Econ 366

Fall 2012

Renewables:

Opportunities and Barriers

Renewables

- Increasing prices of conventional energy resources, environmental concerns / sustainability, and energy security issues have led to a growing interest in mass production of energy based on renewables such as wind, biomass, ...
- Renewables (hydro, wind, biomass) currently account for 16% of Alberta's electricity generation portfolio and about 13% of primary energy worldwide (see textbook)
- Growth of renewables has been about 2.3% per year (starting from a very small base) over past 3 decades (higher than overall growth rate of primary energy supply);

Renewables

- Wide variations across regions, with renewables accounting for:
  - Almost 50% of primary energy in Africa
  - Over 30% of primary energy in Latin America
  - Over 25% of primary energy in much of Asia

- In low income countries, mostly ‘traditional’ energies: bio-mass;
  - not necessarily sustainable (deforestation, for example);
  - not necessarily clean (particulate matter);
  - low conversion efficiency compared to other sources of energy
  - primarily used in the residential sector

Figure 11.1

Fig. 11.1 Regional distribution of renewable energy use in 2007. *Data source* IEA (2009)

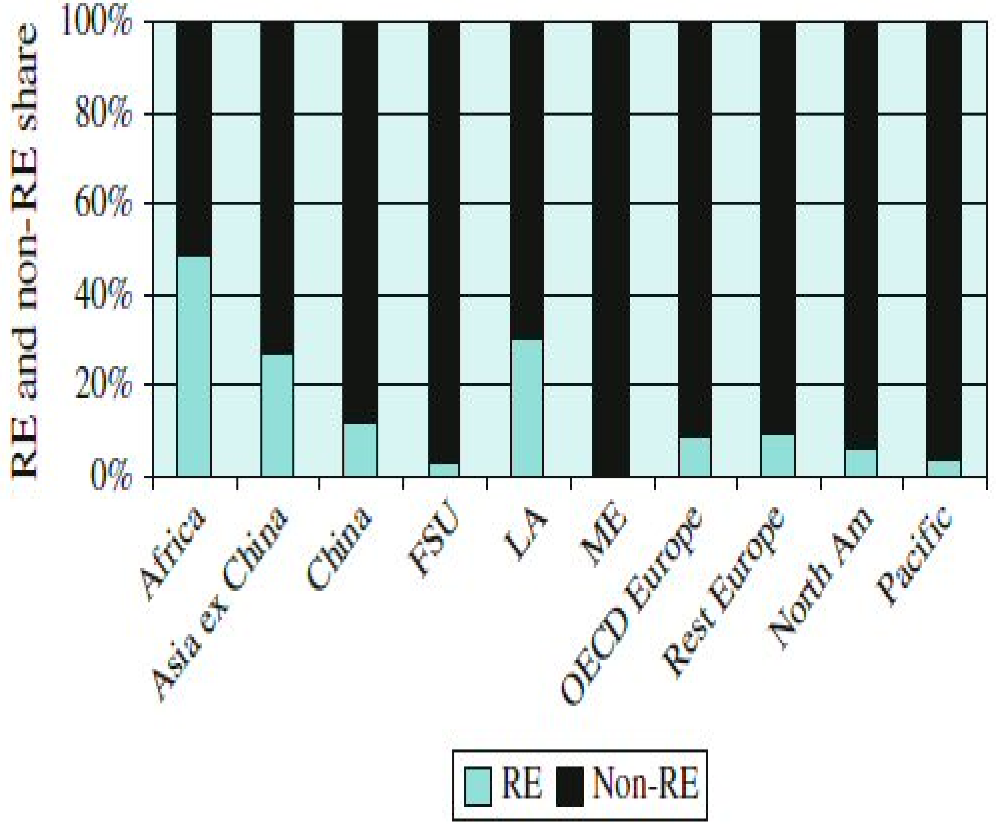
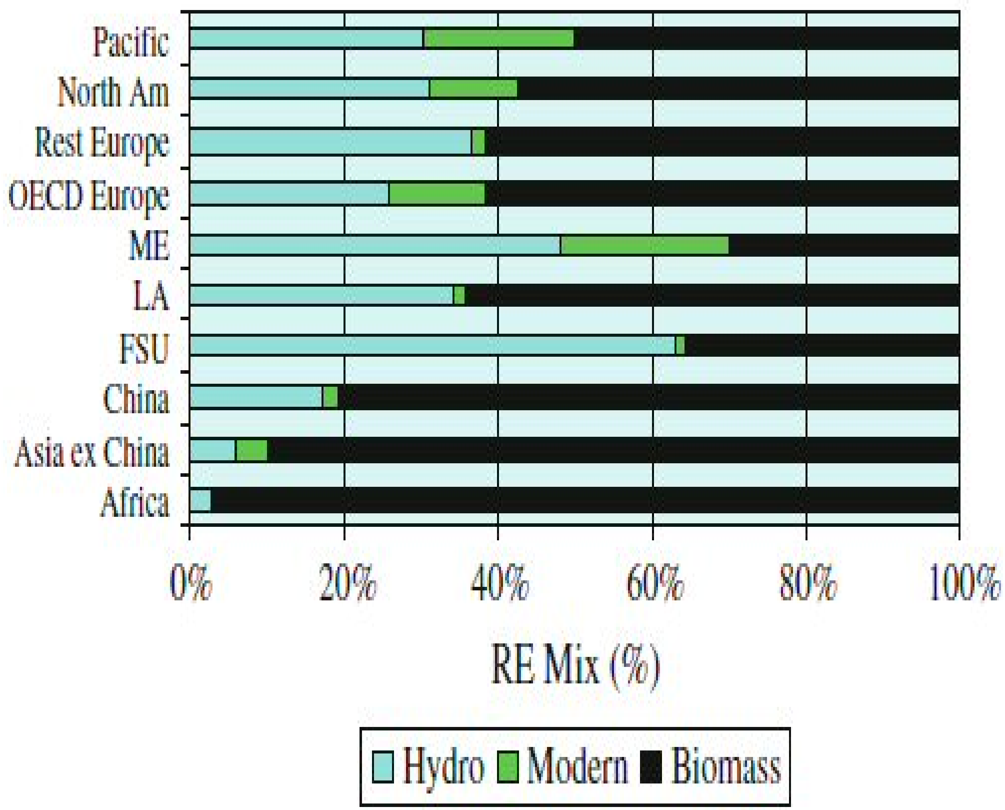


