ANALYZING GLOBAL TRENDS

for Business and Society

Week 6

The Quest for Sustainability

Mauro F. Guillén

Mini-Lecture 6.1

- This week we will examine the global quest for sustainability.
- We will cover trends in energy, water, and food.
- We will consider the demographic, economic, and geopolitical issues covered in previous weeks as they affect sustainability.

Key Drivers

- Population growth: in some parts of the world.
- Urbanization: cities are growing by 1.5 million a week.
- Rise of the global middle class: 30 trillion dollars worth of new consumption in 20 years.
- Geopolitical hotspots: large reserves of not only fossil fuels and minerals but also of arable land.

Two Definitions

- Thomas Jefferson (1789): “Then I say the Earth belongs to each generation during its course, fully and in its right no generation can contract debts greater than may be paid during the course of its existence.”
- United Nations’ Brundtland Commission on Environment and Development (1987): “Meet the current needs without destroying the ability of future generations to meet theirs.”

What is Sustainability?

- Sustainability refers to making decisions and adopting courses of action about the use of natural resources that support life on the planet at the present time without placing onerous limitations on the availability of those resources in the future.

What's at stake?

- Quality of everyday life (e.g. air pollution).
- Sustenance (e.g. food scarcity, water contamination).
- Future of life (e.g. global warming).

It's Controversial…

- There is considerable debate about the kinds of changes required to achieve sustainability.
- There is also debate as to whether we are reaching a point of no return.
- Much discussion involves the relative merits of market-based versus regulatory solutions.
- Population and economic pressures pose formidable challenges.

It’s all about tradeoffs

- Sustainability involves fundamental tradeoffs:
  - Enjoyment of life today versus that of future generations.
  - Short-run economic growth versus long-term sustainability.

Think about the levers

- Technological breakthroughs.
- Incremental, innovative improvements.
- Cultural values priorities in life.
- Cultural norms regarding behavior.

It’s also about fairness

- Between generations.
- Between the poor and the rich.
- Between different countries.

Milestones

- 1972: Club of Rome's *The Limits to Growth* report. It was billed as 'defeatist' and 'elitist'.
- 1979: The U.S. National Academy of Sciences linked greenhouse gases to global climate change.
- 1984: Bhopal gas leak.
- 1986: Chernobyl nuclear explosion.
- 1989: Exxon Valdez oil spill.
- 2011: Fukushima nuclear accident.

Interest in Sustainability

- It ebbs and flows, losing momentum during times of economic malaise and becoming more salient in the wake of major environmental disasters.
- “The debate over climate change has become a big cultural process, almost like the Renaissance, the Reformation or similar world-historical events.”

—Andrew Hoffman, University of Michigan.

Mini-Lecture 6.2

- Energy and sustainability.
- Primary energy sources.
- Global warming.
- The geopolitics and geoeconomics of energy.

Issues Regarding Energy

- Renewability (e.g. wind vs. oil).
- Greenness (e.g. solar vs. coal).
- Carbon footprint (e.g. nuclear vs. fossil fuels).
- Reliability (e.g. coal vs. wind)
- Cost (coal vs. wind).
- Jobs.
- Trade balance & foreign exchange.
- National energy independence.

Was He Correct?

"The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil."

—Sheikh Ahmed Zaki Yamani, Oil Minister of Saudi Arabia, 1970s.

Primary Energy Supply (%)

	1973	2011
Oil	46.0	31.5
Coal/peat	24.6	28.8
Natural gas	16.0	21.3
Biofuels and waste	10.6	10.0
Nuclear	0.9	5.1
Hydro	1.8	2.3
Total (million tons of oil equivalent)	6,109	13,113

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Electricity Generation by Fuel (%)

	1973	2011
Coal/peat	38.3	41.3
Natural gas	12.2	21.9
Hydro	21.0	15.8
Nuclear	3.3	11.7
Oil	24.6	4.8
Other (geothermal, solar, wind, etc.)	0.6	4.5
Total (TWh)	6,115	22,126

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Oil Production and Trade

Producers	Mt	Net exporters	Mt	Net importers	Mt
Saudi Arabia	544	Saudi Arabia	353	United States	500
Russia	520	Russia	247	China	251
United States	387	Iran	122	Japan	177
China	206	Nigeria	121	India	172
Iran	186	UAE	114	South Korea	125
Canada	182	Iraq	108	Germany	90
UAE	163	Venezuela	93	Italy	77
Venezuela	162	Kuwait	89	France	64
Kuwait	152	Canada	82	Singapore	58
Iraq	148	Angola	79	Netherlands	57
Others	1492	Others	574	Others	508

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Natural Gas Production and Trade

Producers	bcm	Net exporters	bcm	Net importers	bcm
United States	681	Russia	185	Japan	122
Russia	656	Qatar	120	Germany	70
Qatar	160	Norway	109	Italy	68
Iran	158	Canada	57	South Korea	48
Canada	157	Algeria	48	Turkey	45
Norway	115	Turkmenistan	37	United States	43
China	107	Indonesia	37	France	43
Saudi Arabia	95	Netherlands	34	UK	37
Netherlands	80	Nigeria	27	China	36
Indonesia	77	Malaysia	21	Ukraine	32
Other	1149	Other	154	Other	283

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Coal Production and Trade

Producers	Mt	Net exporters	Mt	Net importers	Mt
China	3549	Indonesia	383	China	278
United States	935	Australia	302	Japan	184
India	595	United States	106	India	158
Indonesia	443	Russia	103	South Korea	126
Australia	421	Colombia	82	Taiwan	65
Russia	354	South Africa	72	Germany	45
South Africa	259	Kazakhstan	32	UK	44
Germany	197	Canada	25	Turkey	29
Poland	144	Mongolia	22	Italy	24
Kazakhstan	126	Vietnam	18	Malaysia	22
Other	808	Other	23	Other	213

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Nuclear Electricity Production

Producers	TWh	Producers	% of all electricity
United States	821	France	79.4
France	442	Ukraine	46.3
Russia	173	South Korea	29.8
South Korea	155	United States	19.0
Germany	108	UK	18.9
Japan	102	Germany	17.9
Canada	94	Russia	16.4
Ukraine	90	Canada	14.7
China	86	Japan	9.8
UK	69	China	1.8
Other	444	Other	11.5

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Hydroelectric Production

Producers	TWh	Producers	% of all electricity
China	699	Norway	95.3
Brazil	428	Brazil	80.6
Canada	376	Venezuela	68.6
United States	345	Canada	59.0
Russia	168	Sweden	44.3
India	131	Russia	15.9
Norway	122	China	14.8
Japan	92	India	12.4
Venezuela	84	Japan	8.7
Sweden	67	United States	7.9
Other	1054	Other	13.6

