ENE 101: Introduction to Energy Engineering

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Week 5: Energy Economics

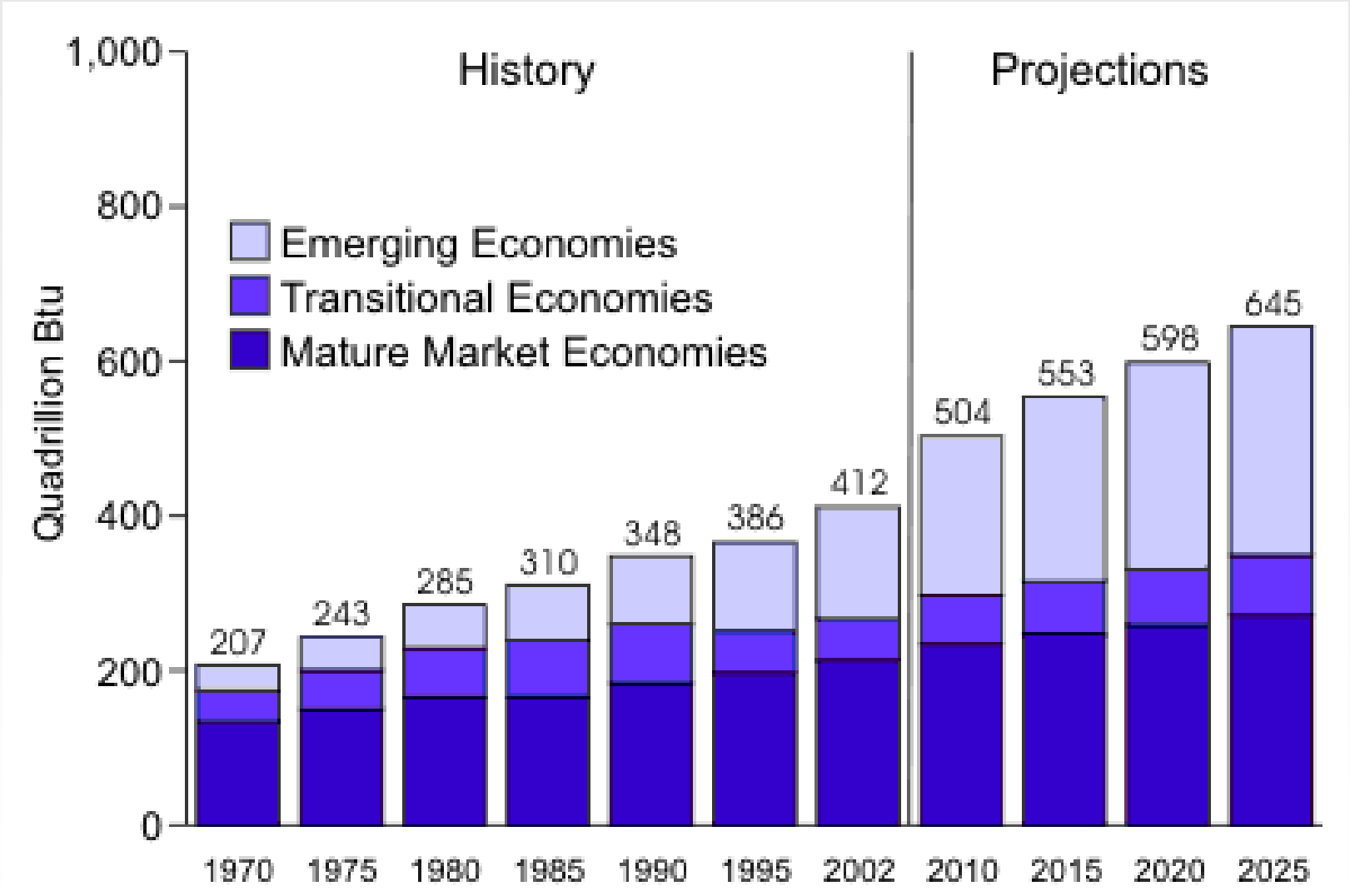
Energy Economics

Energy economics is a broad scientific subject area which includes topics related to *supply* and *use of energy* in societies.

Energy economics is the *application of economics to energy issues*. Central concerns in energy economics include the supply and demand for each of the main fuels in widespread use, competition among those fuels, the role of public policy, and environmental impacts

Source: International Energy Agency (IEA 2013)

