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Renewable energy supporting mechanisms
A review

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Contents

International energy context

- Sustainability
  - Climate change (CO_2, Kyoto protocol, AP6)
  - Other pollutants (SO_x, NO_x)
  - Availability for future generations
- Security of supply
  - External dependency on energy imports
    - Low political stability in exporting countries
  - Future scarcity
- Competitiveness
  - Energy has a direct and important impact on the economy
  - Availability of energy at reasonable prices is crucial
  - Higher and more volatile energy prices

Renewable Energy Sources (RES)

- Sustainable
  - Major player in CO_2 reductions
  - Environmentally friendly
  - Renewed for future generations by definition
- Secure supply
  - Usually local resource
  - Only guaranteed future energy source
- Competitive
  - Non-volatile prices
  - Not yet competitive with fossil energy sources?

Support for renewable energy

- Externalities are not taken into account in today's energy price
  - Climate change
  - Local pollution
  - Long term availability
  - External dependency
- Most of renewable energy technologies are not yet fully mature
  - Needs an initial push to become competitive

Electricity production from RES (i)

Electrical Power generation	Existing Capacity end of 2004 (GW)	Average growth 2000-2004
Large hydropower	720	2%
Small hydropower	61	2-4%
Wind turbines	48	**28%**
Biomass power	39	2-4%
Geothermal power	8.9	2-4%
Solar PV, off-grid	2.2	17%
Solar PV, grid-connected	1.8	**60%**
Solar Thermal power	0.4	-
Ocean (tidal) power	0.3	-
Total		
with large hydropower	880 (23%)	
without large hydropower	160 (4.2%)	

Source: Renewables 2005 Global Status Report

Electricity production from RES (ii)

- Renewable energy generators are still very concentrated in a few countries
  - Wind
    - Germany, Spain, USA, India, Denmark
  - PV
    - Germany, USA, Japan
  - Solar thermal
    - California
    - Spain, Israel, USA ?

Source: Renewables 2005 Global Status Report

Local context

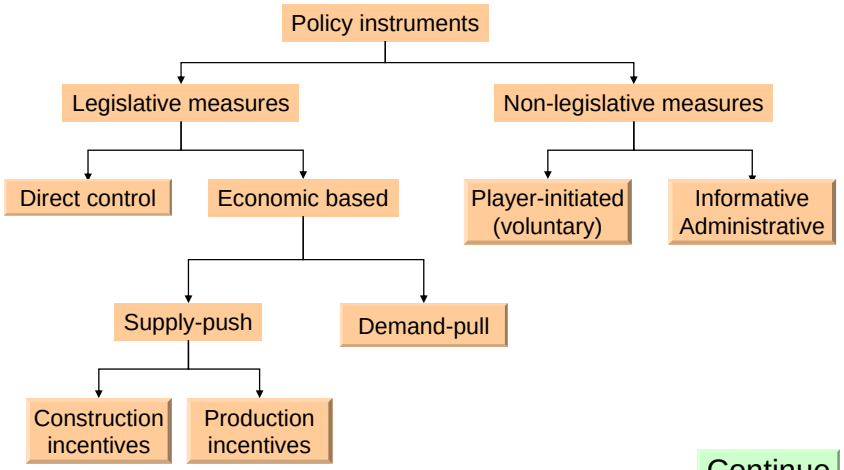
- Large number of different supporting mechanisms
  - Very different levels of RES penetration
- Very different local context
  - Environmental commitment
    - Level of local support (public in general, government, institutions)
  - External dependency
    - Countries with highest penetration of renewable sources are highly dependent on energy imports
  - Regulatory framework and tradition
    - Market oriented or regulation oriented
    - Recent history and regulatory processes
  - Local resources
    - Fossil fuels and renewable energy sources

Contents

- Renewable energy in the international energy context
- Supporting mechanisms for renewable electricity generation
- Theoretical framework for comparison of supporting mechanisms

RES supporting mechanisms classification

From Enzesberger et al, 2002



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Informative & administrative