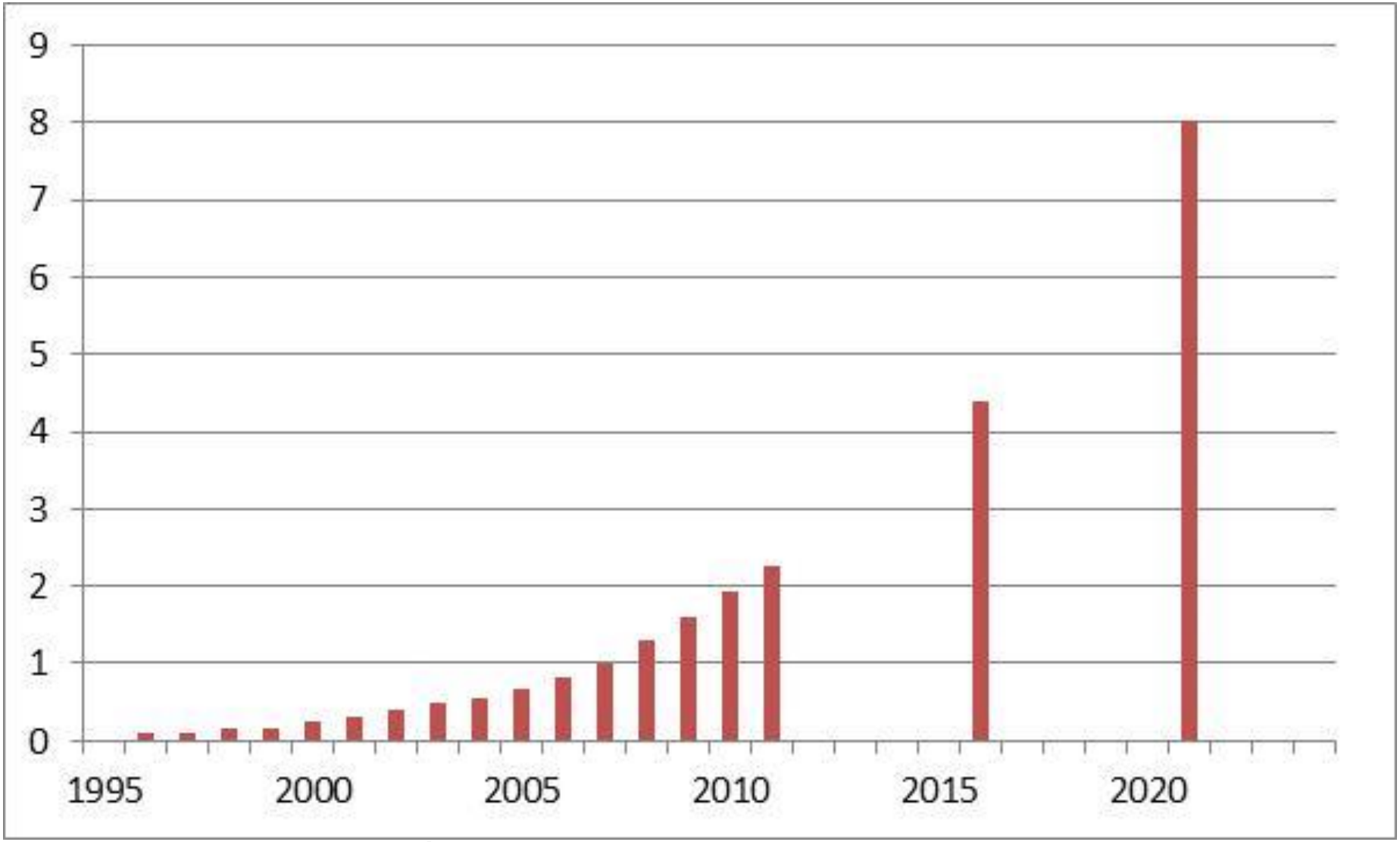
Source: International Energy Agency, *Key World Energy Statistics 2013*.

Average Cost Projections for 2018

	Cents per KWh
Natural gas	6.71
Wind	8.66
Hydro	9.03
Conventional coal	10.01
Nuclear	10.84
Solar	14.43
Wind (offshore)	22.15

Source: U.S. Energy Information Administration.

Wind Power's Contribution to World Electricity Supply



Source: BMT Consult.

Mini-Lecture 6.3

- Carbon emissions and global warming.
- The role of the U.S. and China.

Carbon Emissions by Region (%)

	1973	2011
Rich countries (OECD)	66.1	39.4
China	5.8	25.5
Asia, excluding China	3.1	11.1
Less developed Europe	16.2	8.7
Middle East	0.8	5.1
Latin America, excluding Mexico	2.6	3.5
Africa	1.8	3.1
Total (million tons)	15,628	31,342

Source: International Energy Agency, *Key World Energy Statistics 2013*.