Figure 11.2

Fig. 11.2 Renewable energy use by type in 2007. *Source* Based on IEA (2009) data



Potential of Renewables

- Technically, with current technologies, it may be possible to generate:
  - 43 PWh of wind-based energy
  - 939 PWh of Solar-PhotoVoltaic
  - 7 PWh of biomass energy
- Technical progress should increase these potentials
- Current global electricity use: 13.3 PWh

Barriers to Increased Renewables

- Technical: intermittency of supply (the wind doesn’t necessarily blow at the right time)
- Uneven playing field (externalities: prices of fossil fuels do not reflect their full social costs)
- Market barriers (access to grid, regulatory barriers, lack of incentives)
- Non-market barriers (administrative, information)

Barriers and Externalities based on assignment answers (2011)

Energy Source	Barriers Identified	Externalities Identified
Wind	- need advantageous locational characteristics which may be remote - transmission access - storage problems /intermittency → needs to be augmented by other sources / technologies (pumped storage hydro, for example) - lack of versatility (can only be used to generate electricity) - capital costs (partially due to market power of 4 big producers) - political will	- noise / vibrations (one person noted that there's evidence that people complain more about wind farm noise than other similar types of noises) - aesthetics ("asparagus"), including negative impacts on tourism (can be positive if people like they way they look) - shading - impacts on agricultural land

Aesthetics of Wind Turbines (photos by J Banister)

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Aesthetics of Wind Turbines (photos by J Banister)

- Each turbine generates 2.1 megawatts of power and the total generated from the entire farm is over 50 megawatts.
- This particular wind farm provides power for over 20,000 Missouri homes.

