Economic Development and the Clean Economy

Robert Pollin
Department of Economics and Political Economy Research Institute (PERI)
University of Massachusetts-Amherst

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The Threat of Climate Change and Greenhouse Gas Emissions

- **Debate among Climate Scientists**
  - Need to purchase insurance against threat
  - Relevant economic question is how much does insurance cost
    - How serious are trade-offs?
- **Basic Conclusion:**
  - Building a Green Economy can be positive engine of job opportunities and even GDP growth

Meeting Obama 2030 Emissions Target

- **4,200 mmt of Greenhouse Gas Emissions by 2030**
  - As of 2009, total U.S. emissions 6,600 mmt
    - Obama target would cut emissions by 36% by 2030
    - 80% of emissions from energy sources
      - Burning coal, petroleum, natural gas
    - Need to lower energy-based emissions to ~3,200 mmt
- **Fundamental Projects for achieving target**
  1. Energy Efficiency
  2. Clean Renewables

How to Meet 2030 Targets: 1. Energy Efficiency

- U.S. currently consumes 95 quads of energy
  - Per capita consumption roughly double Germany, France, Japan, UK
- EIA reference case projection for 2030 is 111 quads
  - 6,200 mmt of CO2—94% above Obama target on energy
  - Even with rising efficiency—0.7% average annual growth
- $1.8 trillion in investments over 20 to reduce total consumption to ~ 65 quads
  - $90 billion/year

Main Sources of Energy Efficiency

- **Building Sector**
  - Insulation, heating/cooling, lighting
- **Industry Sector**
  - Combined Heat and Power Systems (CHP)
- **Transportation Sector**
  - Doubling auto fuel efficiency
  - Public transportation?
- **Rough costs per quad of efficiency saving**
  - $37 billion/quad of saving relative to EIA reference case
  - McKinsey estimate: $38 billion/quad
  - Short-term capital investments with high rates of return
    - 3-5 years for full payback

Breakdown of Energy Efficiency Requirements

Table 1.
Summary Estimates for Creating High Efficiency Economy by 2030

	EIA Reference Case Consumption Level for 2030	Consumption Levels for High Efficiency Economy	Percentage Reduction in Consumption in High Efficiency Case	Investment Costs through 2030 for High-Efficiency Economy	Average Investment Costs/year for 20 years
Buildings	47 quads	25 quads	-46.8%	$650 billion	$32.5 billion
Industry	33 quads	20 quads	-39.4%	$370 billion	$18.5 billion
Transportation	31 quads	17 quads	-45.2%	$785 billion	$39.2 billion
TOTAL	111 quads	62 quads	-44.1%	$1.8 trillion	$90 billion

Sources: U.S. Energy Agency 2011 *Annual Energy Outlook* and discussion in text.

Policy Requirement for Efficiency Investments

- Organize financing more important than subsidies
  - Cost savings are immediate
  - Spreading costs/sharing risks
    - On-bill financing
    - PACE financing
      - Attached to real estate taxes

2. Renewables

- Need to achieve ~15 quads of clean renewables by 2030
  - 2009—7.5 quads
  - EIA reference case for 2030—15 quads
    - But 80% biofuels/biomass and hydro
    - 2030 needs:
      - Hydro fixed at 3 quads
      - 12 quads from wind, solar, geothermal, clean biofuels

Total Levelized Costs for Renewable Electricity

Table 3.
Estimated Levelized Costs of Renewable Energy Electricity Generation
For Plants Entering Service in 2016 (2009 dollars)

In Billions of dollars per Quad of BTUs

	Levelized Capital Costs	Fixed Operations and Maintenance	Variable Operations and Maintenance, including Fuel	Transmission Investment	Capacity Factor, in percentages	Total System Levelized Costs
Hydro	25.0	1.3	2.0	0.6	53%	28.8
Wind onshore	26.5	3.0	0	1.1	34%	30.6
Geothermal	24.6	3.8	3.0	0.3	91%	31.8
Biomass	17.6	4.4	13.5	0.4	83%	35.9
Solar PV	62.1	3.8	0	1.3	25%	67.2
Wind Offshore	66.8	9.0	0	1.9	34%	77.6
Solar Thermal	82.7	14.8	0	1.8	18%	99.4