- Policy instruments
  - Non-legislative measures
    - Informative & administrative
      - Resource mapping
      - Investor advising
      - Publicity / campaigns
      - Improved administrative procedures

These are necessary but not sufficient measures for RES uptake

Player-initiated (voluntary)

- Policy instruments
  - Non-legislative measures
    - Player-initiated (voluntary)
      - Green pricing
      - Certification
      - Self-obligation

Marginal push for renewables

Direct control

- Policy instruments
  - Legislative measures
    - Direct control
      - Forced investment
      - Forced shut-downs
      - Standards (safety, reliability)

Design to act where economic instruments cannot reach or are too risky (nuclear, safety issues)

Demand-pull

- Policy instruments
  - Legislative measures
    - Economic based
      - Demand-pull
        - Tradable Green Certificates (Quota systems)
        - Tax deductions for green power purchasers

One main type of RES supporting mechanism

Construction incentives

- Policy instruments
  - Legislative measures
    - Economic based
      - Supply-push
        - Construction incentives
          - Direct subsidies
          - Accelerated depreciation
          - Tax deduction
          - Below-market-rate loans

Usually in addition to some other mechanism

Production incentives

- Policy instruments
  - Legislative measures
    - Economic based
      - Supply-push
        - Production incentives
          - Feed-in Tariffs (fixed tariff, market + premium)
          - Tax exemption
          - Competitive tenders for long-term power sales contracts

Second main type of RES supporting mechanism

Main supporting mechanisms

- Tender schemes
  - Disappearing but for specific sites
- Feed-in Tariffs (FiT)
  - Expanding throughout Europe
  - In a number of USA states
- Tradable Green Certificates (TGC)
  - Growing steadily, still a lot of questions about performance

Contents

Setting the objectives of the policy

- Environmental objectives
  - CO_2, SO_x, NO_x emissions reduction
  - Sustainability
- Political objectives
  - Price volatility reduction
  - Low energy prices (long term)
  - Increasing security of supply
- Economic development vs. import costs
  - Local employment
  - Industry development
  - Local economic development

Policy evaluation (i)

- Effectiveness in terms of RES deployment
  - What is the target and has it been fulfilled
- Efficiency in terms of cost
  - Least cost solution
    - Least cost technology & better locations (high resources)
    - Cost impact in the existing system
  - Long-term cost reduction
    - Dynamic efficiency
      - Manufacturing, construction, know-how
  - Minimising cost transfer to final customers
  - Transaction costs

Policy evaluation (ii)

- System conformity
  - Integration in the system and regulatory framework
    - Network development
    - System operation
    - System security
    - Compatibility with other mechanisms (GHG emission reduction)
- Flexibility
  - Capacity to adapt to new and evolving data
- Local economic development induced

Factors affecting the results (i)

- Design
  - For each mechanism, there are several possible design choices that can affect performance
  - In addition, a combination or accumulation of different mechanisms may be used
- Settings
  - Time horizon, target in TGC, price in FiT, etc.
- Structure
  - Size of the market, number of potential participants
- Context
  - Physical, social and regulatory context

Factors affecting the results (ii)

- Context
  - Physical
    - Network & system capacity
    - Resource availability
      - RES and conventional
    - Local R&D and manufacturing facilities
  - Social
    - Agents (promoters, DSO, TSO, SO, regulator), society and administration attitude towards RES
  - Regulatory
    - Previous regulation (tradition)
    - Adaptation of TSO, DSO, SO regulation to RES penetration
    - Standards

Tender scheme (i)

- Good theoretical properties
  - Known capacity
  - Ex-post marginal cost knowledge
  - High competition between promoters
  - Low cost transfer to customers (no margin to producers)
- Bad practical experiences
  - Stop & go effect
    - No industry development
    - No dynamic efficiency
  - Low cost bids leading to non development of projects
  - High entry cost
  - Low number of contenders (possible market power)

Tender scheme (ii)

