Options for a new EU energy technology policy towards 2050: What way to go?

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Agenda

1. Decarbonization: A clear target for 2050?
   - Decarbonization objective
   - Decarbonization scenarios

2. Do we need a (new) (EU) energy technology policy?

3. Options for a new EU energy technology policy

4. What way to go?

5. First conclusions

Decarbonization: A clear target?
The decarbonization objective

- “2050 objective”: Commitment to reduce GHG emissions to 80-95% below 1990 levels by 2050

- Electrification of other sectors
  - Uncertain at which pace and to which extent

See e.g. visions regarding the penetration of electric vehicles:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>EVs in 2020</th>
<th>EVs in 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline scenario</td>
<td>3.3mn</td>
<td>50mn</td>
</tr>
<tr>
<td>Pessimistic scenario</td>
<td>2mn</td>
<td>20mn</td>
</tr>
<tr>
<td>Optimistic scenario</td>
<td>5.5mn</td>
<td>93mn</td>
</tr>
</tbody>
</table>

Source: Kampman et al. (2011)

➢ Every policy must allow for such electrification

Very high degree of decarbonization of the electricity sector

Decarbonization: A clear target?
Different possible ways to decarbonize

a) Consumption-oriented:
   – Increase in energy efficiency
   – Behavioral changes

b) Production-oriented:
   – Low-carbon generation (RES, nuclear)
   – Decarbonization of fossil fuels (CCS)

Huge uncertainty regarding the 2050 system

Energy Roadmap 2050:

“The energy transition will primarily result from countless private decisions on energy supply and use, shaped by the entrepreneurial actions of private innovators” (Lester and Hart, 2012)
Decarbonization: A clear target?

Similar visions

- Several other roadmaps differ in assumptions, baseline and concrete 2050 scenarios
- ... but all scenarios have some aspects in common
  
  - Energy efficiency improvements of utmost importance
- Three main variables are on the production side, i.e. shares of RES, nuclear and CCS
  ... hence, policy decisions related to nuclear phase-outs or CCS deployment are decisive for scenario outcomes

- Way towards 2050, in any case, should
  - Be cost-efficient and
  - Foster European competitiveness in RD&D and manufacturing of low-carbon technologies

Agenda

1. Decarbonization: A clear target for 2050?

2. Do we need a (new) (EU) energy technology policy?
   - Why “an” energy technology policy?
   - Why “an EU” energy technology policy?
   - Why “a new EU” energy technology policy?

3. Options for a new EU energy technology policy

4. What way to go?

5. First conclusions
Why “an” energy technology policy?
Four kinds of reasons for policy intervention

Market failures
- Environmental externality
  - Reduction of GHG emissions is a global public good
- Capital market imperfections
  - Funding gap
    (high-risk profiles of innovation projects // high TAC // high capital costs)

Innovation externalities
- Spillover effects and related appropriability problem

Increasing global competition
- Challenge: “remain at forefront of booming international market” at a time when MS curtail public spendings

Strategic trade and policy issues

Why “an” energy technology policy?
European players facing global competition

- Top-European turbine manufacturers (Vestas, Siemens, Gamesa…) see reduction in their global market share
  - Chinese manufacturers gain (production 30% cheaper than in other regions)
- BUT: only European manufacturers active in offshore wind market
  - (Siemens 80% share in 2011)
  - Chance to use this advantage of being ‘pioneer’?
    ... and benefit (1) from domestic technology adoption as well as (2) from exporting the technology

- Manufacturing of cells and modules: EU loses market shares
  - Labor-intensive, low transportation cost, efficiency and quality of Chinese products comparable to European ones → China = low-cost competitor
- BUT: still strong position of European firms in solar PV manufacturing equipment which is sold to Asian countries, too → High-tech segment
  - Argument for public support to keep this competitive advantage?
    ... and strengthen the industrial base, benefit from economies of scale/scope
Why “an EU” energy technology policy?
Rationales for EU involvement

- Any trans-national involvement must be justified on the grounds of subsidiarity
  - Art. 192 and Art. 194, Treaty of the Functioning of the EU
- There must be economic rationale(s) for public involvement beyond the MS level
  - Presence of externalities
  - Need to coordinate market failure corrections among MS (heterogeneity can distort competition)
  - Single MS might be too small to implement certain instruments (e.g. ETS), to compete on a global scale, etc.
- De-centralized, regional solutions fail in implementing the necessary regulatory actions
  - Probably yes in certain cases