Incremental Primary Energy Demand
by Fuel and Region, 2008-2035

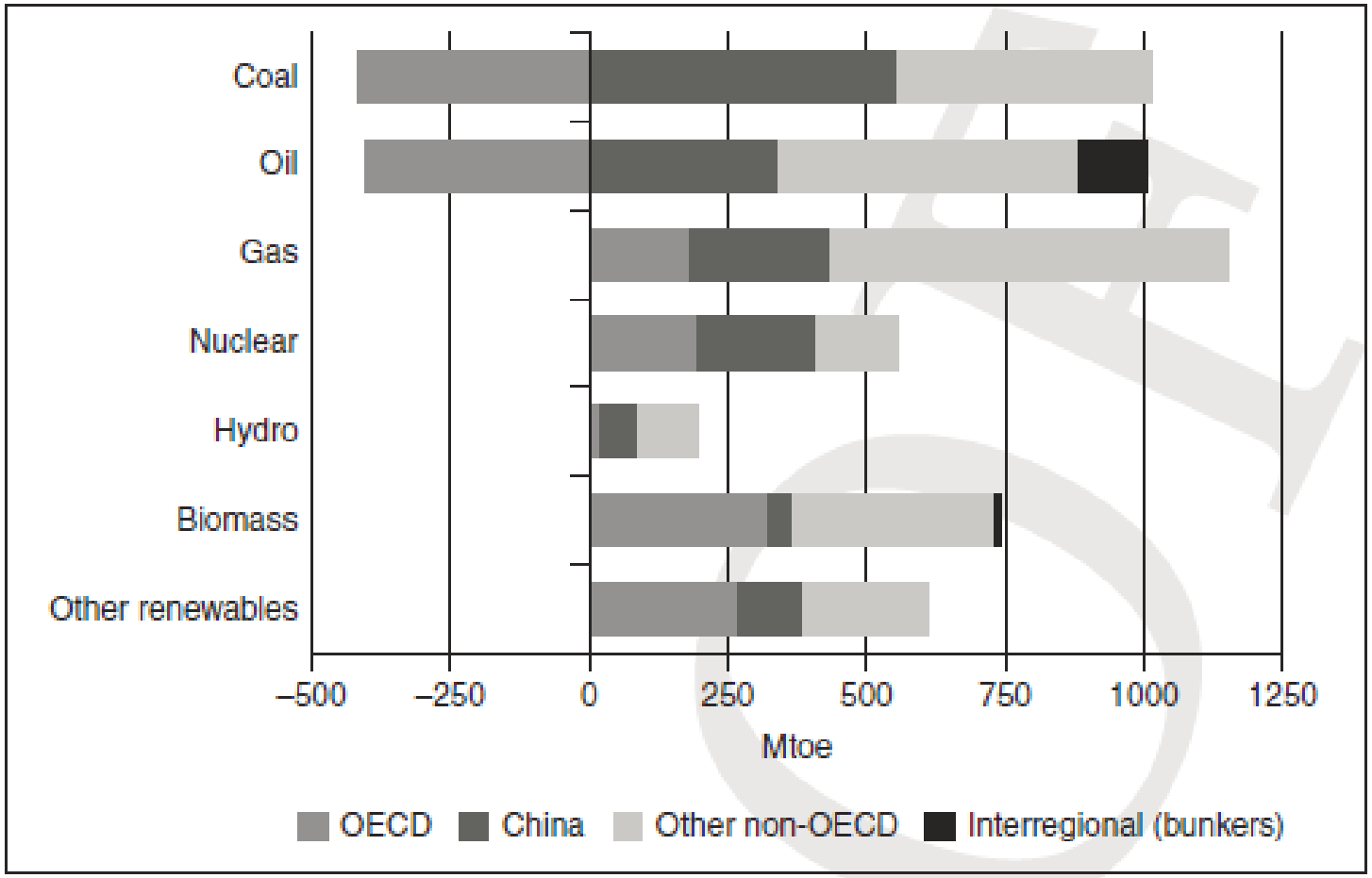


Figure 7.3 Incremental primary energy demand by fuel and region, 2008–2035

Source: International Energy Agency, *World Energy Outlook* (2010, figure 2.6, p. 86). © OECD/International Energy Agency.

China's Share of Projected Net Global Increase for Energy

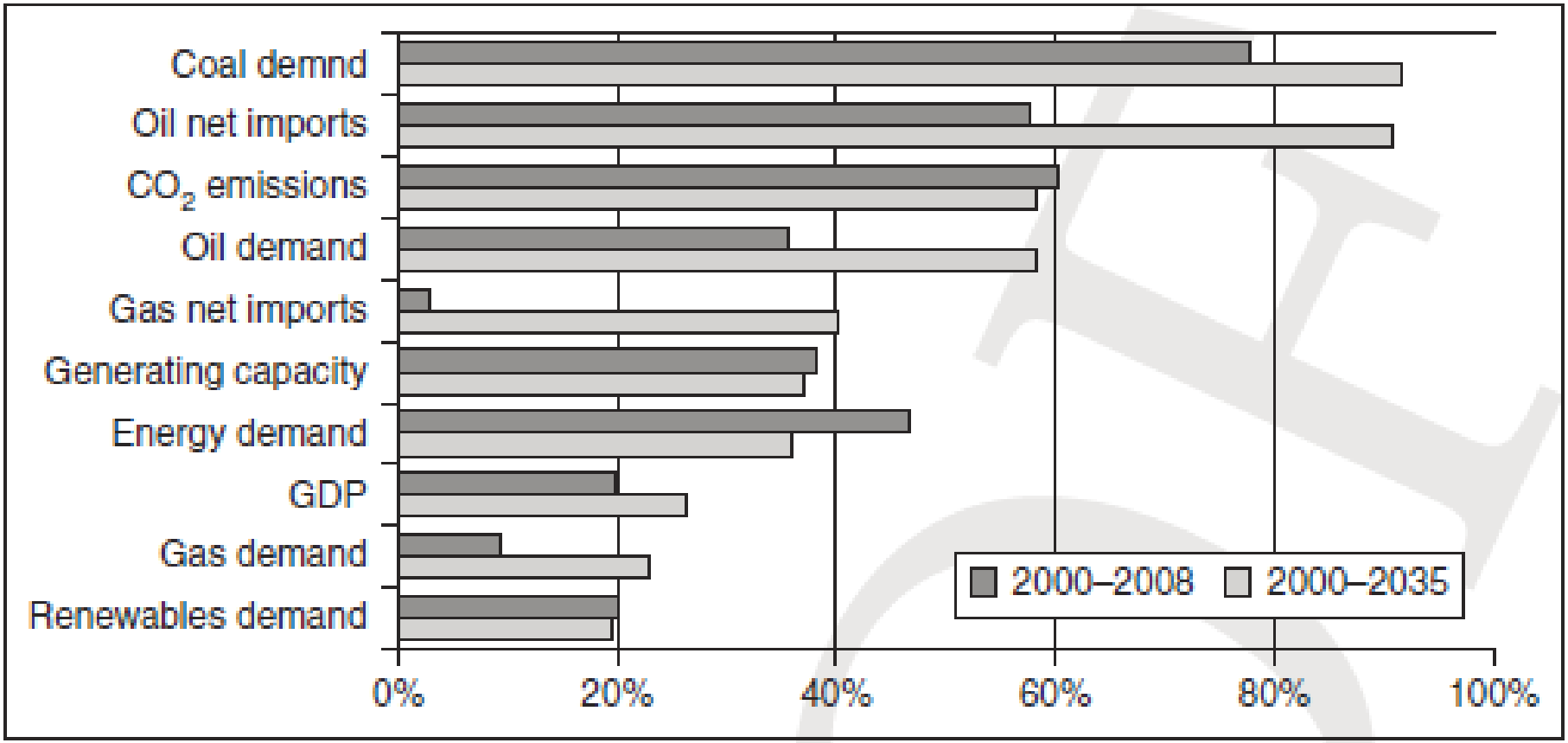


Figure 7.5 China's share of projected net global increase for selected energy indicators

Source: International Energy Agency, *World Energy Outlook* (2010, figure 2.16, p. 99). © OECD/International Energy Agency.

