Discussion of

Douglas J. Arent, A. Wise, R. Gelman

"The Status and Prospects of Renewable Energy for Combating Global Warming"

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Potsdam Institute for Climate Impact Research

Workshop on the
Economics of Technologies for Combating Global Warming
Snowmass, Aug 3, 2009

PIK
Potsdam-Institut für Klimafolgenforschung

Three Options for Combating Global Warming

- Renewable Energy
  Status and prospects presented by Douglas J. Arent
- Nuclear Energy
  Status and prospects presented by John F. Ahearne
- Carbon Capture and Sequestration
  Status and prospects presented by Howard Herzog

No silver bullets here! But important options.

Difficult to assess their mitigation potential in isolation

➔How are they embedded in a system perspective?

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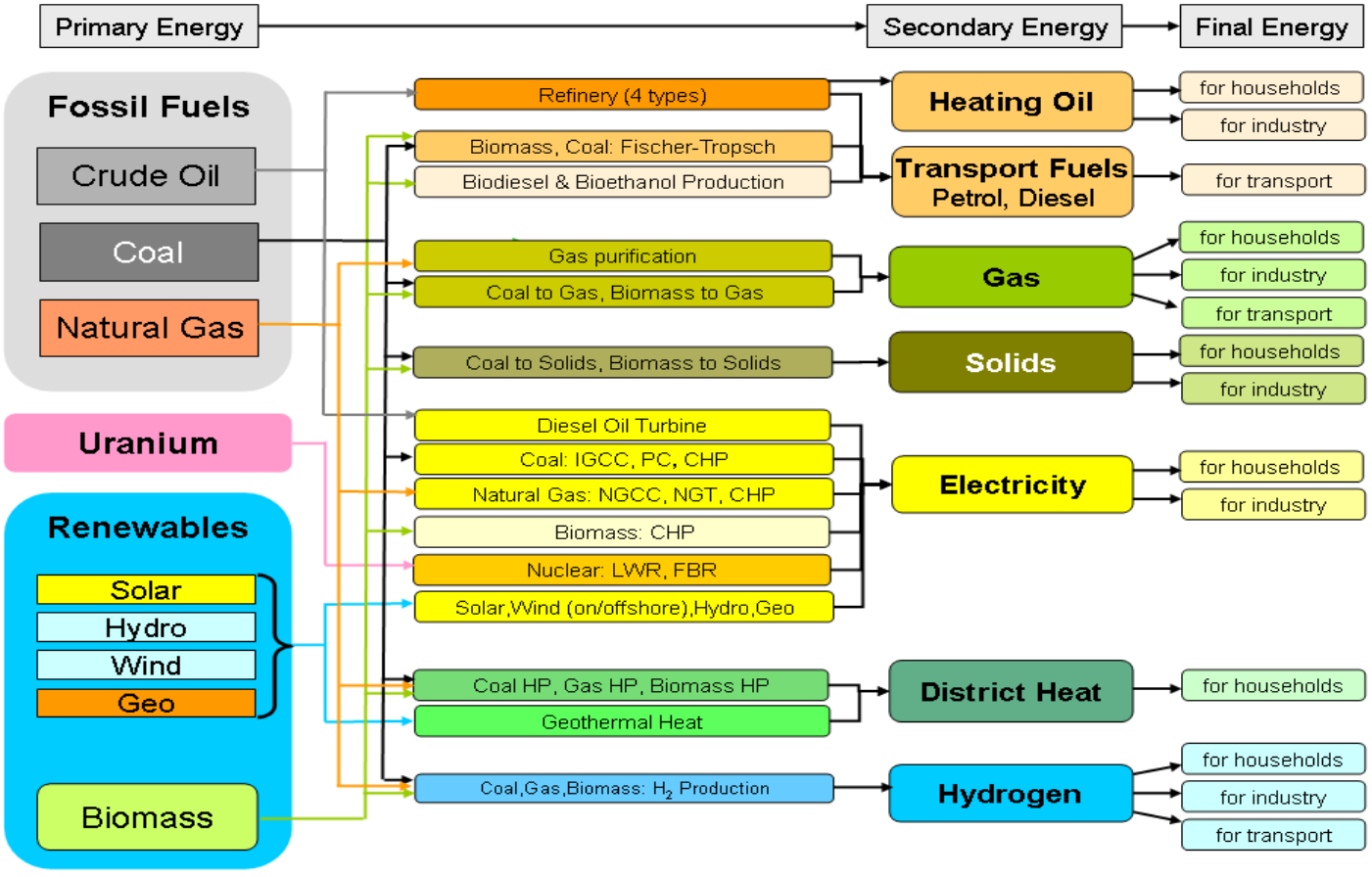
From Primary to Final Energy: System Perspective