Why “a new” EU energy technology policy?
Limitations of existing policies

1. Limitations of existing policies addressing the environmental externality

- 20-20-20 targets
- Improved ETS (EU-wide, decreasing cap, more auctioning, etc.)
- Burden-sharing for non-ETS sectors
- National RES support policies (FITs, FIPs, TGC...)
- Some efficiency standards
Why “a new” EU energy technology policy?
Limitations of existing policies

2. Limitations of existing policies addressing the innovation externalities
   - SET Plan
     “Technology pillar” of the EU energy and climate policy
     ✓ (i) bringing stakeholders together,
     ✓ (ii) more coordinated planning,
     ✓ (iii) joining forces
   - Direct support to innovation
     - Funding at EU and MS level
     - Mix of technology-neutral and directed funding
     - Grants and contracts by far preferred instruments; smaller role of e.g. public loans or equity

   Limited time horizon (2020)
   Within-sector approach regarding planning and priority setting
   Not necessarily support for cost-efficient portfolio of low-carbon technologies
   Not perfectly coordinated between MSs and MS/EU
   Carvalho Report: “FP7 still characterized by excessive bureaucracy and undue delays”
   Not necessarily optimal use of limited public €

Why “a new” EU energy technology policy?
Limitations of existing policies addressing...

3. ... the EU financial crisis and market liquidity
   - Crisis had severe consequences on the ability to mobilize private and public funds
   - All MS are affected, but not all in the same way and to the same extent
   - European Energy Programme for Recovery
     Co-financing offshore wind (€ 565mn) and CCS demonstration (€ 1bn)

4. ... increased global competition
   - Innovation is key
   - Communication identifying “Key Enabling Technologies”
     i.e. cross-cutting technologies feeding into many value chains

   No adequate remedies yet
   Need for further policy intervention remains to be discussed
Agenda

1. Decarbonization: A clear target for 2050?
2. Do we need a (new) (EU) energy technology policy?
3. Options for a new EU energy technology policy
   - Toolkit for policy instruments
   - Three polar policy options
4. What way to go?
5. First conclusions

Options for a new EU energy technology policy

Introduction

- **Challenges** for a future EU energy technology policy
  - Eliminate limitations of existing policy instruments and give a clear and stable vision for post-2020 period
  - Reinforce European competitiveness in low-carbon technology sectors
  - Be robust to scarce financing caused by current (and possible future) financial crises and be consistent with future developments of the EU institutional system

- There are different policy **options**

- How do these options **answer to the challenges**?
Options for a new EU energy technology policy
... can be described using a ‘toolkit’

- **Market pull** instruments (‘creating markets’)  
  a) Building on strong price signals and/or  
  b) Providing signals through quantitative targets

- **Technology push** instruments (‘direct support to innovation’)  
  a) Directed technology push and/or  
  b) Technology-neutral support to innovation

- **Governance** of instruments  
  a) ... decentralized national action (e.g. national RES support schemes, national RD&D support, or maybe even sub-national action) and/or  
  b) ... centralized (e.g. EU ETS, cross-national planning and priority setting as within the SET Plan, EU funds supporting innovation)

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Options for a new EU energy technology policy
Three (polar) options

**Policy option**

1

**Reference case**
... continuation of the status quo – replicate SET plan for 2050 horizon

- **Market pull**: Hybrid  
  ‘Weak’ carbon price, EU level targets for RES and EE (à la 20-20-20), national energy policies to meet national targets

- **Technology push**: Hybrid  
  Information exchange, planning and priority setting within sectors  
  Some directed TP as well as funds for which innovation projects compete

- **Governance**: Hybrid  
  Centralized (e.g. EU ETS, Framework Programmes, EERA, etc.)  
  ... as well as decentralized instruments (e.g. non-ETS emissions, RES support policies, national support to innovation, etc.)
Where else could we go?

Where do we come from?

Option 1 – “Reference case”
... continuation of the status quo

Option 2 – “Focus on price signals”
... strong carbon price and technology-neutral support to innovation
... predominantly centralized governance

Option 3 – “Sectoral targets”
... sectoral targets and directed technology push targeting prioritized technologies
... predominantly decentralized governance

Options for a new EU energy technology policy
Three (polar) options

Policy option: Focus on price signals

2

• Market pull: Focus on price signal
  Key instrument = ‘Strong’ carbon price (ideally covering all GHG emissions)
  20-20-20 targets cease after 2020

• Technology push: Focus on price signal
  Technology-neutral R&D support of high importance → decarbonization technologies discovered by the market
  After having delivered its initial push, SET-plan as an instrument to prioritize among technologies and projects ceases by 2020

• Governance: Predominantly centralized
  Key instrument is the strong carbon price, minor importance of directed, national TP
  (Part of) auction revenues from ETS could be collected on EU level and be used for coordinated support to innovation
Options for a new EU energy technology policy
Three (polar) options

Policy option 3: Sectoral targets

- **Market pull**: Focus on signals from target setting
  Binding EU-level and corresponding national sectoral targets* to support an ex-ante determined optimal portfolio

- **Technology push**: Directed TP
  “SET plan plus” to support planning and priority setting across sectors ‘winner picking’

- **Governance**: Predominantly decentralized
  Implementation of targets relies on decentralized national action
  Need to align national implementation, i.e. to harmonize national support policies and coordination of TP?

