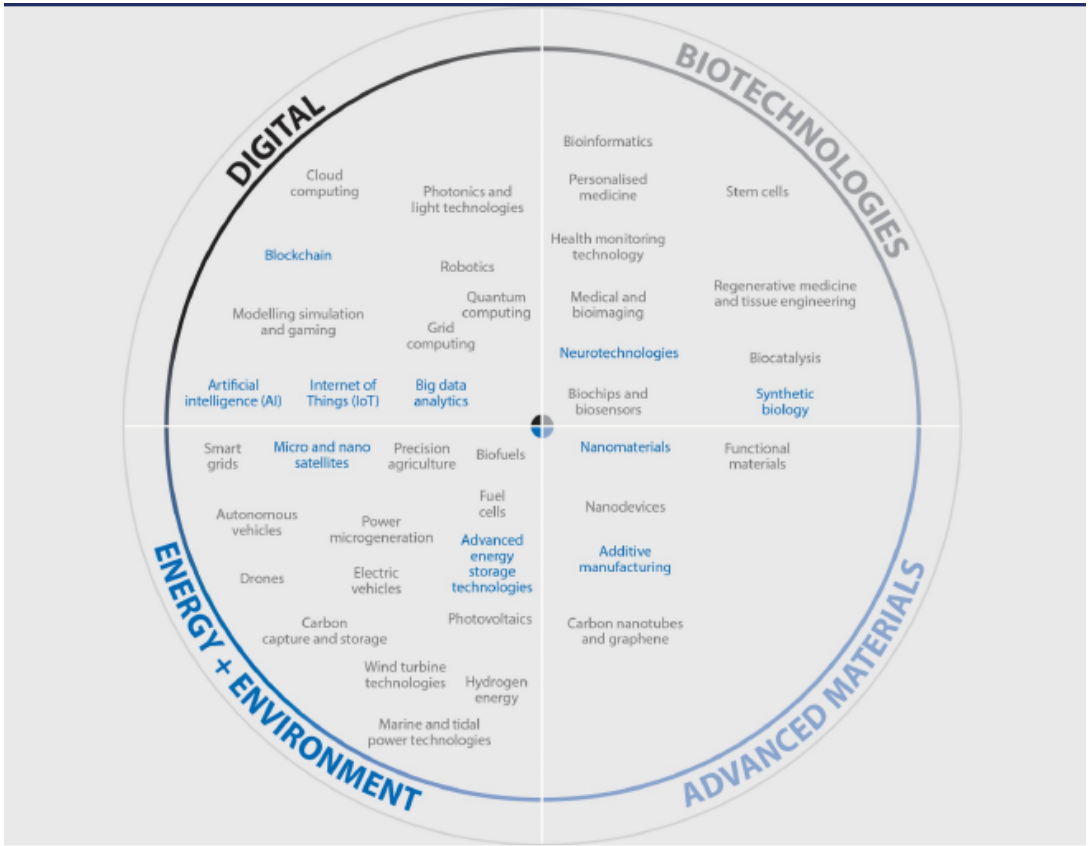
- **Negative**
  - May results in destabilizing socio-economic adjustments
    - Winners and losers
  - May increase the gap between 'haves' and 'have-nots'

  ➡ Analog to digital photography, LCD televisions

© OECD/IEA 2017

Horizon scanning for disruptive innovation

Energy technologies are linked to many other emerging and nascentareas of research



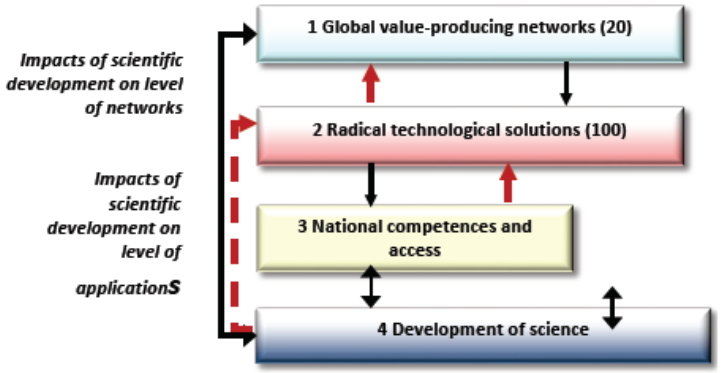
Source: OECD (2016), *Science and Technology and Innovation Outlook*.