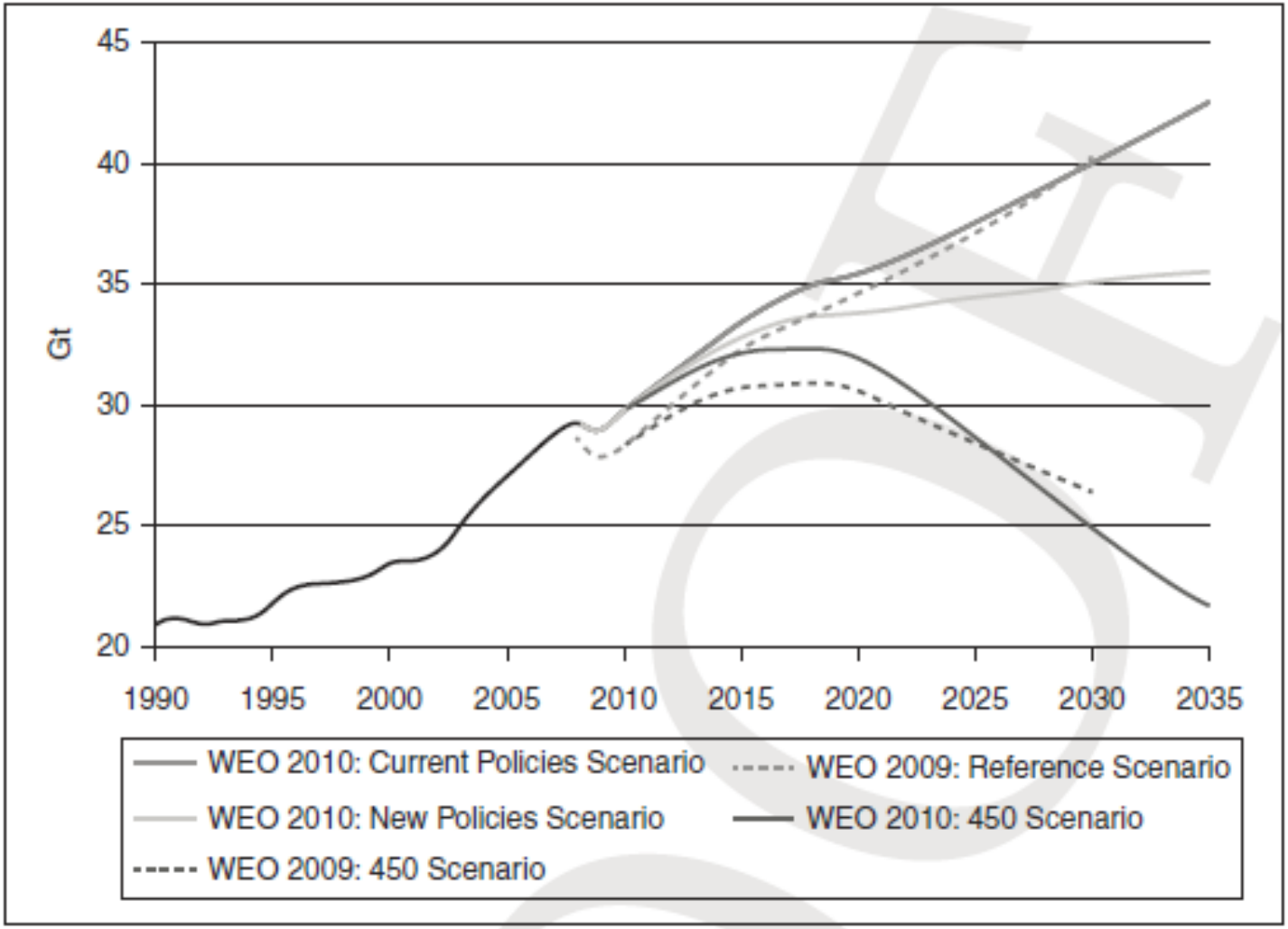


Figure 7.4 Global CO_2 emissions (gigatonnes)

Note: The 450 Scenario aims at limiting the long-term concentration of greenhouse gases in the atmosphere to 450 parts per million of carbon-dioxide equivalent.

Source: International Energy Agency, *World Energy Outlook* (2010, figure 13.2, p. 384). © OECD/International Energy Agency.

Efforts to Reduce Emissions

- Europe continues to lead the world.
- The United States and China are the key players, but they are not working as hard to reduce their emissions:
  - Cheap shale gas in the U.S. may help considerably by phasing out coal-fired power plants.
  - China has an incentive to reduce emissions so as to ameliorate air pollution in its biggest cities.

The Example of CFCs

- Chlorofluorocarbons were used as a refrigerant, propellant, and solvent.
- CFCs were identified as contributing to the depletion of the ozone layer, which protects Earth from ultraviolet radiation.
- Production peaked about 1990 at 1.2 billion tons.
- Within a decade, CFC production had been brought down to less than 100 million.
- The ozone layer to completely recover by 2050.
- What made this possible?

The Montreal Protocol of 1987

- The original protocol and subsequent amendments and additions have been ratified by virtually every country.
- Scientific proof of the damage was widely accepted.
- Alternative chemical compounds were found to exist without adding to the cost of production or consumption.
- Little behavioral change required.

The Challenge ahead

"The energy challenge of the twenty-first century will be to satisfy a dramatically larger demand for energy while producing dramatically less carbon. Yet the availability of carbon-free energy on a mass scale will not happen without significant technological developments."

—Paul Roberts, *The End of Oil* (2004), p. 309.

Mini-Lecture 6.4

- The case of biomass in the developing world: firewood, charcoal, crop waste, animal dung, residues, etc.

Biomass

- 2.7 billion people burns it at home for cooking and heating, mostly in very poor countries.
- It costs less than coal, kerosene, or gas.
- Incomplete combustion releases hazardous smoke.
- Inadequate ventilation adds to the problem.
- It affects more frequently women and small children.
- Burning biomass kills as many as malaria or tuberculosis, and half as many as AIDS.
- Deforestation and carbon emissions.

Wood Fuel vs. Charcoal

- Charcoal is produced by eliminating water and other substances from wood.
- Demand for charcoal up due to growth of cities: It is cheaper to transport, easier to use, and releases less smoke.
- However, firewood is gathered on the roadside or outside forests, while charcoal is produced from forest resources.
- Depending on the type of wood and the efficiency of the conversion process, charcoal may require 2 or 3 times as much wood to deliver the same amount of energy.

Solutions

- Link charcoal production to reforestation.
- Introduce better techniques for producing charcoal, and better training for charcoal makers.
- A trading system for charcoal makers.
- Improve stoves with:
  - chimneys.
  - internal secondary combustion of partially combusted smoke.
  - importance of training the user.

Mini-Lecture 6.5

- Are subsidies for green energy the solution?