* Sector = solar, wind, nuclear...

Options for a new EU energy technology policy
Summary of key drivers

<table>
<thead>
<tr>
<th>Policy option 1: Reference</th>
<th>Policy option 2: Focus on price signals</th>
<th>Policy option 3: Sectoral targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market pull</td>
<td>Hybrid</td>
<td>Strong carbon price</td>
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<tr>
<td></td>
<td>Hybrid</td>
<td>Sectoral targets</td>
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<td>Technology push</td>
<td>Hybrid</td>
<td>Technology-neutral TP</td>
</tr>
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<td></td>
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<td>Directed TP</td>
</tr>
<tr>
<td>Governance of instruments</td>
<td>Hybrid</td>
<td>Predominantly centralized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Predominantly decentralized</td>
</tr>
</tbody>
</table>

* MP = market pull / TP = technology push
* Sector = solar, wind, nuclear...
## Agenda

1. Decarbonization: A clear target for 2050?
2. Do we need a (new) (EU) energy technology policy?
3. Options for a new EU energy technology policy

4. What way to go?
   - Evaluation of policy options
   - From polar options to applied measures

5. First conclusions

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## What way to go?

Translating challenges into evaluation criteria

- The three challenges for a future EU energy technology policy become effectiveness criteria
  - **Climate-effectiveness**: Does the policy deliver decarbonization by 2050?
  - **Green growth**: Does the policy respond to fierce global competition in green-tech markets?
  - **Robustness to EU financial and institutional crises**

- Since all benefits that increase the effectiveness of future policies come at certain costs and differ regarding potential difficulties related to their implementation, we further add
  - **Cost-efficiency**: Does the policy option achieve climate and growth goals at lowest costs? (accounts for both abatement and transaction costs (consisting of administrative-, monitoring-, and (re-) negotiation costs.)
  - **Feasibility / subsidiarity compatibility**: Are policies politically and institutionally feasible? Which barriers to implementation are expected?
Evaluation of policy options
Climate-effectiveness

1 – Reference
- Less predictable (no overall GHG emission cap)

2 – Strong carbon price
- Yes (given that all emissions included into a cap-and-trade scheme)

3 – Sectoral targets
- Less predictable (no overall GHG emission cap)

Evaluation of policy options
Green growth

1 – Reference
- No remedy yet
- Individual MS action probably not sufficient, most MS too small to compete on a global scale

2 – Strong carbon price
- Approach = let industry discover promising areas // public intervention only when technology is close to market
- Risk of intervening too late?

3 – Sectoral targets
- By ‘picking winners’ in early stages one can support industrial leadership
- Risk of ‘picking the wrong winners’?
- Risk of ‘institutional lock-in’ in the allocation of funds
- Risk of ‘political lock-in’
Evaluation of policy options
Robustness to EU financial and institutional crises

1 – Reference
- Lack of certainty to investors
- Not sufficient remedies yet

2 – Strong carbon price
- Affordable for all?

3 – Sectoral targets
- More successful to mobilize funds?
- Decentralized governance allows for tailored national solutions
- But underlying assumption of the EU staying a ‘strong’ Union

Evaluation of policy options
Cost-efficiency

1 – Reference
- Multiple targets (20-20-20 style) → interactions mitigating signals
- *No optimal portfolio* (within-sector approach): risk to favor too expensive technologies
- *Low implementation cost (negotiation, etc.)*

2 – Strong carbon price
- *Most cost-efficient abatement*
- *Risk of not getting an optimal portfolio?* - containing (i) existing, (ii) close-to-market and (iii) highly immature technologies
- Takes time until investors trust the signal → *risk of delayed action*

3 – Sectoral targets
- Cross-sector optimization
- ... but optimal portfolio only under quite strong assumptions; risk to favor too expensive technologies
- *High implementation cost (negotiation, etc.)*
Evaluation of policy options
Feasibility / subsidiarity compatibility

1 – Reference
- Given

2 – Strong carbon price
- Difficulties
  (a) to implement "high-enough", adequate carbon price and
  (b) to include all GHG emissions into scheme

3 – Sectoral targets
- Difficulties
  (a) to agree on sectoral targets and
  (b) to agree on a burden sharing among MS
- Regular renegotiations necessary to adapt to changed situations
- Close to subsidiarity problem!