- Although some of its disadvantages may be overcome by better auction design, they are no longer popular
- New applications
  - Specific large projects
  - All the planning is already done
    - Site selection
      - Resource known
      - Permits granted
    - Network connection already in place or planned
  - Adjusts price to marginal cost

TGC (Quota system)

- Preferred option of 'market mechanism promoters'
  - High competition between generators for least cost options
    - Both technologies and sites
  - Marginal cost of RES should be determined by the market
  - TGC allow burden to be shared between all consumers
  - Better market integration than FiT (see later)
- Disadvantages
  - Market will pick a winner
    - No support for a broad range of technologies
  - Pressure for best spots may concentrate RES deployment
    - NIMBY effect
    - Integration problems may arise
  - High risk for the investment (volume, price and regulatory)
    - Price may not be as competitive as expected

TGC: results

- Effectiveness
  - Until now, no record of meeting the intended target
    - Complex design prone to flaws and stakeholder pressure
    - Inherent high risk for promoters
    - Impact of a derivative market on risk mitigation?
- Efficiency
  - Practical experience
    - European (UK, Italy) experience show higher prices with TGC than with FiT
    - USA experience show need of additional support for RES deployment to happen
    - Australia has had low prices (ignoring the cost of supporting hydro and solar water heating), but this might be related to high resources and small target
  - Lack of dynamic efficiency for non-mature technologies

TGC: results

- System conformity
  - Does allow a certain level of integration into the market
    - Still the TGC premium distorts the wholesale market economic signal
  - Does not interfere with network integration
  - Concentration of RES deployment may stress
    - Network
    - System operation (high correlation of outputs)
- Flexibility
  - Changes in the target may jeopardise the stability of the market created, increasing the risk
- Local economic development
  - Does not seem to lead to local industry development, although it might be related to the small amount of RES being driven

TGC: assessment

- Design
  - Complex
  - Some improvements may found a difficult equilibrium
    - Support to specific technologies through technology quotas may lead to small markets and lose least-cost advantage
- Settings
  - RES target can radically change the characteristics of the supporting mechanism
    - As a marginal market, it is highly dependent on the marginal technology and spot price
      - Flat marginal cost curve is most suitable
      - Ambitious target may lead to high marginal costs

TGC: assessment

- Structure
  - Need a large market to avoid market power
  - Does not allow small- and medium-sized participants
- Context
  - Concentration of deployment in a few spots may lead to DSO, TSO and local community opposition
  - Availability of resources
    - Flat marginal cost curve is most suitable

FiT or market + premium

- Treats RES as a regulated activity
  - Installed capacity driven by the price
  - Low risk for the promoter
    - Allows deployment of a large spectrum of technologies at different stages of maturity
    - Allows small- and medium-sized facilities (increases social acceptance and widens installed capacity potential)
  - Allows deployment in non-optimal resource locations (reduces NIMBY effect)
  - High competition at the manufacturing and construction stages
- Disadvantages
  - Regulation picks winners
  - FiT may act as a barrier for a correct integration into the system
  - High short-term cost (high cost technology, sub-optimal spots)

FiT: results

- Effectiveness
  - Hard to meet the intended target exactly, but may be exceeded or fall short
  - Has driven most of today's RES facilities
- Efficiency
  - High cost in the short term
    - Although lower than TGC for the same technology and resource level (low associated risk)
  - High cost reduction induced in several technologies (dynamic efficiency)
    - Hard to transfer cost savings to customers
      - A predetermined decreasing path of tariff may help solve this problem
  - Strong competition at the manufacturing and building stages
    - Similar results to a RPI-X regulation

FiT: results

- System conformity
  - FiT is a barrier to system integration
    - Market + premium helps, but still has the same problems as TGC and also has other associated risks
  - Does not allow network integration without modification
  - Spread out RES deployment may help to avoid stress of
    - Network
    - System operation (non-correlation of outputs)
- Flexibility
  - Although in theory easily adapted, changes have been difficult because of strong lobbying activity
- Local economic development
  - Early adopters have seen large industrial development
  - Strong impact on the local economy due to high deployment