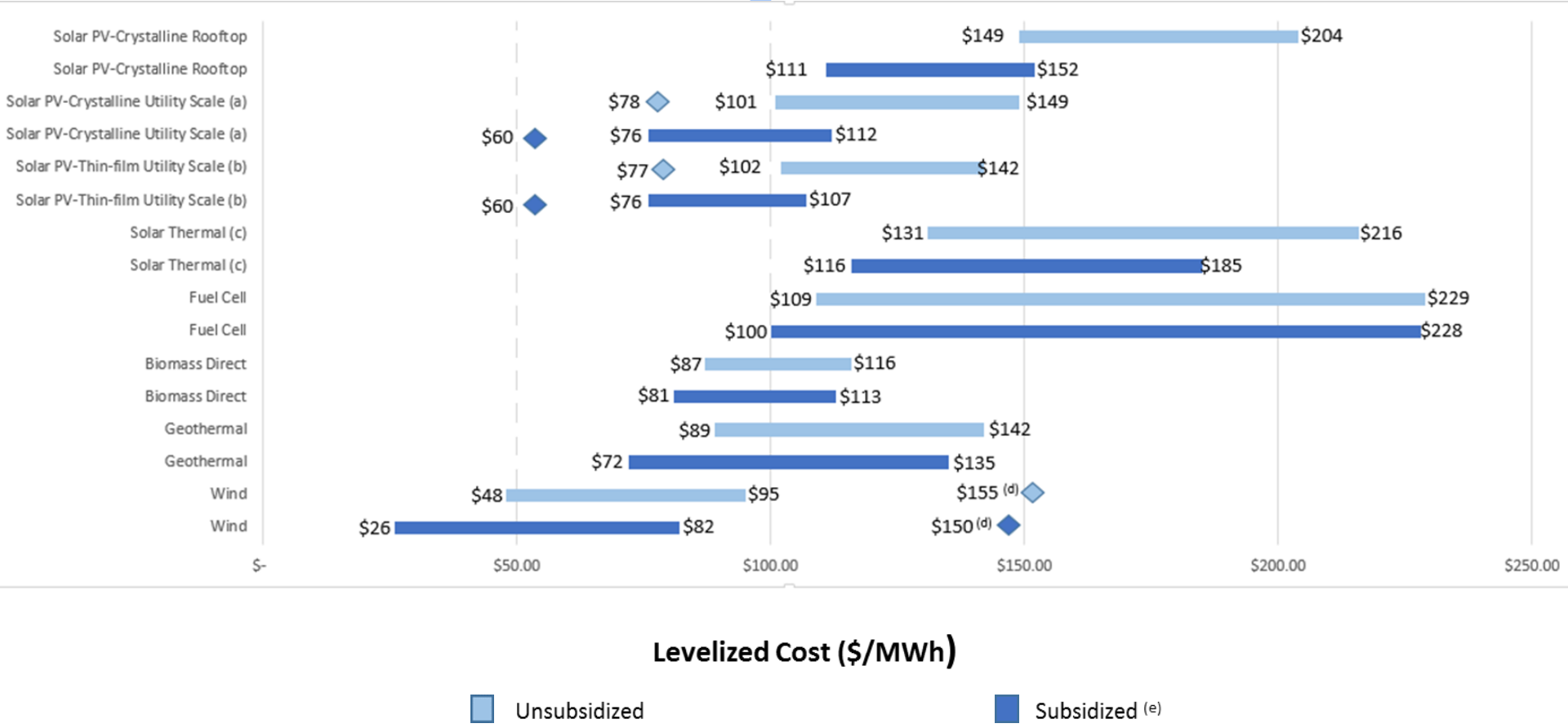
Energy Return on Energy Invested

a.k.a. energy input/output balance

	Return		Return
Oil and gas in 1930	>100:1	Wind	18:1
Oil and gas in 1970	30:1	Concentrated solar	1.6:1
Oil and gas in 2005	11-18:1	Photovoltaic solar	6.8:1
Shale oil	5:1	Sugarcane ethanol	0.8-10:1
Nuclear	5-15:1	Corn ethanol	0.8-1.6:1
Hydro	>100:1	Biodiesel	1.3:1

Source: D. J. Murphy and C. A. S. Hall, "EROI or energy return on (energy) invested." *Annals of the New York Academy of Sciences* (2010).

Subsidies make a difference
Dollars per MWh



Source: Lazard estimates

(a) Low end represents single-axis tracking. High end represents fixed-tilt installation. Diamonds represent estimated implied levelized cost of energy in 2015, assuming a total system cost of $1.75 per watt for a single-axis system

(b) Assumes fixed-tilt installation. Diamonds represent estimated implied levelized cost of energy in 2015, assuming a total system cost of $1.50 per watt

(c) Represents solar tower with and without 3 hour storage capability

(d) Represents midpoint of levelized cost of energy for off-shore wind, assuming a range of total system cost of $3.10-$5.00 per watt