Evaluation of policy options
Summary

➢ No single policy option is clearly superior to the others
  - But, reference option performs worst as it does not respond to all the flaws of existing instruments
  - Option 2 probably can pave the way towards a diversified technology portfolio in 2050
  - Option 3 probably can pave the way for scenarios that need a stronger technology push, such as "high RES" or "high energy efficiency"

➢ There are trade-offs within individual evaluation criteria
  - E.g. one policy can lead to cost-efficient abatement, but in contrast, can involve very high administrative efforts

➢ There are trade-offs across competing criteria
  - E.g. a certain policy option can theoretically result in a more cost-efficient outcome than others but might be difficult to implement or involve very high costs related to policy design and enforcement
**What way to go?**
From polar cases to applied measures

**What are feasible future policies?**

- Assumption that 2050 climate objective will be reached under all options
- **Trade-offs** are among cost-efficiency, green growth and robustness to crises, and feasibility

**Market Pull**

- Cost-efficiency calls for a strong carbon price
  
  - Strengthen role of the EU ETS and introduce an as wide as possible carbon price
    
    [... potentially using a carbon tax which takes account of distributional impacts for different income groups and countries]
  
  - Increase banking and borrowing possibilities

- But (i) price signal will never be perfect and (ii) target setting is superior with respect to the ability to enhance green growth in the shorter-run, and robustness to crises
  
  - Introduce some complementary technology targets
  
  - Revised SET-Plan to prioritize among decarbonization technologies
  
  - National support schemes: Align with new SET-Plan and consider some harmonization

**Technology Push**

- Certain technologies are key to achieve 2050 // reasonable concerns that without explicit support they will not be developed and deployed at the necessary scale and/or on time
  
  - many consumption-oriented measures, CCS? ...

- Need to respond to fierce global competition (supporting industrial leadership to benefit also from exporting technologies, etc.)
  
  - especially for high-tech segments or parts of the value chain that cannot be outsourced to low-cost competitors, but where European players likely will be able to keep a competitive advantage

  - Consider some directed technology push instead of building fully on technology-neutral support to innovation

- Joint action allows addressing projects that are too big for single Member States or that require a coordinated action
- Need to avoid unnecessary duplication of national or regional initiatives
- Catalytic role of European co-funding
- European technology push can help to keep wealth within the Union

  - EU-level action is justified
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5. First conclusions
   — Summary
   — “No-regret” measures for any policy option
   — “Regret” measure industry and trade policy?

Summary

No single policy option is clearly superior to the others, but
• There are trade-offs within individual evaluation criteria
• There are trade-offs across competing criteria

For any feasible future EU energy technology policy ...
... trade-offs imply that relying on price signals is cost-efficient, but not as effective for green growth and robustness to crises as relying on targets

- Strengthen the role of the EU ETS and introduce an as wide as possible carbon price — potentially using a carbon tax which takes account of distributional impacts for different income groups and countries
- New, more focused SET-Plan that provides the basis for technology prioritization and EU research funding
- Introduce some directed technology push since
  (i) certain low-carbon technologies are key to achieve 2050 and there are reasonable concerns that without such support they will not be developed/deployed at the necessary scale and/or on time
  (ii) possible justification as a means to respond to fierce global competition in green-tech markets
- EU-level action in this regard justified
Remark

Need to adjust EU measures to foreign policy paths

- Market pull and technology push measures need to be discussed considering the global perspective

- Market pull versus technology push:
  - Market pull measures set incentives that go beyond European borders
  - If foreign countries opt for strong technology push in certain sectors, a strong EU push in the same sectors might be counterproductive

- Prioritization of certain technologies:
  - Improvements in energy efficiency are key to achieve 2050 goals, as are enabling technologies
  - Policies targeting consumption-oriented measures lower operating costs of European players
    - Hence, tackles global competitiveness of all EU industries (whereas production technology oriented push will only stimulate the clean-tech industry)
  - Implementation of consumption-oriented decarbonization measures typically quite labor-intensive
    - Hence, any public support – be it pull or push policies – will create employment within the EU

“No regret” measures for any policy

Mobilization of private and public funds is key

➢ Spend public money wisely (see THINK #1)
  - No “grants-for-all” policy – consider alternative support instruments such as low-interest loans, loan guarantees, technology prizes, etc.
  - Smart design of public support – encourage efficiency while not discouraging private sector participation

➢ Enable an attractive and stable business environment
  - Need for credible, longer-term policies and stable funding – predictability and transparency
  - Remove barriers to behavioral change and investments into consumption-oriented decarbonization measures – phase-out regulated end consumer prices, information policies, innovative financing arrangements, etc.