Barriers and Externalities

Energy Source	Barriers Identified	Externalities Identified
Ethanol / Biofuels	- export tariffs (54 cents per gallon US tariff on Brazilian production) - expensive feedstocks (limited supplies) due to competition for land - infrastructure needed for processing - inefficiencies related to collection of feedstock from multiple locations (animal waste, straw) / lack of an established marked - vehicle design → corrosive if not mixed with conventional gasoline	- fertilizer use → runoff into waterways - GHG effects from the energy used throughout various stages of the production process - reduced odours from animal waste (positive externality)

Barriers and Externalities

Energy Source	Barriers Identified	Externalities Identified
Tidal	- high dollar and time costs of construction - locational requirements	- destruction of habitat
Solar	- lack of accessible information - income constraints for home-based solar - intermittency - cost of conversion technology - clouds / building orientation issues - % of windows needed for passive solar → construction challenges for net-zero homes	- disposal issues for old panels (arsenic) - habitat damage from large scale solar farms - indirect emissions related to construction of panels

Barriers and Externalities

Energy Source	Barriers Identified	Externalities Identified
Hydro	- regional geography	dams → -loss of habitat; -displacement of people; -loss of farmland - mercury bacteria; change in water temperatures - flood control (+ve) - irrigation (+ve) - navigation opportunities (+ve) - recreational water sport opportunities (+ve)

Barriers and Externalities

Energy Source	Barriers Identified	Externalities Identified
Geothermal	- capital costs - locational considerations - disruptions from drilling	- utility from "knowing something is being done"
Nuclear	- political opposition - construction costs	- nuclear waste disposal - catastrophic risks

Renewables and Electricity Generation

- Feasibility of various renewable options vary according to regional characteristics
- Possible renewable generation sources:
  - Hydro
  - Wind*
  - Solar*
  - Tidal*
  - Biomass

  * Supply is intermittent → not feasible as part of baseload generation

Renewable Electricity Supply: Costs

- Relatively lower operating / variable costs (no need to purchase fuels)
- For many sources, the majority of costs are related to installing and maintaining the generation capacity
- Fewer (although not necessarily zero) externalities

Renewable Electricity Supply: other issues

- Many sources not always available and output is not easily storable → provides complications for merit-order dispatch
- Low capacity utilization rates (if only occasionally dispatched) → affects financial viability
- Externalities (noise, aesthetics) associated some sources such as wind farms
- Must be complemented with more reliable supplies (often based on fossil-fuel generation)

Bio-fuels (used largely in transportation sector)

- Bio-ethanol can be produced from a variety of feed stocks such as sugarcane, sugar beets or corn
- Bio-diesel can be produced from oil seeds such as canola
- Liquid fuels can be produced from animal fats and biomass
- Trade-off between land use for energy production vs land use for food production