Solar, wind, hydro, geothermal energy very different from bioenergy

From Primary to Secondary Energy: System perspective

		Primary energy carriers						
		Exhaustible				Renewable		
		Coal	Oil	Gas	Uranium	Solar, Wind, Hydro	Geo-thermal	Biomass
Secondary energy carriers	Electricity	PC*, IGCC*, CoalCHP	DOT	GT, NGCC*, GasCHP	LWR, Gen IV	Solar PV, CSP, Wind, Hydro	HDR	BioCHP, BIGCC*
	H2	C2H2*		SMR*				B2H2*
	Gases	C2G		GasTR				B2G
	Heat	CoalHP, CoalCHP		GasHP, GasCHP			GeoHP	BioHP, BioCHP
	Liquid fuels	C2L*	Refin.					B2L*, BioEthanol
	Other Liquids		Refin.					
	Solids	CoalTR						BioTR

Abbreviations: PC = conventional coal power plant, IGCC = integrated coal gasification combined cycle, CoalCHP = coal combined hat power, C2H2 = coal to H2, C2G = coal to gas, CoalHP = coal heating plant, C2L = coal to liquids, CoalTR = coal transformation, DOT = diesel oil turbine, Refin. = Refinery, GT = gas turbine, NGCC = natural gas combined cycle, GasCHP = Gas combined heat power, SMR = steam methan reforming, GasTR = gas transformation, GasHP= gas heapting plant, LWR = light water reactor, SPV = solare photo voltaic, WT = wind turbine, Hydro = hydro power, HDR = hot-dry-rock, GeoHP = heating pump, BioCHP = biomass combined heat and power, BIGCC = Biomass IGCC, B2H2 = biomass to H2, B2G = biogas, BioHP = biomass heating plant, B2L = biomass to liquids, BioEthanol = biomass to ethanol, BioTR = biomass transformation
* These technologies are also available with carbon capture.

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Technology Characteristics

Coal and biomass are substitutes (but can be complements in co-firing)

Coal: Exhaustible, but plentiful. High energy density. CO_2 emitter.
Biomass: Renewable, but limited. Low energy density.
CO_2 neutral, but not GHG neutral.

➔Necessary conditions for significance of bioenergy:
productivity (increases) of land, ability to limit co-emissions of GHGs.

Solar and wind energy are imperfect substitutes of coal in electricity sector only

- "lower grade" electricity because of fluctuating output
- cannot be "stand alone" substitutes but only in a package with storage, backup and grid integration.

➔Necessary conditions for significance of solar and wind energy:
importance of electricity (e.g. e-mobility), storage & grid capacities.

Prospects of Renewable Energy

Arent et al. paper discusses prospects in terms of
- cost trends
- efficiency trends
- policies (Renewable Portfolio Standards)

These are important factors, but prospects of renewable energy will also depend on above mentioned characteristics and conditions.

Biomass: Assess prospects on land requirement and co-emissions for growing woody (non-food) energy crops

Solar & Wind: Assess prospects for the whole “vertically integrated package” of electricity generation, storage, and grid upgrading

Finally, prospects of renewable energy will depend on prospects of competing technologies for combating global warming