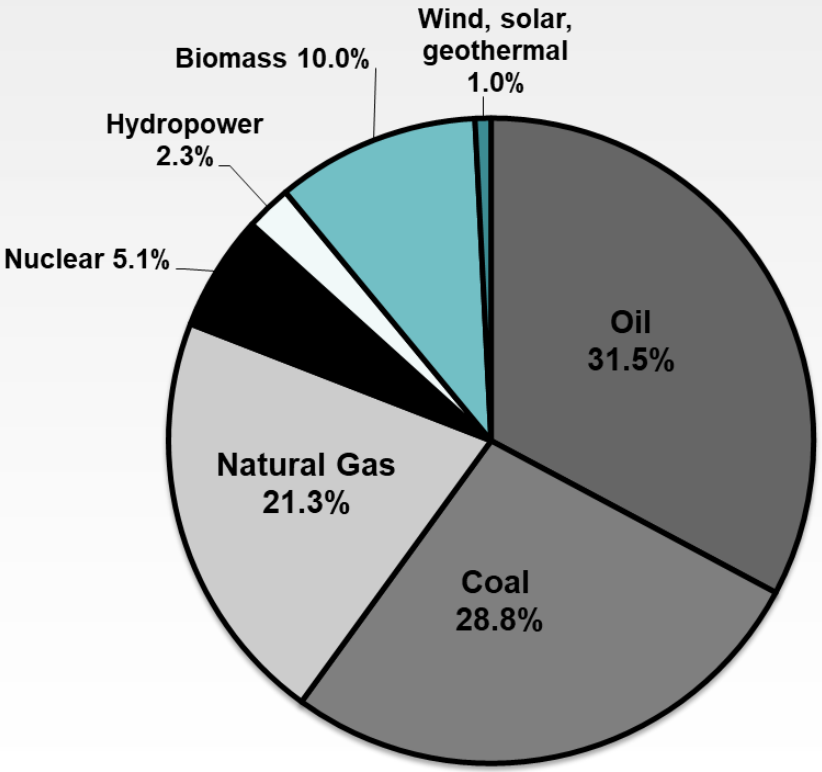
Future Energy Needs



http://www.eia.doe.gov/emeu/plugs/plsept05.gif

Global Energy Consumption by Source, 2012

- The population is growing everyday.
- The energy demand is sky-rocketing.
- The energy resources are depleting.
- Therefore, the **efficient usage of energy resources** is a vital factor to provide life sustainability.



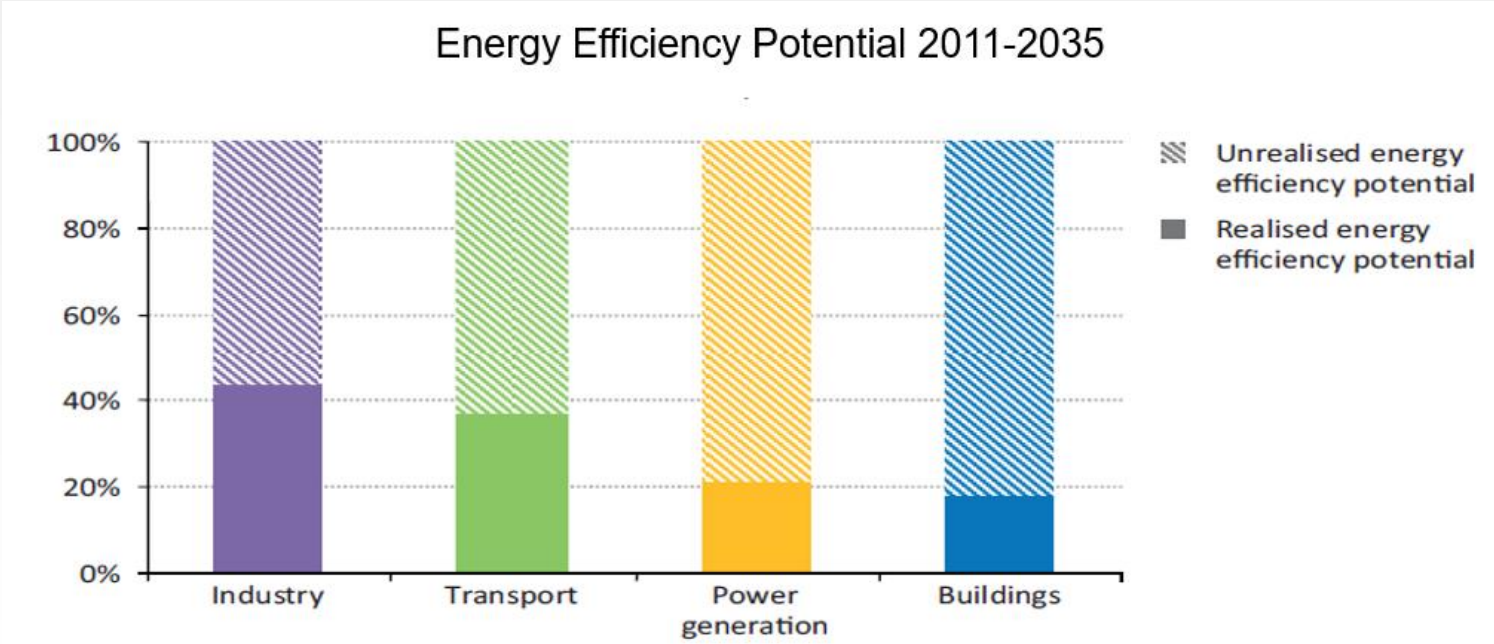
Source: International Energy Agency (IEA 2013)

Energy Efficiency

- Efficient energy use, sometimes simply called **energy efficiency**, is the goal to reduce the amount of energy required to provide products and services.
- For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Installing fluorescent lights, LED lights or natural skylights reduces the amount of energy required to attain the same level of illumination compared with using traditional incandescent light bulbs.
- Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production process.

How efficient we utilize the energy? Energy Efficiency

- Buildings have the highest level of energy loss



Source: *World Energy Outlook 2012, International Energy Agency*

Energy Efficiency Improvement

- Several efforts have been applied in different sectors to increase energy usage efficiency and to reduce energy loss.