Figure 11.9

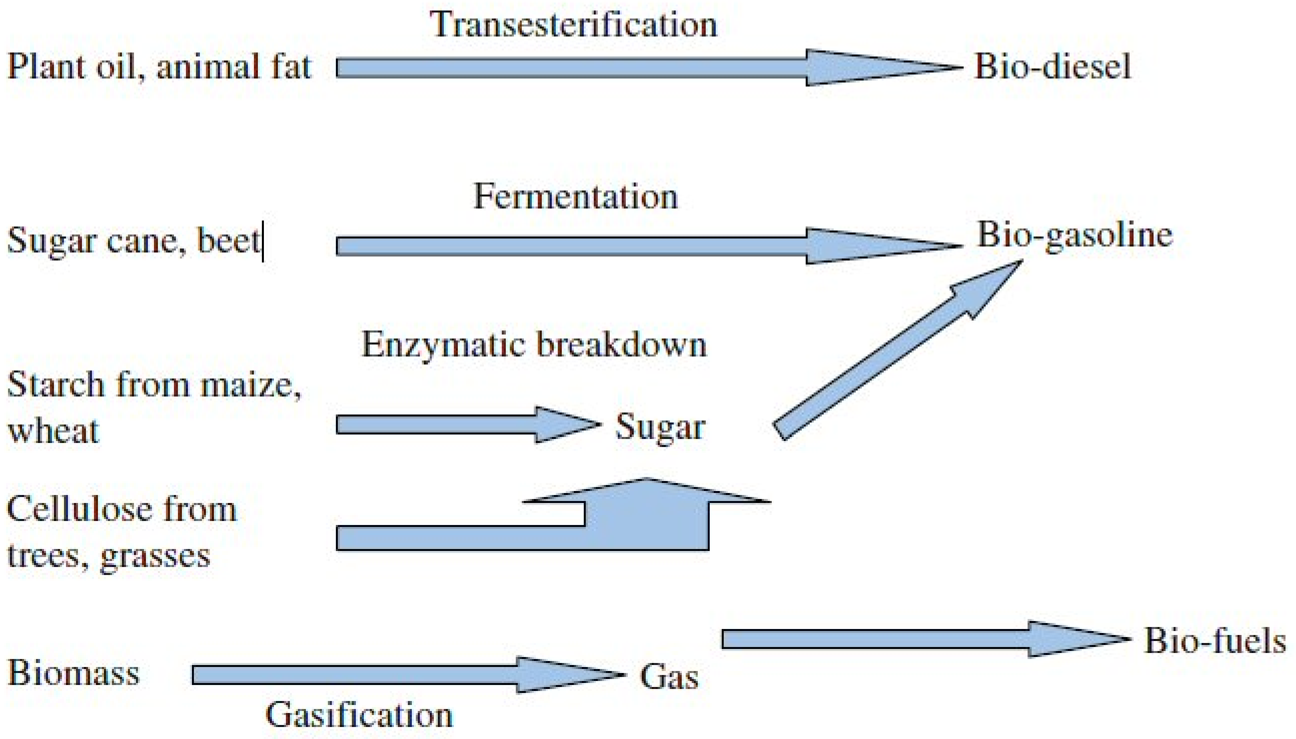


Fig. 11.9 Alternative feed-stocks and transformation processes for bio-fuel production. *Source* Bomb et al. (2007)

Economics of Bio-fuels

- Bio-ethanol
  - Major cost component: feedstock
  - Substantial labour and energy costs
  - Cost of production falls with size of conversion plant (economies of scale); competitive with other fuels in Brazil
  - Increased demand for feedstock → impact on food price of feedstock → diversion of land away from food-based agricultural activities → impact on food supply and prices (with a large impact on those with low incomes)

Economics of Bio-fuels

- Bio-diesel
  - Major cost component: feedstock (80%)
  - Competition from other uses (cooking) makes the feedstock expensive
  - Not yet cost-competitive anywhere
  - Support mechanisms used to promote bio-diesel

Policy Tools for Promoting Increased Supply of Renewables

(1) Feed-in Tariffs:

- utilities required to buy renewable electricity at prices that are usually higher than the market price (Ontario, California, Europe);
- cost often passed on to end-users (customers)
- promotes high cost supply
- may lead to oversupply, with the utility ‘on the hook’ for purchasing this supply
- Suppliers may earn ‘rents’ (price greater than mc)
- Possible income distribution impacts (German study)

Policy Tools for Promoting Increased Renewables

(2) Renewable Obligations

- Examples: Renewable Portfolio Standard (US); Renewable Obligation system (UK); EU bio-fuels directive
- Electricity suppliers obligated to purchase a percentage of their product from renewable sources (or EU members required to ensure minimum bio-fuel supplies in their markets)