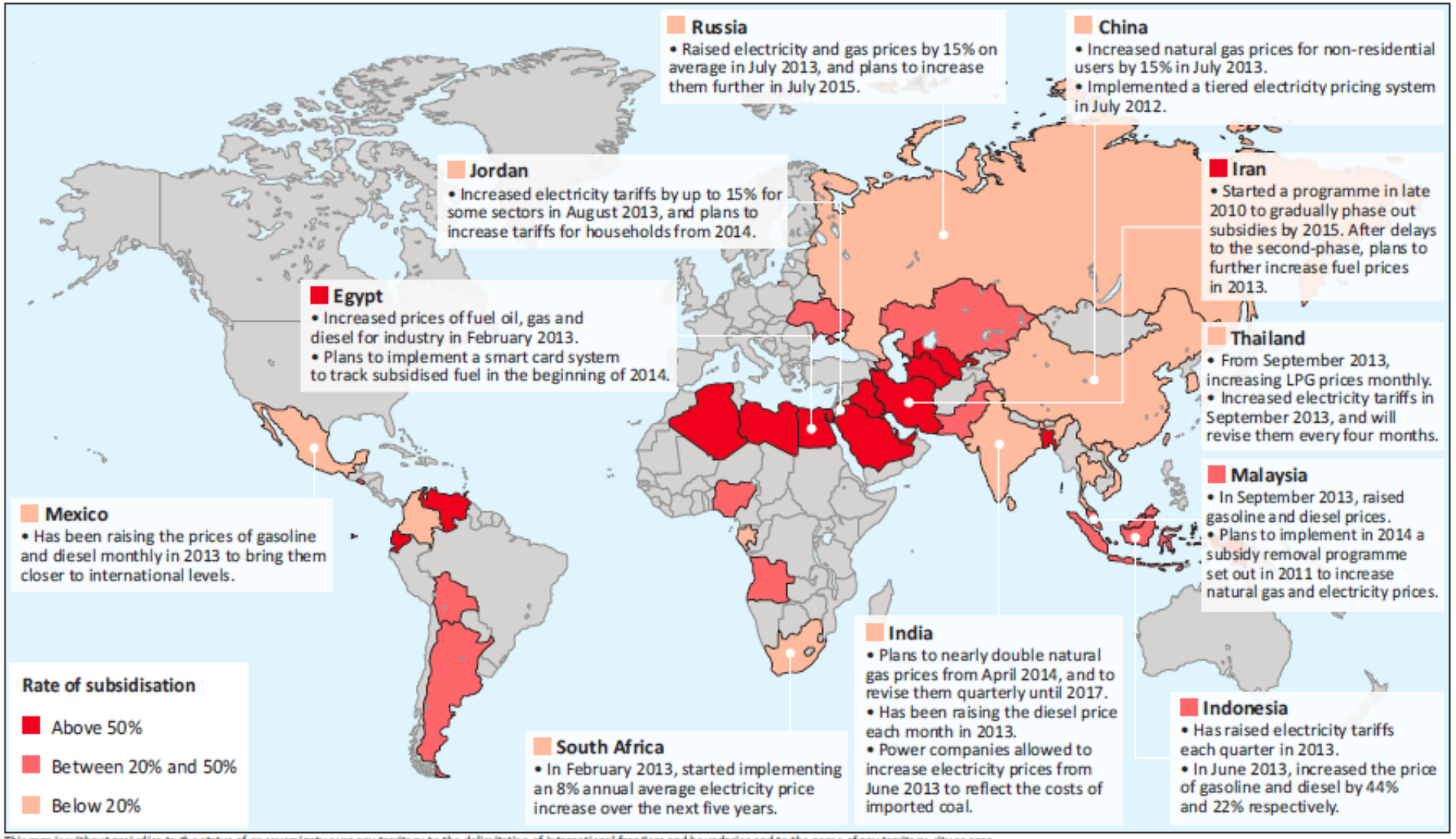
(e) Reflects Production Tax Credit or Investment Tax Credit, as applicable. Assumes 30% debt at 8.0% interest rate, 50% tax equity at 9.5% cost and 20% common equity at 12.0% cost

Subsidies

- Subsidies for renewable and/or green energy may make sense, but only if:
  - They promote technological innovation as opposed to just production.
  - They do not create perverse incentives.
  - They do not create other negative externalities.
- Most subsidies for solar & wind encourage investment in technologies that are not cost-competitive with conventional sources.
- Policy needs to emphasize technological innovation not production.

“Global subsidies for fossil fuels are 12 times greater than green subsidies”

Figure 2.19 ▷ **Rates of fossil-fuel consumption subsidies in 2012 and recent developments in selected countries**



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.

Mini-Lecture 6.6

- Are biofuels the solution to the energy crisis?
- American corn-based ethanol.
- Brazil's sugarcane ethanol program.

Biofuels

- Advantages:
  - Renewable.
  - Up to 90% lower carbon monoxide balance.
  - Job creation.
- Disadvantages:
  - Crop displacement.
  - Upward pressure on food prices.
  - Impact on water resources due to irrigation.
  - Potential loss of biodiversity.
  - Is it really green and sustainable?

Biofuel Statistics

- Rapid growth:
  - 17 bn liters in 2000.
  - 85 bn liters in 2011.
- Biggest producers: US (62%), and Brazil (25%).
- In US most fuel includes up to 10% ethanol.
- In Brazil it's up to 25%, and they also have 15 million vehicles with flex-fuel engines.

Advantages of Sugarcane Ethanol

- 7 times the energy returned on energy invested of corn-based ethanol.
- Sugarcane ethanol is competitive when oil prices are above $30 per barrel, while corn-based ethanol is competitive at $80 per barrel.
- Smaller impact on global food prices.

Sugarcane Ethanol in Brazil

- Sugarcane introduced in 1530.
- Northeast: slave labor plantations.
- 1900s: Southeast (state of Sao Paulo).
- 1975: Ethanol program launched to address rising oil prices.
- 1999: Removal of ethanol price controls.
- 2003: Flex-Fuel engines introduced.
- 2007: Elimination of differential taxation for ethanol and gasoline.
- Brazil has the world's most extensive biofuels economy.

Relative Prices in Brazil

- At the pump, and adjusting for mileage per gallon, ethanol enjoyed a 10-20% price advantage between 2000 and 2009.
- After 2009 a series of factors have made sugarcane ethanol slightly less competitive than gasoline:
  - Unfavorable weather.
  - Higher global prices for sugar.
  - A price freeze on gasoline imposed by the gov't.

The Debate Continues

- Biofuels have pluses and minuses.
- They are a useful component of the energy matrix.
- They will never completely displace fossil fuels.

Mini-Lecture 6.7

- Food and Water.
- Impact of:
  - –population growth.
  - –urbanization.
  - –the new global middle class.

Global Food Demand 1961=100

	2010	2050
Meat	380	600
Dairy	260	390
Cereals	270	360
Starchy roots	190	280

Source: FAO.

Agriculture

- Agriculture is the largest sector of the economy in poor countries, and the smallest in rich countries.
- Agricultural yields per hectare vary widely.
- More than 70% of all fresh water usage is for agriculture. Just 10% is consumed directly by humans. The rest is for industrial use.
- Efficiency in water use varies widely.

Water

- Much of the water used in food production is wasted.
- Irrigation can be massively improved.
- Urbanization has exacerbated water shortages.
- Today 900 million people lack access to safe water.
- By 2030 the OECD projects that 4 billion people (or 50% of the population) will live in areas subject to serious water shortages.