➢ Think about new EU funding sources, e.g.
  - EU tax?
  - Wider use of auction revenues from the EU ETS to fund innovation
“Regret measures”
... for industry and trade policy?

• Global clean-tech market is huge in volume (€ 198bn in 2011)
... industry- and trade policy are tempting

• Industry policy
  - COM(2012) 582 calls for a reinforcement of industrial policy for a “stronger European industry”
  - BUT sensitive issue: EU champions for clean-tech versus internal competitive energy market

• Trade policy
  - First mover advantage argument [especially within option 3, technology push can be used to support competitiveness of domestic players]
  - BUT possible regret measure: might lead to trade disputes, as for China and US

Industry and trade policy go beyond addressing environmental and innovation externalities and capital market imperfections – Handle with care!

Looking forward to your thoughts!
Contact: sophia.ruester@eui.eu
The SET-Plan (Strategic Energy Technology Plan)
- Technology pillar of the EU’s energy and climate policy, launched in 2008
- Institutionalizes technology development to achieve “2020” and contribute to “2050” → Technology Roadmaps covering 2010-2020 (SEC(2009) 1295)
- Three implementation instruments: SETIS, EERA and EIIs

**SETIS** (SET Information System)
- PROVIDE DATA AND MONITOR
  - Data and information system hosted by EU and JRC

**EIs** (European Industrial Initiatives)
- DEVELOP TECHNOLOGIES
  - Bring together industry, academia, MSs and the EC
  - Implementation plans (cover 3a, annually revised)

**EERA** (European Energy Research Alliance)
- CONDUCT JOINT RESEARCH
  - Alliance of European research organizations (‘joint programming’) to align RD&D activities of individual research organizations to SET-Plan priorities

**4 MAIN OUTPUTS:**
- Technology Mapping (state of the art, current R&D, industry structure, etc.)
- Capacity Mapping (Review current R&D spending)
- Technology Roadmaps (Define EIs and put forward action plans)
- Review of SET-Plan (Monitor progress)

Notes:
- EERA programs individually apply for funding at EU and national level
- EIs cooperate with respective EERA research program

6 +31 EIs exist

EERA runs 13 joint programmes
### Simplified innovation chain

and relative importance of TP and MP

<table>
<thead>
<tr>
<th>Step</th>
<th>Technological risks</th>
<th>Market risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic research</td>
<td>Typically smaller investments</td>
<td>No returns</td>
</tr>
<tr>
<td>Research &amp; development</td>
<td>Technical risks</td>
<td>Technical &amp; political risks</td>
</tr>
<tr>
<td>Demonstration</td>
<td>Risky returns</td>
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<tr>
<td>Deployment</td>
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<td>Commercial returns</td>
</tr>
<tr>
<td>Commercialization</td>
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</table>

#### Examples of low-carbon technologies

- **Nuclear fusion**
- **New materials** for various applications
- **Ocean wave energy**
- **CCS**
- **Different hydrogen/FC battery systems** for electricity storage
- **Onshore wind**
- **Solar PV** (both still with public support)
- **Hydropower**
- **Nuclear fission**
- **Generation IV**
- **Different battery systems** for electricity storage
- **Hydropower**
- **Nuclear fission**
- **Generation III**
- **Different energy efficiency applications**

### What way to go?

**Distributional impacts of policy options**

#### Distributional impacts:

Varying impacts of alternative policy instruments on different stakeholders or Member States can have important implications for considerations of fairness or political opposition

**Producer side:**

- European players might suffer from weakened positions on the global market if subject to strong carbon prices that are absent in other economies
- Certain Member States would be more affected than others depending on the product specializations of their economies
  - Free allocation of emission allowances improves political feasibility
  - **Auctioning** has advantage that revenues could be used to finance reductions in existing, distortionary taxes (‘revenue recycling effect’), or to provide funding to low-carbon RD&D

**Consumer side:**

- EU ETS and other market pull schemes (e.g. FIT) set prices that are common to all (industrial) consumers, and are (to a large extent) passed on to end-users
  - Such common prices will likely hit lower income groups hardest
- In contrast, **technology push** for prioritized sectors will to a large extent be tax-financed
  - Option 3 leaves more room to include social aspects into energy technology policy, within but also across Member States
Excursus
Some international experiences