FiT: assessment

- Design
  - Simple (difficult to get it wrong)
- Settings
  - Price has dramatic effects on installed capacity
    - Target exceeded or shortfall
    - Seems not too difficult to set a price that drives deployment without exceeding target too much
    - Market + premium option is hard to tune correctly in the long term due to market volatility
- Structure
  - No major problem with the size of the market
  - Allows small- and medium-sized participants
  - Easy of entry

Combination of mechanisms

- (Midttun and Gautesen) suggest that these mechanisms are complementary and should be implemented at the same time
  - FiT for emerging technologies
  - TGC for mature technologies

Exploring the use of Contracts for Differences (CFD)

- Evolution of FiT
  - Keeps main advantages of FiT
    - Low risk
    - Dynamic efficiency
    - Low transaction costs
  - Better integration in markets and networks than TGC or FiT
    - Any existing economic signal reaches the RES
    - Need aggregators for small- and medium-sized facilities to be installed and maintain same ease of entry as FiT

Further reading (i)

1. Bolinger, M. and R. Wiser, *Case Studies of State Support for Renewable Energy. The impact of State Clean Energy fund Support for Utility-Scale Renewable Energy Projects*. May 2006, Berkeley Lab and the Clean Energy States Alliance.
2. Butler, L. and K. Neuhoff, *Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development*, in *Cambridge Working Papers in Economics CWPE 0503*, U.o.C.-D.o.A. Economics, Editor. 2004, The Cambridge-MIT Institute. p. 35.
3. Enzensberger, N., M. Wietschel, and O. Rentz, *Policy instruments fostering wind energy projects--a multi-perspective evaluation approach.* Energy Policy, 2002. **30**(9): p. 793-801.
4. Fairley, P., *The greening of GE.* IEEE Spectrum Online, 2005. **July**.
5. Hamrin, J., D. Lieberman, and M. Wingate, *Regulator's Handbook on Renewable Energy Programs & Tariffs*. 2006, Center for Resource Solutions. p. 72.
6. Huber, C., et al., *Green-X. Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricy market*. 2004. p. 154.
7. Jacobsson, S. and V. Lauber, *The politics and policy of energy system transformation--explaining the German diffusion of renewable energy technology.* Energy Policy, 2006. **34**(3): p. 256-276.
8. Komor, P. and M. Bazilian, *Renewable energy policy goals, programs, and technologies.* Energy Policy, 2005. **33**(14): p. 1873-1881.
9. Lauber, V., *REFIT and RPS: options for a harmonised Community framework.* Energy Policy, 2004. **32**(12): p. 1405-1414.

Further reading (ii)

10. Martinot, E., *Renewables 2005. Global status report*. 2005, REN21 Renewable Energy Policy Network. Worldwatch Institute: Washington DC. p. 35.
11. Menanteau, P., D. Finon, and M.-L. Lamy, *Prices versus quantities: choosing policies for promoting the development of renewable energy.* Energy Policy, 2003. **31**(8): p. 799-812.
12. Midttun, A. and A.L. Koefoed, *Greening of electricity in Europe: challenges and developments.* Energy Policy, 2003. **31**(7): p. 677-687.
13. A. Midttun and K. Gautesen, "Feed in or Certificates, Competition or Complementarity? Combining a Static Efficiency and a Dynamic Innovation Perspective on The Greening of The Energy Industry," The Norwegian School of Management, pp. 10.
14. Mitchell, C., D. Bauknecht, and P.M. Connor, *Effectiveness through risk reduction: a comparison of the renewable obligation in England and Wales and the feed-in system in Germany.* Energy Policy, 2006. **34**(3): p. 297-305.
15. Mitchell, C. and P. Connor, *Renewable energy policy in the UK 1990-2003.* Energy Policy, 2004. **32**(17): p. 1935-1947.
16. Sawin, J.L., *National Policy Instruments. Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World*, in *International Conference for Renewable Energies*. 2004, Secretariat of the International Conference for Renewable Energies: Bonn.

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