Each sector has energy efficiency gains (1990-2010)

Residential
- 36%
- $9.0 billion savings

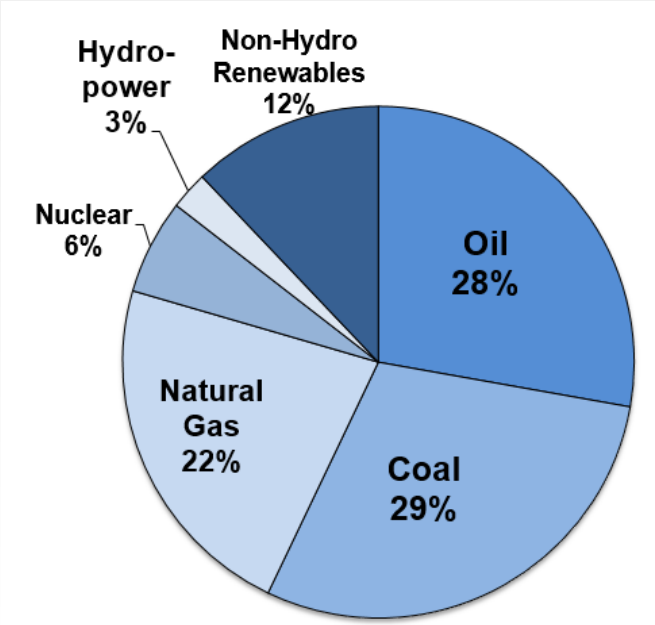
Transportation
- 24%
- $8.2 billion savings

Commercial / Institution
- 30%
- $5.6 billion savings

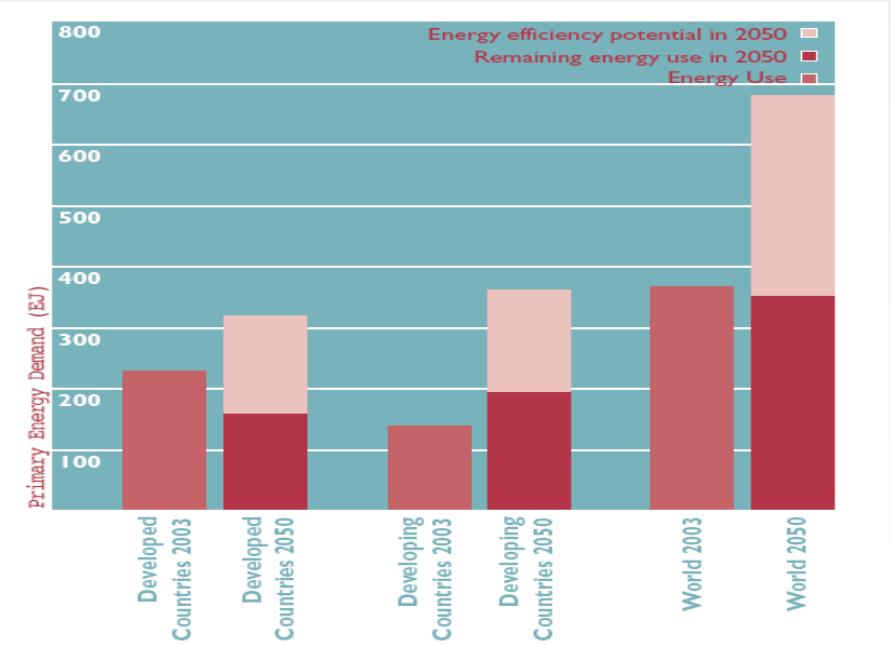
Industrial
- 20%
- $6.1 billion savings

Energy Efficiency

Projected 2035 Global Energy Demand, by Source



2050 Energy Efficiency and Energy Use



Source: International Energy Agency, 2011.

Source: Blok et al. (2008) *Global status report on energy efficiency 2008*. Renewable Energy and Energy Efficiency Partnerships. www.reeep.org

Cost of Energy Production

How much does electricity cost?

- Photovoltaic cells: $0.20-0.40 per kW-hr
- Wind turbines: $0.04-0.05 per kW-hr
- Gas: $0.02-$0.03 per kW-hr
- Coal: < $0.03 per kW-hr

Energy Availability

- Together with energy efficiency, another important factor in energy economics is **energy availability**.
- Considering the fact that in the near future, the fossil fuels are going to be depleted, this factor is more important for non renewable energy sources.
- This availability should be evaluated in Likely-Developable Locations.

Energy Availability of Renewable Resources

Energy Source	Total Global Availability (trillion watts)	Availability in Likely-Developable Locations (trillion watts)
Wind	1700	40 – 85
Wave	> 2.7	0.5
Geothermal	45	0.07 – 0.14
Hydroelectric	1.9	1.6
Tidal	3.7	0.02
Solar photovoltaic	6500	340
Concentrated solar power	4600	240

Total global energy use in 2006: 15.8 Trillion Watts

Source: Jacobson and Delucchi (2011); U.S. Energy Information Administration;

Can we supply world energy demand only by use of renewable energy sources?

If yes, what we would be required to achieve this goal?