Interdependence in the Energy Sector: REMIND Example

Baseline

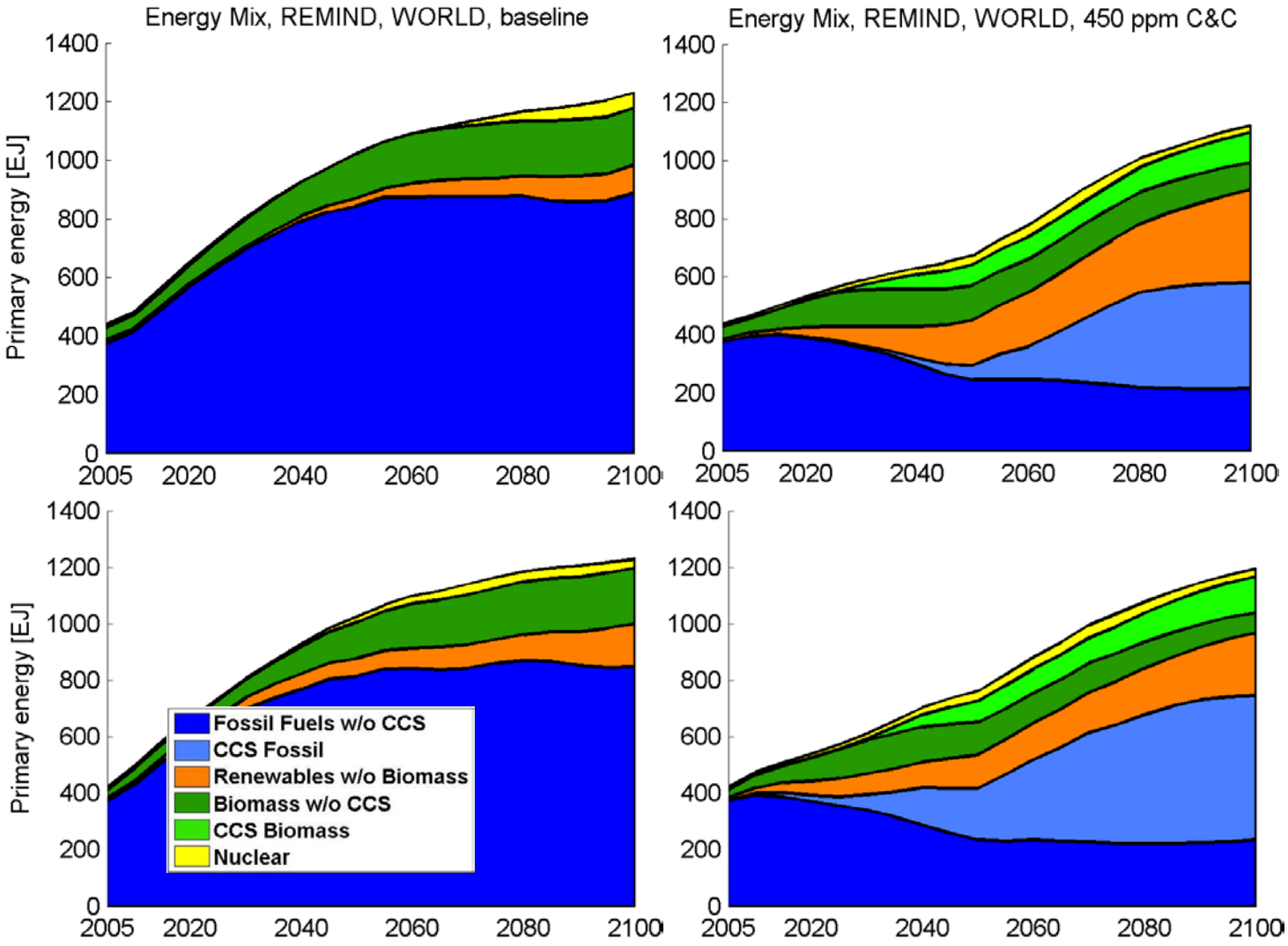
450 ppm CO_2

Coal to gas
Expensive

Limited geological storage
(in some regions)

Coal to gas cheap

Geological storage not a limitation



“Looking up” the learning curve

Arent et al. paper mainly discusses conventional RETs in deployment phase

- wind power (121 GW)
- solar PV (16 GW)
- bioenergy (3 GW electricity, 30 billion gallons biofuel / yr)
- geothermal power (10 GW)

Given their potential limitations, “looking up” the learning curve for emerging RETs in the R&D phase is useful.

Concentrated Solar Power: comes with overnight storage
~0.6 GW operating, 1.7 GW under construction, 14 GW announced

Algae: > 10 times higher productivity than woody biomass, can be deployed on marginal land

Note: I do not claim these are “silver bullets”

Deployment gap and policies

Deployment gap (H. Herzog): Difference between
- mitigation technology costs – conventional technology costs
- too weak carbon price signal (due to political feasibility)

Initial deployment gap may not deter private investment if expectation of future carbon prices exceeding mitigation costs is strong

Expectations are set by credible policies

Additional policies like renewable portfolio standards (RPS) may fill the deployment gap for RETs.