China
- Centralized approach
  - Renewable Energy Law (2005) mandates 15% RES share in electricity generation by 2020
  - Sectoral targets (e.g., wind deployment in 2050) determined at national level, disaggregated into regional sectoral targets with clear milestones for action led by the government, wind industry, grid companies
  - Large, centralized R&D programs; governmental funding increased rapidly in the past (e.g., 2008 level 7 times higher than 2003 level)

US
- Difficulties to implement a federal policy
  - President Obama declared quite ambitious targets after his election – but American Clean Energy and Security Act (2009) trying to establish an emissions trading plan died at the Senate
  - Some sectoral research programs with roadmaps (e.g., SunShot, a wind program, roadmap for Solar Energy Development on Public Lands, etc.)
  - ARPA-E (established in 2007, funded initially through economic stimulus package) made significant resources for energy-related projects available (> 80bn USD)
  - ... but federal funding and policies for energy innovation could not be put on a more permanent footing; federal R&D funding amounts have to be approved by the Congress on a yearly basis

Backup
2050 scenarios
### EC 2050 Energy Roadmap

<table>
<thead>
<tr>
<th>Sources (generation)</th>
<th>RES</th>
<th>Nuclear</th>
<th>Fossil/CCS (CCS viable from)</th>
<th>2030</th>
<th>2030</th>
<th>2030</th>
<th>2040</th>
<th>2030</th>
</tr>
</thead>
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<tr>
<td></td>
<td>40.3%</td>
<td>26.4%</td>
<td>33.3% (2030)</td>
<td>48.8%</td>
<td>20.6%</td>
<td>30.6% (2030)</td>
<td>64.2%</td>
<td>14.2%</td>
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<td></td>
<td>59.1%</td>
<td>3.5%</td>
<td>21.6% (2030)</td>
<td>60.7%</td>
<td>16.1%</td>
<td>9.6% (2030)</td>
<td>64.8%</td>
<td>19.2%</td>
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<tr>
<td></td>
<td>64.8%</td>
<td>2.5%</td>
<td>24.8% (2030)</td>
<td>64.8%</td>
<td>2.5%</td>
<td>20.1% (2040)</td>
<td>32.7%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

### Transport electrified by 2050

- NO
- Partly, for transport according to White Paper on Single Transport Area COM2011(144)

### 2050 power demand

- 4130 TWh
- 3951 TWh
- 3203 TWh
- 3377 TWh
- 3618 TWh
- 3585 TWh
- 3552 TWh

### Energy efficiency & Infrastructure

- According to latest Energy Efficiency Plan in CPI
- Energy intensity improvements around 2.5% p.a.

### Carbon price

- Around 50 €/tCO2 in 2050
- 254 €/tCO2 in 2050
- 205 €/tCO2 in 2050
- 260 €/tCO2 in 2050
- 270 €/tCO2 in 2050
- 310 €/tCO2 in 2050

### Climate goal

- -40% emission by 2050
- 85% emission reduction by 2050

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### EC 2050 Energy Roadmap scenarios

#### Main assumptions on market pull / technology push

- **Baseline**
  - 2020 horizon: 20-20-20 targets, existing ETS and non-ETS policies, etc.
  - 2025+ horizon: Carbon prices determined such that 2050 targets are reached, equal prices/values for ETS and non-ETS
  - Increasing fuel efficiency in transport sector

- **Diversified supply technologies**
  - No technology preferred
  - Driven only by the strong carbon pricing scheme

- **High EE**
  - Political commitment to higher energy savings
  - Additional strong requirements and obligations

- **High RES**
  - Strong support measures (MP and TP)
  - Also facilitation and enabling policies (permitting, preferential grid access)

- **Delayed CCS**
  - Similar to ‘diversified supply technologies’ with delayed CCS deployment

- **Low nuclear**
  - Similar to ‘diversified supply technologies’ without any new built nuclear
Alternative 2050 scenarios