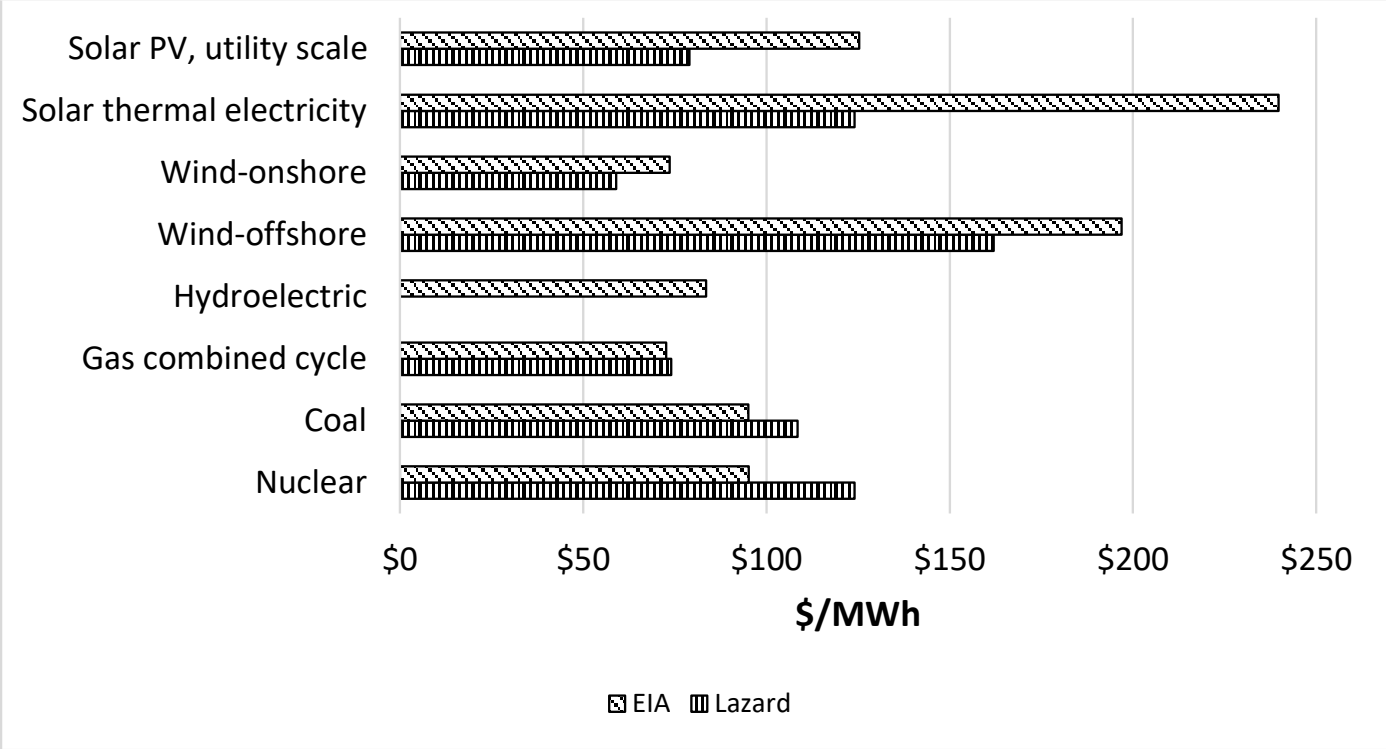
Which renewable technology is more promising?

Infrastructure Requirements for Supplying All Global Energy in 2030 from Renewable Sources

Energy Source	Percent of 2030 Global Power Supply	Number of Plants/Devices Needed Worldwide
Wind turbines	50	3,800,000
Wave power plants	1	720,000
Geothermal plants	4	5,350
Hydroelectric plants	4	900
Tidal turbines	1	490,000
Rooftop solar PV systems	6	1.7 billion
Solar PV power plants	14	40,000
Concentrated solar power plants	20	49,000
TOTAL	100	

Source: Jacobson and Delucchi (2011).

Cost of Electricity for New Generation



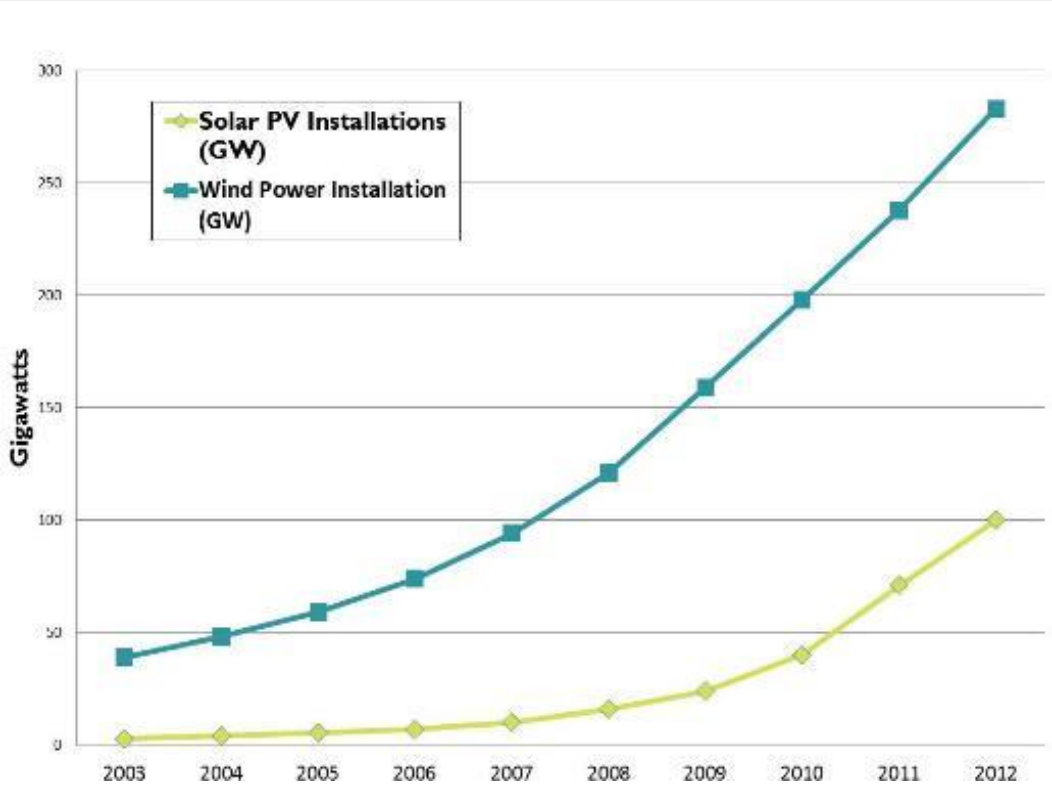
Sources: http://www.lazard.com/perspective/levelized-cost-of-energy-v8-abstract/http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