Example: EU Climate & Energy Package 2020
20 % reduction of GHG emissions by 2020 (base year 1990)
20 % RPS by 2020

EU Post-Kyoto Cap and Trade System (2013-2020)

Overall: -20% (1990)

Trading sector: -21% (2005)

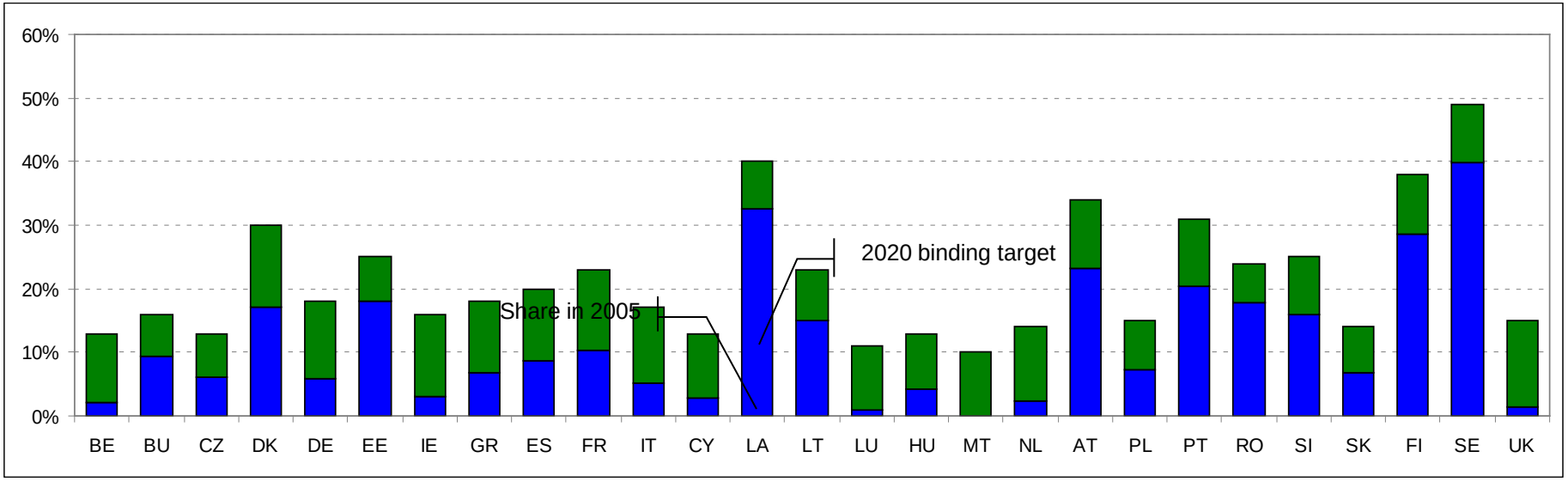
- Energy activities (refineries, power plants etc), metal and mineral industries, petrochemicals, ammonia, aluminium sectors, aviation
- ~50% of total GHG emissions
- Auctioning of 50% (2013) to 75% (2020) of permits
- Offsets for up to 50% of emissions abatement (only from LDC based on bilateral agreements)

Non-trading: -10% (2005)

- Member states responsible
- 27 individual targets
- Banking, borrowing, trade allowed
- CERs for up to 3% of 2005 emissions

EU Renewable Portfolio Standards

- 20% of primary energy consumption from renewable energy sources by 2020 (8.5% in 2005)
- 10% in transport sector (biofuels or electricity)
- Legally binding national targets



Example of Private Sector Response: DESERTEC

Extra-EU cooperation on RPS

- Imports from non-EU countries allowed
- The electricity must be consumed within the Community
  - Except where interconnector is being constructed (2016-2022)
  - Then electricity may already count towards national target

DESERTEC consortium (so far only words, no investment yet)

- Munich Re (lead), Deutsche Bank, Siemens, ABB, E.ON, RWE and 6 other firms
- 400 billion Euro investment in CSP plants in North Africa and high-voltage DC transmission lines to Europe until 2050
- Goal: Cover 15% of European electricity demand by 2050, growth in MENA electricity demand including desalinization