England’s RO system

- Set of eligible technologies: wind, solar, biomass, etc
- Renewable electricity producers receive a tradeable Renewables Obligation Certificate
- Renewable generators can sell electricity and ROCs
- Ideally, this leads to the least cost way to achieve the RO
- In the case of non-compliance there are fines or buy-out prices

Figure 11.17

Fig. 11.17 Economic logic for certificates trading. *Source* Menanteau et al. (2003)

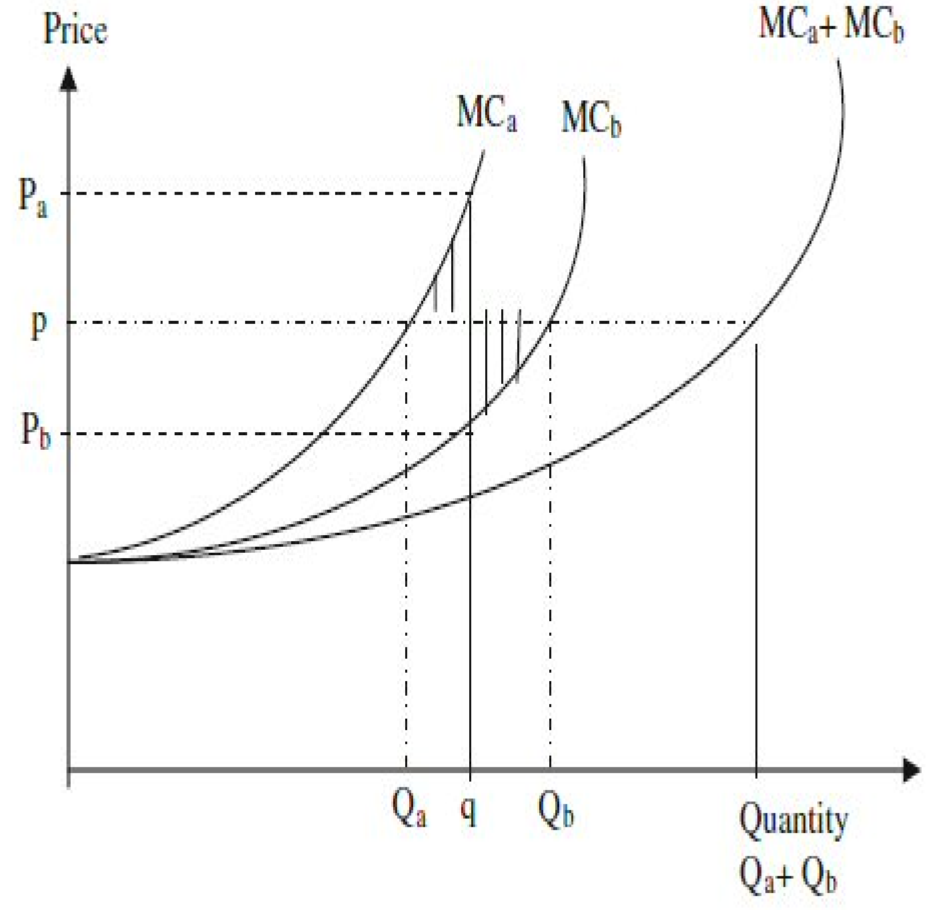


Figure 11.17

- Suppose that there are two electric utilities, each with the same renewable target (q) → an overall target of 2q
- One utility (a) faces a high cost of producing renewable energy (less wind?, no access to tidal sources?)
- With no trading, it would cost Pa to meet its RO standard
- But (b) could expand its production of renewables relatively cheaply and 'sell' part of its ROC to (a)
- This leads to a lower cost of achieving the overall RO of 2q

Policy Tools for Promoting Increased Renewables

(3) Competitive Bidding

- In jurisdictions where there are mandates for renewable energy contributions in the electricity generation mix the set of suppliers can be selected through a competitive bidding process
- Proposals accepted based on bid price up to the desired quantity (if each supplier gets price that it bids → rents not earned on low cost projects)