PV Economics Basics

- Solar Photovoltaic Cells convert sunlight directly into electricity
- They are sold on a $/Wp basis or $/power
- Wp is the power in Watts for **Peak sun hours** -- the equivalent number of hours per day, with solar irradiance equaling 1,000 W/m^2, that gives the same energy received from sunrise to sundown.
- To convert power to energy simply multiply by the amount of time that the cell is illuminated
  - W * hr = 1 W-hr
- Electricity (energy) is normally billed $/kW-hr

Growth of Solar PV and Wind Installations (2003-2012)

- In the course of time, the efficiency of these technologies gets improved.
- In the meantime, their production and installation become cheaper.



Source: Worldwatch Institute (2014).

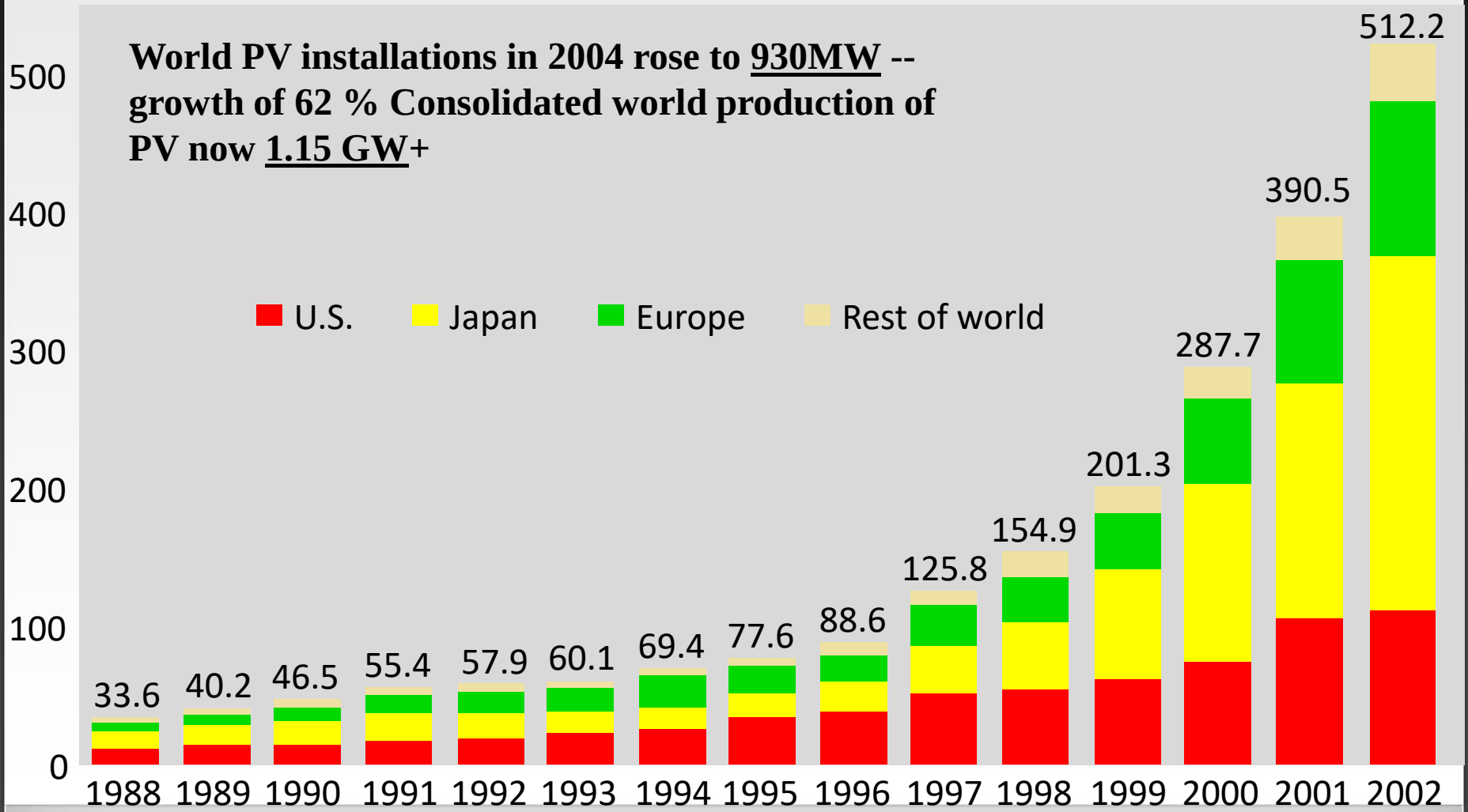