Scenario overview

<table>
<thead>
<tr>
<th>Author</th>
<th>Roadmap Title</th>
<th>Scenarios</th>
<th>Emissions 2050</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECF</td>
<td>ECF Roadmap 2050</td>
<td>Baseline</td>
<td>80% less to 1990 in all scenarios</td>
<td>EU 27 + Norway/Switzerland</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40% RES (RES share is an input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60% RES (RES share is an input)</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>80% RES (RES share is an input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenpeace</td>
<td>Energy (R)evolution</td>
<td>Reference (from IEA World Energy Outlook 2009, extrapolated to 2050)</td>
<td>16% less to 1990</td>
<td>EU 27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy (R)evolution</td>
<td>80% less to 1990</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced Energy (R)evolution</td>
<td>95% less to 1990</td>
<td></td>
</tr>
<tr>
<td>IEA</td>
<td>ETP 2010, Blue Map</td>
<td>Baseline (based on IEA Outlook 2009)</td>
<td>8% less to 2007</td>
<td>OECD Europe plus World</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BLUE (RES share is an output here, “degree scenario”)</td>
<td>75% less to 2007</td>
<td></td>
</tr>
<tr>
<td>IEA</td>
<td>ETP 2012</td>
<td>6DS (worst case)</td>
<td>+ 6°C</td>
<td>OECD Europe plus World</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4DS (baseline)</td>
<td>+ 4°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2DS (vision)</td>
<td>+ 2°C</td>
<td></td>
</tr>
<tr>
<td>Eurelectric</td>
<td>Power Choices</td>
<td>Baseline</td>
<td>Not calculated</td>
<td>EU 27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Choices</td>
<td>75% less to 2005</td>
<td></td>
</tr>
</tbody>
</table>
Global clean-tech market
Case study: German solar industry

- Several bankruptcies – European and US companies face (and fear) **competition from China**
- BUT: This is not the whole picture → substantial part of the value can still be generated domestically, even if solar panels are imported

<table>
<thead>
<tr>
<th>RD&amp;D</th>
<th>Fraunhofer ISE = Europe’s largest solar research institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream</td>
<td>Wacker, the largest German manufacturer of solar silicon, reports increasing production</td>
</tr>
<tr>
<td>Midstream</td>
<td>Germany is a high-cost country + production of panels is labor-intensive + transport possible at low cost → China dominates sector</td>
</tr>
<tr>
<td>Downstream</td>
<td>24 of the top 30 system integrators are European /// world’s largest inverter manufacturer is German, too</td>
</tr>
<tr>
<td>Equipment</td>
<td>Production equipment sector is (unlike panel production) high-tech → Germany strong position</td>
</tr>
</tbody>
</table>

- Germany actually benefits from solar manufacturing in China by (1) selling production equipment, (2) exporting silicon, (3) getting back cheap solar panels to install
Funding of R&D

**Wind**

- Increase of R&D expenditure (2007-2008) came from business sector, while public sector support decreased
- (Onshore) wind considered as a mature technology → corporate R&D expenditures continue to dominate
- EERP funding (€565m) for deployment of some large-scale offshore wind farms contributed to noticeable increase in public support in late 2009 and 2010 → BUT: Short-term, one-time measure
- Both public and corporate R&D investments largely concentrated in a low number of MS, i.e. DE, DK, ES

*Most important manufacturers:* Vestas (DK), Gamesa (ES), Enercon (DE), Alstom (ES), Dong (DK), Siemens Wind Power (DK), Nordex (DE), LM Glasfiber Holding (DK), BARD Engineering (DE), Acciona Energy (ES), Clipper Windpower (UK), Areva (FR), Multibrid (DE), Vattenfall (SE), Iberdrola (ES), EDF (FR), Vergnet (FR)

Funding of R&D

**Solar PV**

- Sector continues to grow [annual global installation doubled from less than 7.2 GW (2009) to more than 16.6 GW (2010)]
- EU public support grew substantially; share of public support from MS remained stagnant, with total levels increasing
- In 2008, only 4 (Q Cells, Isofoton, Solar World, BP Solar) of the top 15 manufacturers of PV modules were located in the EU [produced 26% of globally produced PV cells]
- Both public and corporate R&D investments largely concentrated in a low number of MS, i.e. DE, FR, IT

*Most important manufacturers:* SMA Solar Technology (DE), Q-Cells Solar (CH), Q Cells (DE), Isofoton (ES), REC Group (NO), Saint-Gobain Solar (FR), Centrotherm PV Group (DE), BP Solar (UK), Helionthos (NL), Meyer Burger (CH), PV Crystalex Solar (UK), Photowatt Technologies (FR), Wacker Chemie – BU Polysilicon (DE), Solar Watt (DE), Roth&Rau PV (DE), Photovoltaitech (BE), Solland (NL), EdF (FR), T-Solar (ES), Abengoa Solar (ES), Solaris (DE), Acciona Energy (ES), Centrosolar (DE), Conergy (DE), Bosch (DE), Siemens (DE), Linde (DE), Iberdrola (ES), Tenesol (FR), Wuerth Solar (DE), Aleo Solar (DE), Solar-Fabrik (DE)
Funding of R&D
Solar CSP