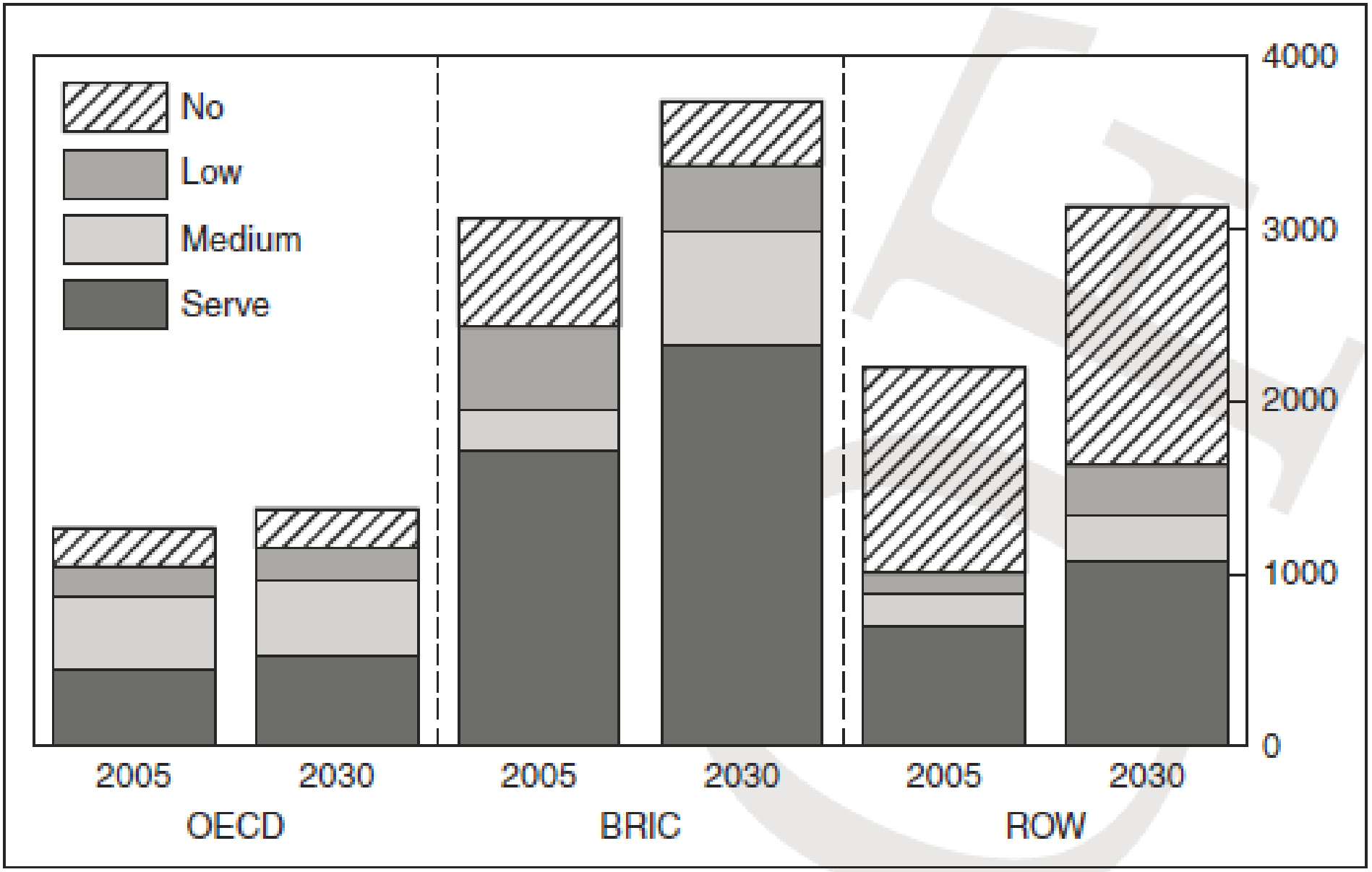


Figure 7.2 People living under severe water stress (millions)

Source: OECD (2011a: 19).

Pressures on Food Production

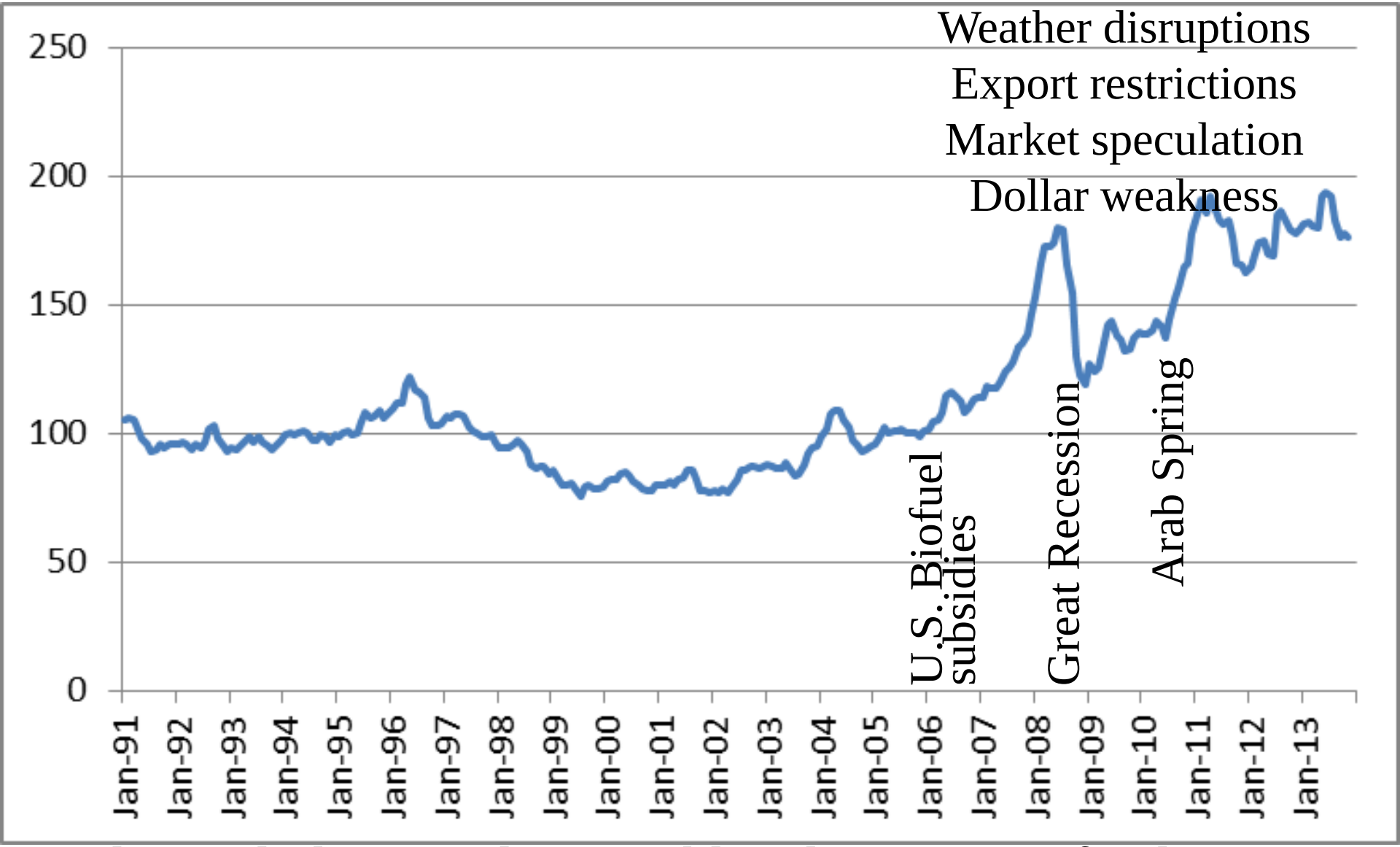
- Urbanization increases the pressure on food production in the rural areas. “Consumers in Lagos or Mombasa are competing for food supplies with those in Shanghai and Mumbai,” according to Jack Goldstone, George Mason University.
- The new global middle class is changing its diet: animal proteins are more energy-intensive to produce.
- Only 11% of the planet’s land area is suitable for agriculture.