Economics of a Solar Electric Home

- A typical American uses ~ 9,000 kW-hrs/year
- A well-designed U.S. home needs 4kW-5kW of PV to provide for its energy needs averaged throughout the year
  - Depends on location (solar flux)
  - Energy use of home
  - Because calculating on /Wp basis you do not need to worry about efficiency
- The price tag for the complete installed system including all labor as of 2006 is between $5/Wp to $10/Wp. **For a 4kW system**:
  - 4000Wp x $5/Wp = $20,000
  - 4000Wp x $10/Wp = $40,000

http://www.eia.doe.gov/emeu/reps/enduse/er01_us.html puts use of 10,654 kW-hrs/year per household

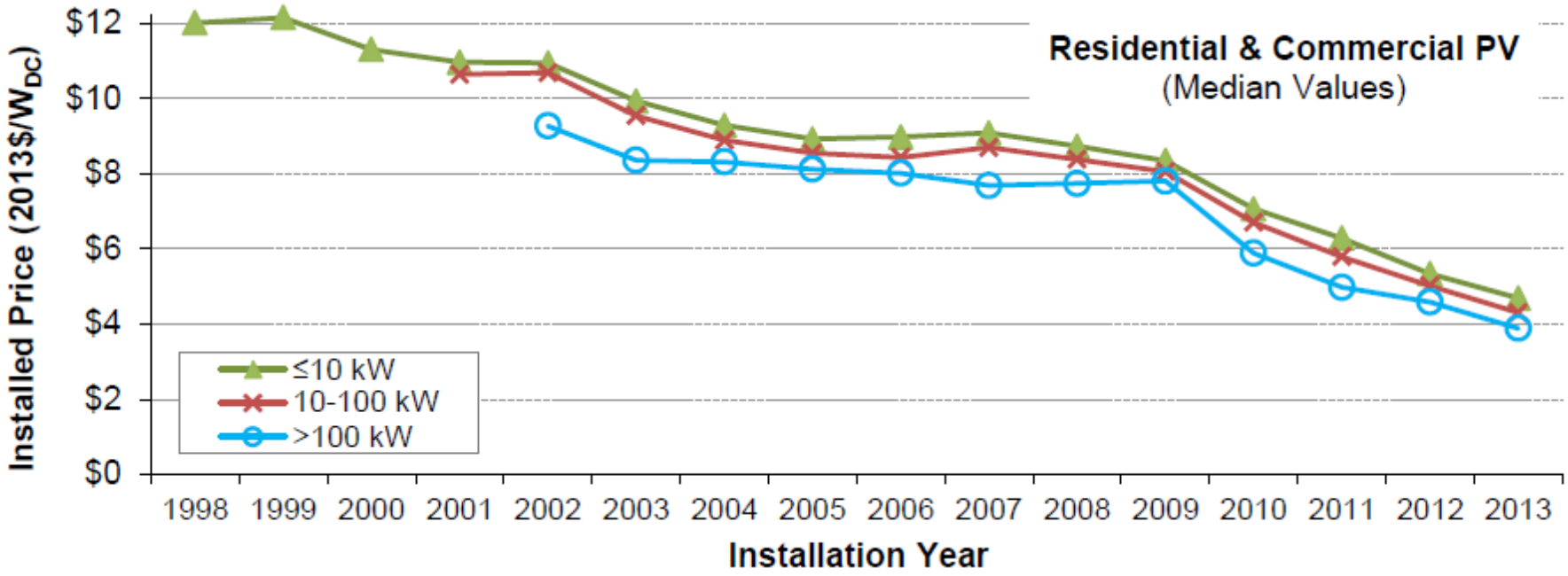
"Electrical Energy." The New Book of Popular Science. 2000 edition. Grolier Incorporated, 1998