© OECD/IEA 2017

Radical Technology Inquirer (RTI)

- **100 Opportunities for Finland and the World**
- **13 related to energy**
  - Rapidly cheapening solar energy
  - Efficient and light solar panels
  - Synthetic fuel from the sunlight and carbon dioxide
  - Producing biofuels using enzymes, bacteria or algae
  - New ways to produce wind energy (e.g. airborne)
  - Piezoelectrical energy sources and kinetic energy
  - Small nuclear reactors, fission and fusion
  - Rapidly charging light batteries and supercapacitors
  - Massive storage of energy in high capacity batteries
  - Solar heat and long-term storage of heat
  - Inexpensive storage of hydrogen in nanostructures
  - Wireless electricity transmission (magnetism)
  - High-performance lasers, wireless power transfer

Figure 1. Four levels of the generic evaluations of the pilot study



Source: Committee for the Future (2014), *100 Opportunities for Finland and the World,* Parliament of Finland.

© OECD/IEA 2017

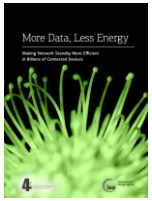
Potential game-changers

- **Near term (5 years)**
  - Energy storage: increasing RE integration and balancing network demand
  - Digitalization: convergence of ICT and energy; blurring the digital/physical divide
- **Medium term (5-10 years)**
  - Transport: Electric vehicles
  - Industry: Carbon capture and storage
- **Longer term (10 years and beyond)**
  - Systems: decentralised electricity generation and mini-grids
  - Electricity: fusion power

© OECD/IEA 2017

Digitalisation

- **Interlinkage between energy and digital**
  - Digital investment in the energy sector and investment by digital companies in energy
  - Assessment of digital readiness across the energy sector
- **Growing interest, yet lack of information on potential impacts**
  - Quantitative and analytically-rigorous assessments are needed
- **Digitalization focus across IEA work streams for many years**
  - Efficiency, system integration, outlooks, sustainability, transportation, industry, buildings, investment, data and statistics, electricity, oil and gas, renewables, technology
  - Growing interest for IEA to focus more on digitalization by IEA Members, company partners
  - Several TCPs have relevant activities: ISGAN (smart grids), Wind TCP; 4E TCP
- **A selection of publications**
  - *Technology Roadmap: Smart Grids* (2011)
  - *Impact of Smart Grid Technologies on Peak Load to 2050* (2011)
  - *More Data, Less Energy* (2014)
  - *How2Guide for Smart Grids in Distribution Networks* (2015)



© OECD/IEA 2017

Digitalisation (2)

- **Impact of the digital economy on energy demand**
  - Past trends and outlook for electricity demand by digitalization
  - Assessment of digitally-enabled impact of energy demand in industry, transport, and buildings
- **Impact on energy supply – primary focus on the power sector**
  - Asset performance improvement and related avoided investment in physic infrastructure
  - Smart energy systems, flexibility, and demand response
  - Digital optimization in upstream oil and gas operation
- **Challenges and opportunities for policy-makers**
  - Facilitating emerging business models to capture value and opportunities
  - Data ownership, privacy
  - Big data for policy design/implementation
  - Regulatory frameworks, digital resilience, economic disruption, energy access
  - No-regrets policy recommendations

Assessing the implications of digitalization on the energy sector, bringing together new quantitative assessments, qualitative insights, and analysis of policy implications

© OECD/IEA 2017

Conclusions

- The IEA is committed to supporting and facilitating innovation
- Innovation can deliver, but policies must consider the full technology cycle and leverage international collaboration
- An integrated systems approach considering all technology options must be implemented now to accelerate progress
- Each country should define its own transition path and scale-up its RD&D and deployment support accordingly
- Through horizon scanning governments can identify possible disruptive innovations and prioritise the relevant R&D investments and policy instruments

© OECD/IEA 2017