Source: U.S. Energy Information Agency Supplement to *Annual Energy Outlook*, http://205.254.135.24/oiaf/aeo/electricity_generation.html

Renewable Electricity Costs vs. Coal and Nuclear

Table 4.
Levelized Costs of Hydro and Wind vs. Fossil Fuels and Nuclear

	Total System Levelized Costs (Billions of dollars/quad of BTUs)	**Total Costs Relative To Hydro** Percentages	**Total Costs Relative to Onshore Wind** Percentages	**Total Costs Relative to Geothermal**
Conventional Coal	30.3	+5.2%	-1.0%	-4.7%
Natural Gas—Conventional Combined Cycle	20.7	-28.1%	-32.3%	-53.6
Advanced Nuclear	36.3	+26.0%	+18.6%	+14.2

Source: U.S. Energy Information Agency Supplement to *Annual Energy Outlook*, http://205.254.135.24/oiaf/aeo/electricity_generation.html

Expanding Renewable Capacity

- **Capital costs at roughly $30 billion/quad for wind, geothermal, clean biomass**
  - Solar more expensive; requires more R&D subsidies to become cost competitive
- **Can expand clean renewables to ~15 quads with $400 billion capital investments**
  - $20 billion per year
  - Government procurement and feed-in tariffs more important than direct subsidies

Requirements for Conventional Energy Sources

- 50 quads total from conventional sources
  - 65 quad economy with 15 quads of clean renewables
- About 20 quads of petroleum needed for 2030 auto fleet
  - Assuming 50 miles/gallon standard
  - Assume biofuels and electric cars supply about 2 quads
- Combinations for remaining 30 quads
  - Depends on policy priorities

Greenhouse Gas Emissions for Conventional Fuel Sources

Table 5. Average Greenhouse Gas Emissions by Fuel Source

Fuel Source	GHG Emissions per Quad of Energy
Coal	95
Petroleum	63
Natural Gas	52
Nuclear Power	0

Source: U.S. Energy Information Agency, "Greenhouse Gas Emissions" http://www.epa.gov/climatechange/emissions/index.html#ggo

Hitting Emissions Target with Nuclear Power

Scenarios 1/2: Midrange and Maximum Nuclear Power

	5-quad Nuclear		*10-quad Nuclear*	
	Non-Renewable Energy Supply (quads)	*Emissions Levels (mmt)*	*Non-Renewable Energy Supply (quads)*	*Emissions Levels (mmt)*
Petroleum	20	1,260	20	1,260
Coal	10	950	10	950
Natural Gas	15	780	10	520
Nuclear	5	0	10	0
TOTALS	**50 quads**	**2,990**	**50 quads**	**2,730**