World PV Module Production (MW) Increases



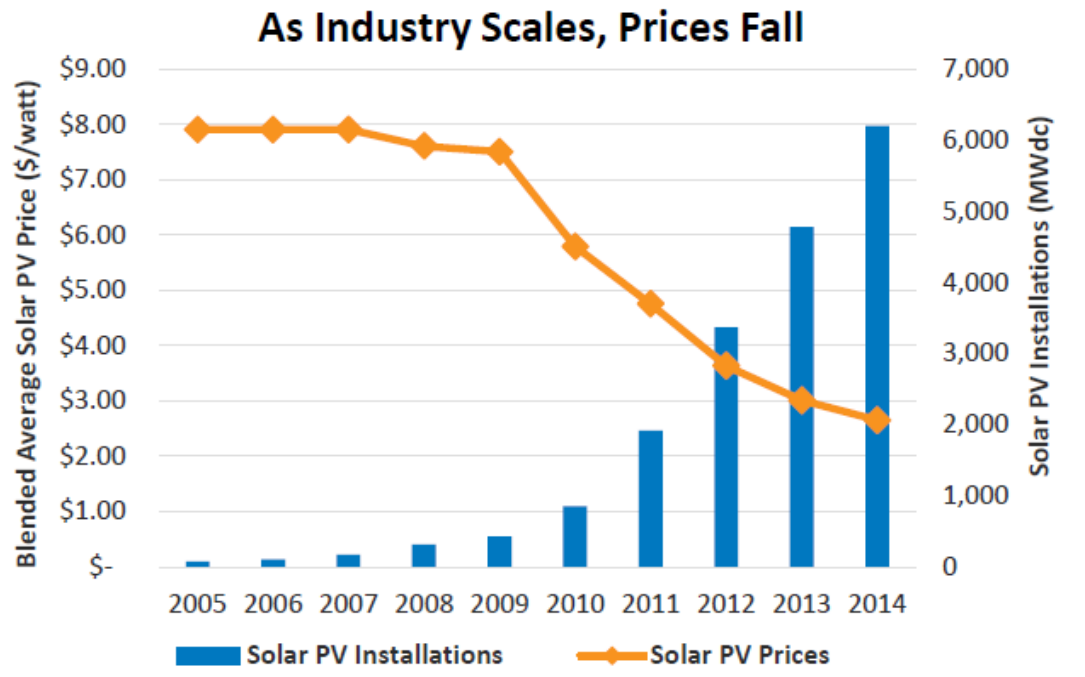
Source: *PV News*, March 2003

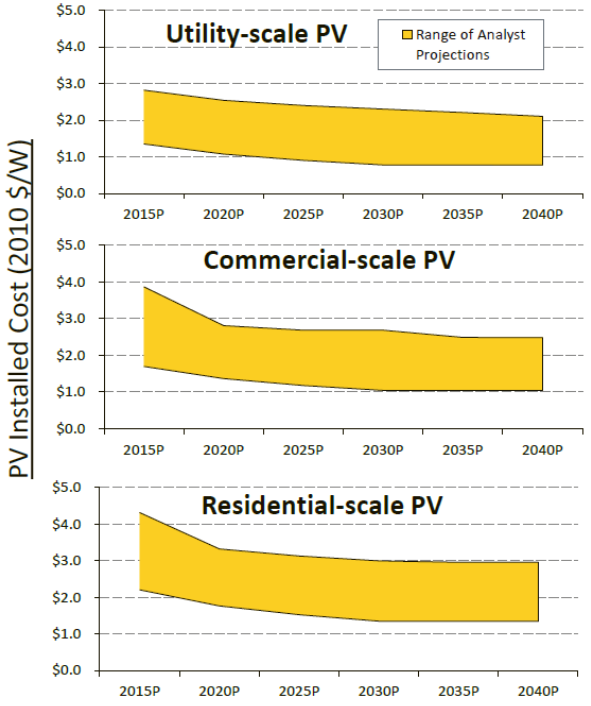
Solar Energy Price Decreases, 1998-2013



Source: Barbose, G., S. Weaver and N. Darghouth. 2014. Tracking the Sun VII: an historical summary of the installed price of photovoltaics in the United States from 1998 to 2013. SunShot Initiative, U.S. Department of Energy

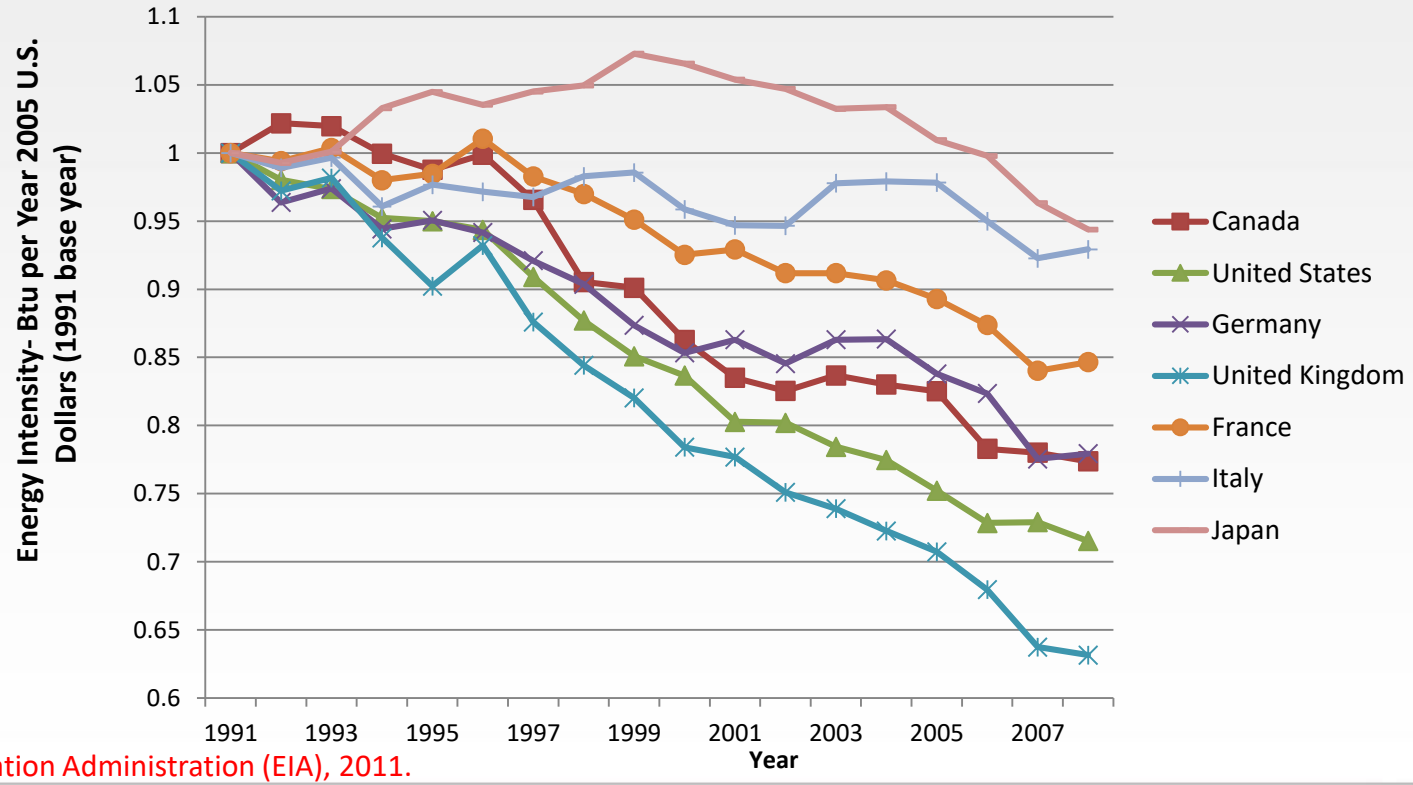
Projected further decreases in solar costs, 2015 - 2040