Policy Tools for Promoting Increased Renewables

(4) Financial Incentives

- Fiscal measures designed to reduce the cost of production or increase the revenues for producers of “renewables” or “clean” conventionals (such as Alberta’s subsidized CCS demonstration projects)
- May include tax exemptions or reductions, investment credits, accelerated depreciation allowances, direct subsidies, rebates, low interest loans
- “cherry picking”, in that they usually reflect preferences for one set of technologies over another

Policy Tools for Promoting Increased Renewables

(5) Carbon Taxes

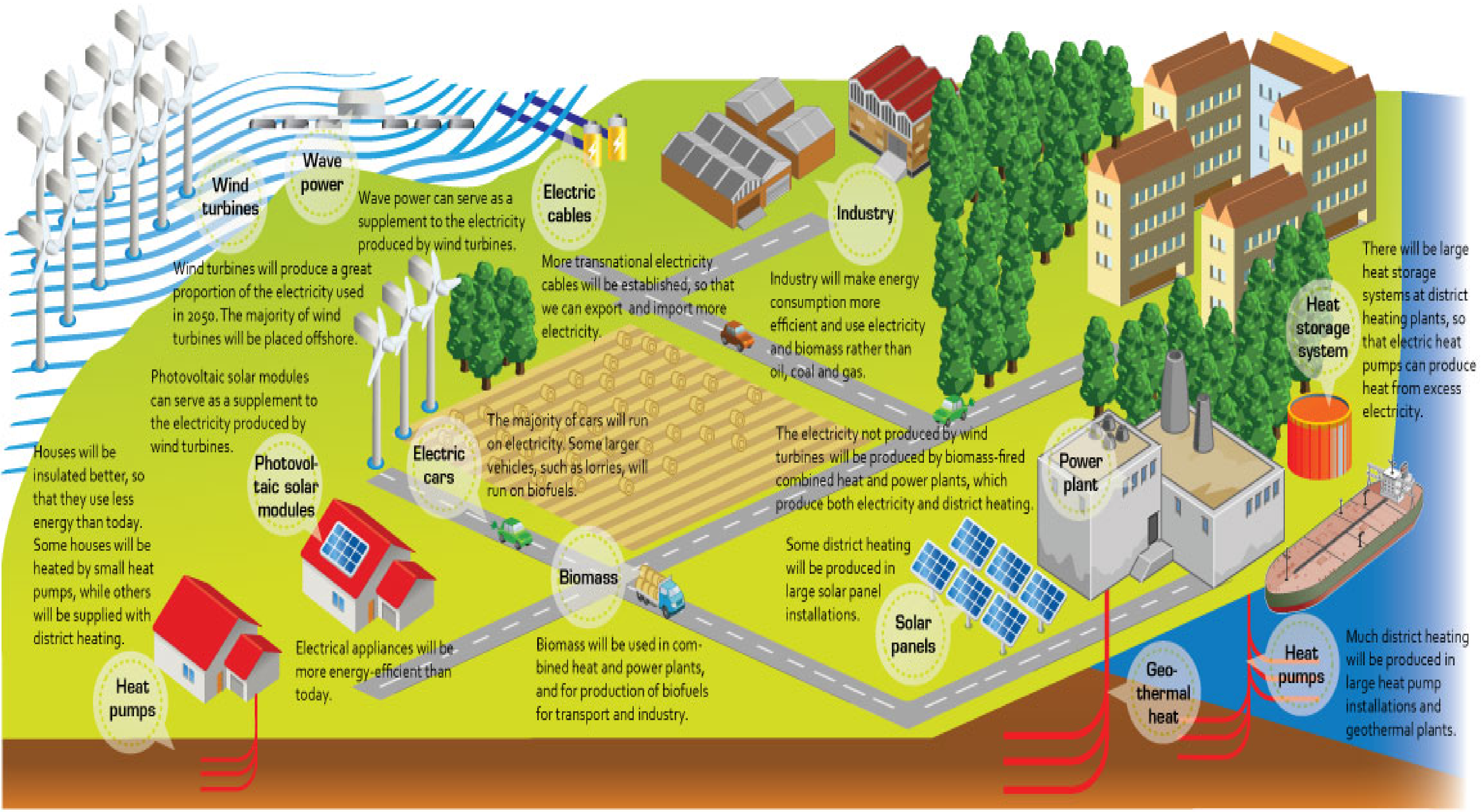
- Can be used to capture the ‘full’ costs of using fossil fuels → price signal
- Common in many European countries
- Canadian example: B.C. carbon tax
  - http://www.fin.gov.bc.ca/tbs/tp/climate/A6.htm