Land for Agricultural Use (million hectares)

	Cultivated		Uncultivated	% of land <6 hours away from market
	1961	2007		
World	1376	1554	446	59
Developed countries	385	360	51	48
Developing countries	704	968		
Sub-Saharan Africa	148	221	202	47
Latin America	104	164	123	76
MENA	86	97	3	87
South Asia	191	205	14	23
East Asia	71	103		
E. Europe & Central Asia	286	254	52	83

Sources: FAO, *World Agriculture towards* 2030/2050; World Bank, *Rising Global Interest in Farmland*.

Food Price Index 2005=100



Index includes cereal, vegetable oils, meat, seafood, sugar, bananas, and oranges. Source of the data: IMF.

Biodiversity Losses

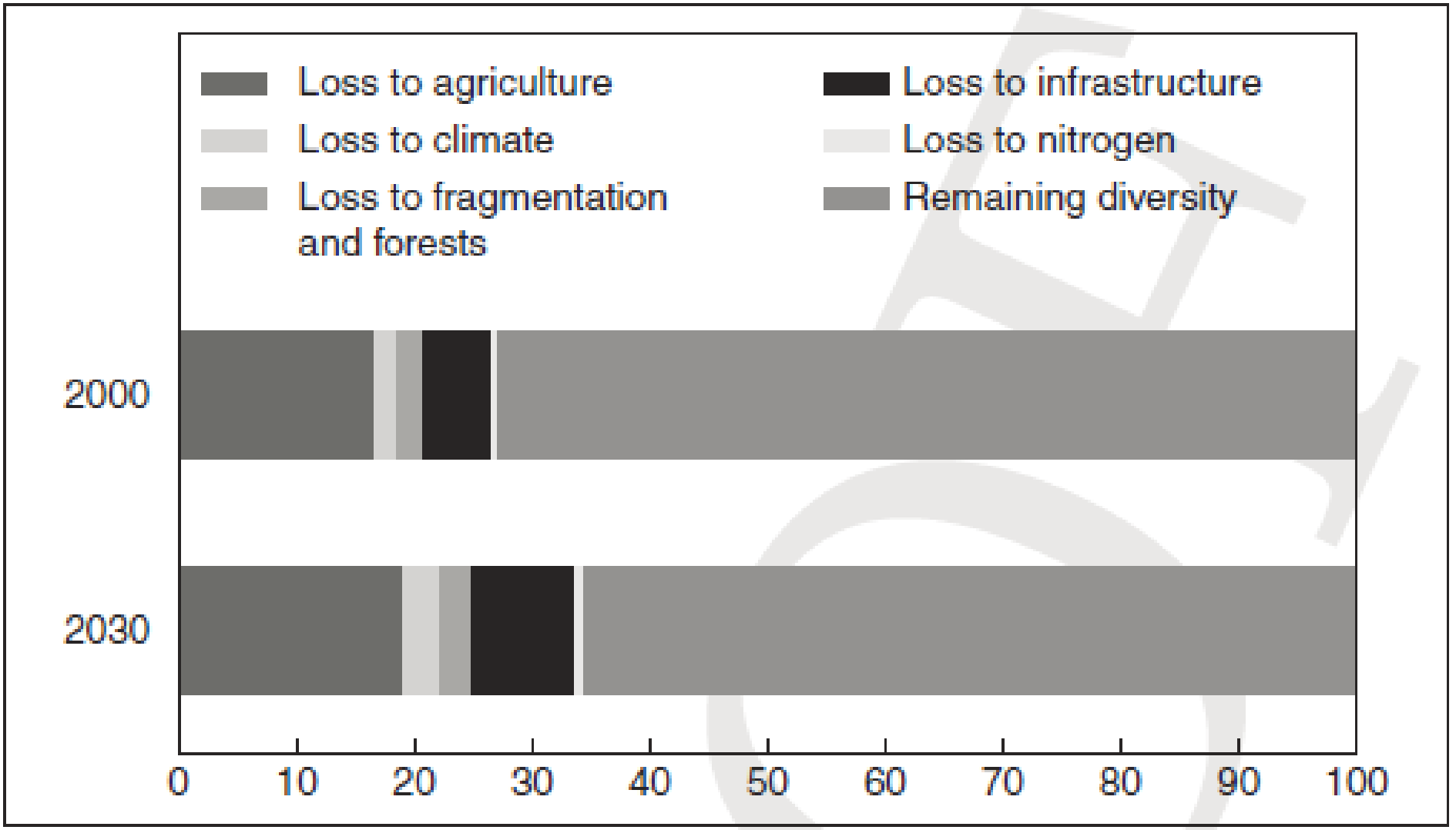


Figure 7.1 World threats to biodiversity (in percentages)

Source: OECD (2011a: 19).

Mini-Lecture 6.8

- Who should do what in the quest for sustainability?
- As with every major issue, there are (and there will be) winners and losers.

Companies

- They have the largest structural power in society.
- They were crucial when it came to phasing out CFCs.
- The overpowering effect of the profit motive. Does it pay to be green? Well, does it pay to innovate?
- The promise of CSR (corporate social responsibility).
- The role of regulation and incentives.

Consumers

- In opinion surveys, most consumers say they are concerned about the environment.
- Yet, they are not willing to pay more for environmentally friendly (‘green’) products and services.
- The most successful experiences have to do with lighting and organic foods.
- Redefine the relationship between consumption and happiness.

Nonprofits and NGOs

- They can play a crucial role in terms of information gathering and diffusion, exposing environmental abuses, and encouraging positive change.
- Help create “collective will.”

Governments

- Ensure that the political process respects the interests of future generations.
- Balance regulation and markets.
- Provide incentives for innovation and for behavioral change.
- Use sanctions if needed.
- Help whoever loses a job or a profit as a result of pursuing sustainability.
- Promote effective global governance over demographic, economic, energy, food, and water issues.

Reading

- Please read the report by the Lauder Institute's Global TrendLab, *Sustainability: New Perspectives and Opportunities*.

- ALL READINGS ARE FREE AND AVAILABLE ONLINE.

Week 6 Test

- I hope you have enjoyed learning about the challenges facing the world in terms of sustainability.
- Now, please take the quiz. It only takes a few minutes to complete.