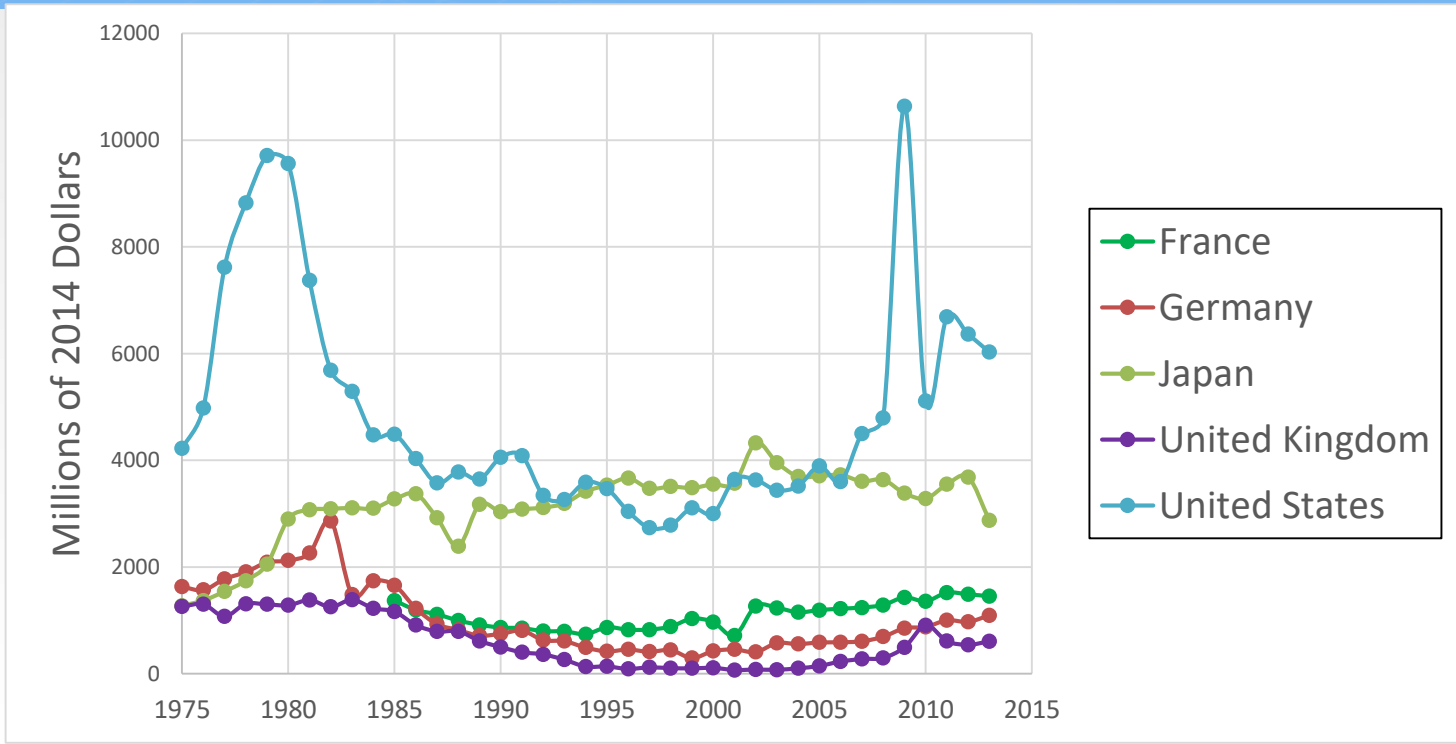
Source: Feldman et al 2014. Photovoltaic System Pricing Trends: historical, recent, and near-term projections. U.S. Department of Energy SunShot Initiative: http://www.nrel.gov/docs/fy14osti/62558.pdf

Declining Energy Intensity in Industrial Economies, 1991-2008



Source: US Energy Information Administration (EIA), 2011.

Public Energy R&D Investment



Source: International Energy Agency, 2014.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