- Burden may be shifted to consumers (providing an incentive to switch to other energy sources?)

Transitioning to Renewables: A Case Study

- Danish Case Study: Government goal to become independent of fossil fuels within the next 40 years
- Richardson, K. Dahl-Jensen, D. Elmeskov, J. Hagem, C. Henningsen, J. Korstgård, J. Buus Kristensen, N. Morthorst, P. Olesen, J. Wier, M. Nielsen, M. Karlsson, K. 2011. Denmark's Road Map for Fossil Fuel Independence. *Solutions.* Vol 2, No. 4. pp. - - http://www.thesolutionsjournal.com/node/954

Figure from Danish Study



Options Considered

			Ambitious World		Unambitious World	
			Reference Scenario	Future Scenario	Reference Scenario	Future Scenario
		2008	2050	2050	2050	2050
Fossil Fuels	Oil	292	200	0	211	0
	Coal	187	27	0	272	0
	Coal + CCS	0	115	0	0	0
	Natural Gas	149	74	0	79	0
	Total	**628**	**417**	**0**	**561**	**0**
Biomass + Waste	Solid Biomass	84	112	124	99	433
	Biogas	4	35	33	31	35
	Waste Including Fossil Waste	40	44	43	45	46
	Total	**128**	**191**	**199**	**175**	**515**
Electricity Producing Renewables	Wind	25	128	265	74	136
	Photovoltaics	0	0	10	0	0
	Wave Energy	0	0	6	0	0
	Total	**25**	**128**	**281**	**74**	**136**
Heat Producing Renewables	Geothermal	1	2	12	2	2
	Solar Heat	1	1	13	1	9
	Heat Pumps	6	65	77	67	59
	Total	**7**	**67**	**102**	**70**	**69**
	Total	**787**	**803**	**582**	**880**	**720**

Options for transitioning to renewables

- Feasible options depend on country-specific characteristics
  - For example, a land-locked country will not be able to harness tidal power
- Danish study includes many renewable sources, but does not include nuclear or CCS options
  - Denmark has good access to (largely off-shore) wind and biomass
  - Plan involves possible imports of electricity from other countries ... (which may be generated from fossil fuels)

What is the plan?

- How does Denmark plan to move from 18% renewables (2009) to 100% renewables?
  - Assumption of improved technologies: electric cars, tidal power, solar power, geothermal power, efficiency of residential heating systems and appliances
  - Assumption of increasing fossil fuel prices that make renewable prices more ‘competitive’
  - Both supply and demand side policies to be implemented
    - Fluctuating energy sources (such as wind-generated electricity) → plan has to include both supply-side and demand-side (smart grid) policies
    - In other words, since wind power is not always available → need to be able to shift some energy consumption to times when there is ‘excess’ supply (this is similar to, but not quite the same as, peak-clipping)

Is the transition economically feasible?

- “Perhaps the most striking finding of all is that the overall cost of achieving fossil fuel independence is only marginally more (on the order of 0.5 percent of GDP in 2050) than predicted total energy-related expenditure in a “business-as-usual” scenario. This near equivalence in cost is due primarily to expected increases in the price of fossil fuels.”

Hanson Lecture on Renewables: Prof. Severin Borenstein

- http://www.ipe.ualberta.ca/en/~/media/ipe/Events%20and%20Seminars/Hason%20Lecture/2012/Borenstein_Presentation.pdf