Alternative Mixes without Nuclear Power

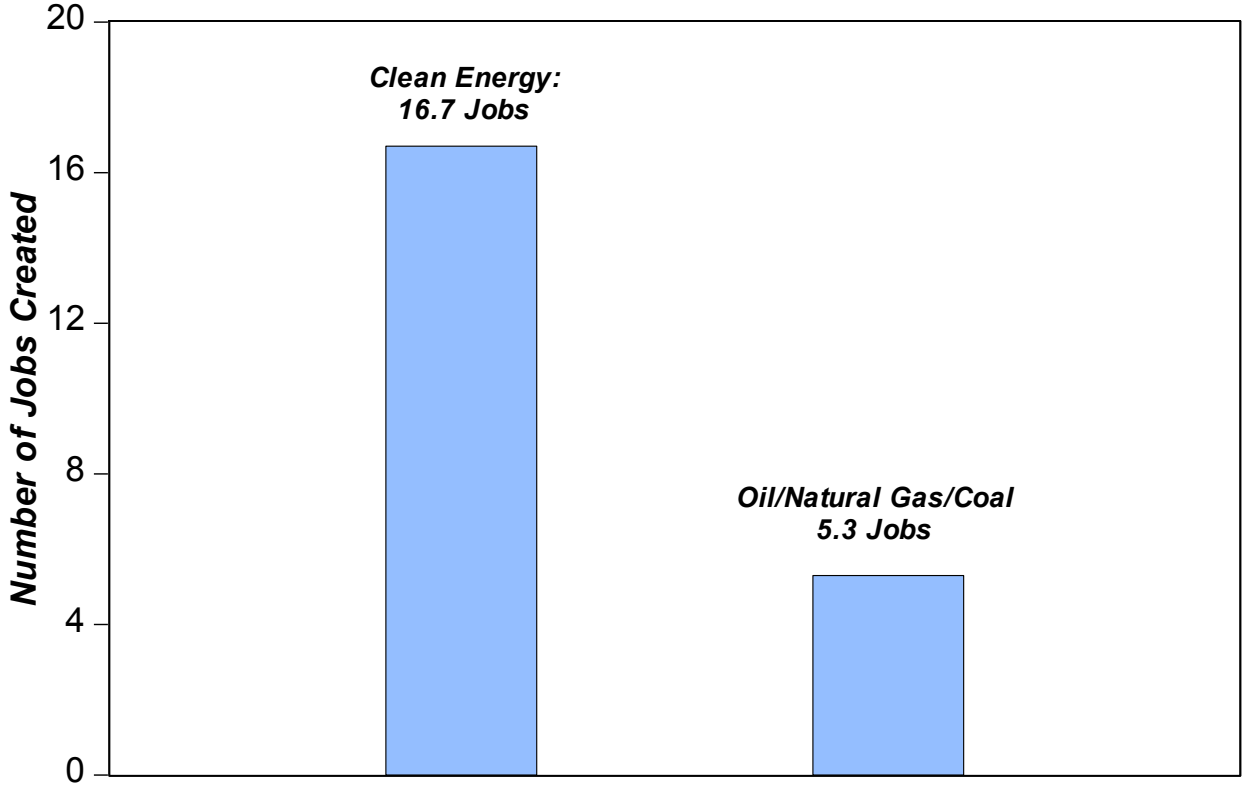
Scenario 3/4: No Nuclear Power with Coal or Natural Gas Substitution

	No Nuclear with Coal Substitution		*No Nuclear with Natural Gas Substitution*	
	Non-Renewable Energy Supply (quads)	*Emissions Levels (mmt)*	*Non-Renewable Energy Supply (quads)*	*Emissions Levels (mmt)*
Petroleum	20	1,260	20	1,260
Coal	15	1,425	10	950
Natural Gas	15	780	20	1,040
Nuclear	0	0	0	0
Petroleum	0			
TOTALS	**50 quads**	**3,462**	**50 quads**	**3,250**

Green Investment Agency and Employment Creation

- **Green Investments net Source of job creation relative to maintaining fossil fuel economy**
  - Labor Intensity
  - Domestic content
  - Pay scales
- **Input/output model Incorporating:**
  - Direct jobs
  - Indirect jobs
  - Induced jobs

Figure 1. Job Creation through $1 Million in Spending: Clean Energy Investments vs. Fossil Fuels



Sources: See Pollin, Heintz, Garrett-Peltier (2009).

Table 7.
Net Employment Effects through $110 Billion Shift from Fossil Fuels to Clean Energy Investments

1) Job creation through $110 billion spending on clean energy	1.8 million jobs
2) Job losses through $110 billion reduction in spending in fossil fuel sector	600,000 jobs
3) Net job creation through shift to clean energy (row 1 – 2)	1.2 million jobs

Source: U.S. Bureau of Labor Statistics and IMPLAN.

Conclusion for Reaching 2030 Greenhouse Gas Emissions Goal

- **Energy Efficiency:** Overall U.S. energy consumption needs to fall from 95 quads to 65 quads
- **Renewables:** Clean renewable energy needs to supply 15 quads
- **Oil:** 20 quads for automobiles
- **Remaining 30 quads:** Can come from variety of conventional sources, depending on priorities
- **Job Creation:** Investing in green energy transformation will be major source of net job creation