- Potential locations for meaningful application concentrated in Mediterranean area → national public R&D investments dominated by IT and ES
- Strong public contribution by DE and CH may be explained by their strong positions in this field of technology
- Spanish and German companies are the main actors involved in ongoing demonstration projects launched in Spain
- Share of public support from MS and EU remained stagnant, with total levels increasing
- Both public and corporate R&D investments largely concentrated in a low number of MS, i.e. IT, ES, DE

Most important manufacturers: Abengoa Solar (ES), Saint-Gobain Solar (FR), MAN Ferrostaal AG (DE), Siemens (DE), Torresol (ES), Solar Millennium incl. Flaysol (DE), Schott Solar (DE), Acciona Energy (ES), Areva (FR), Fristec (DE), Solar Power Group (DE), Kraftanlagen Muenchen (DE), Alcan Solar (DE), Fibreb (DE) Novatec Biologic (DE), Nolari (CH), solar euromed (FR), Solitem Group (DE)

Source: JRC (2011) – Capacities Map

Funding of R&D
Other low-carbon technologies

Biofuels:
- Have become a priority in EU policy over past years with rapidly growing market
- Relatively low share of public R&D investments for 1st generation (relatively mature), 2nd generation research only started by time of publication

CCS:
- Low amount of public funding (CCS only recently has become a priority which might not yet be reflected; single processes are in most cases technically proven)
- R&D concentrates mainly in a few MS: DE, FR, UK

H2/FC
- Technology is considered as strategic research field for many of the large multi-national companies with high overall research expenditures → among them also car manufacturers, oil companies, component suppliers, chemical companies

Smart grids
- Fuzzy boundaries of “smart grids” → difficult to estimate
- Companies active here not only electric utilities and component suppliers, but also firms from ICT sector such as IBM

Nuclear
- Fission: dominated by FR
- Fusion: publicly financed → ITER project; EURATOM program; DE largest investor, followed by IT, FR, UK; EU share in future will probably clearly exceed MS share
## Funding of R&D

### Summary

<table>
<thead>
<tr>
<th>Non-nuclear SET-P priority technologies</th>
<th>Corporate R&amp;D investment 2007 (€ million)</th>
<th>Public EU (FP6 respectively EURATOM; avg per year) in € million</th>
<th>Public R&amp;D spending of EU Member States in 2007 (€ million)</th>
<th>(Out of which demonstration in MS national budgets)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen and fuel cells</td>
<td>375</td>
<td>70</td>
<td>171</td>
<td>(24)</td>
<td>616</td>
</tr>
<tr>
<td>Wind</td>
<td>292</td>
<td>11</td>
<td>91</td>
<td>(24)</td>
<td>363</td>
</tr>
<tr>
<td>PV</td>
<td>221</td>
<td>27</td>
<td>190</td>
<td>(15)</td>
<td>364</td>
</tr>
<tr>
<td>CCS</td>
<td>240</td>
<td>17</td>
<td>39</td>
<td>(0)</td>
<td>206</td>
</tr>
<tr>
<td>Biofuels</td>
<td>269</td>
<td>13</td>
<td>65</td>
<td>(10)</td>
<td>347</td>
</tr>
<tr>
<td>Smart Grids</td>
<td>212</td>
<td>14</td>
<td>47</td>
<td>(5)</td>
<td>273</td>
</tr>
<tr>
<td>CSP</td>
<td>48</td>
<td>5</td>
<td>33</td>
<td>(1)</td>
<td>86</td>
</tr>
<tr>
<td>SUM (non-nuclear LC techs)</td>
<td>1668</td>
<td>157</td>
<td>571</td>
<td>(88)</td>
<td>2385</td>
</tr>
<tr>
<td>Distribution by investor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>69%</td>
<td>7%</td>
<td>24%</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nuclear SET-P priority technologies</th>
<th>Corporate R&amp;D investment 2007 (€ million)</th>
<th>Public EU (FP6 respectively EURATOM; avg per year) in € million</th>
<th>Public R&amp;D spending of EU Member States in 2007 (€ million)</th>
<th>(Out of which demonstration in MS national budgets)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Fusion reactor (mainly reactor related research, thus without safety, waste, environment)</td>
<td>205</td>
<td>4</td>
<td>248</td>
<td>(0)</td>
<td>458</td>
</tr>
<tr>
<td>Nuclear Fusion</td>
<td>0</td>
<td>204</td>
<td>278</td>
<td>(88)</td>
<td>482</td>
</tr>
<tr>
<td>Total SET-Plan priority energy technologies</td>
<td>1862</td>
<td>366</td>
<td>1097</td>
<td>(88)</td>
<td>3325</td>
</tr>
</tbody>
</table>

Source: JRC (2009) – Capacities Map