

How Many Clean Energy Jobs?

An Estimate

Goal: An Economic Approach

- Meta (or systems) economic approach which averages the overall effects of the spending.
- Estimate the number of Clean Energy (CE) **jobs created per dollar invested** by the government or by (public/private) investors.
- Estimate Clean Energy (CE) Megawatt (MW) installed per dollar invested.

Jobs/M\$



This is macroeconomics so far up, it might as well be in orbit!

It is a static picture at a given time.

CE Jobs/M\$

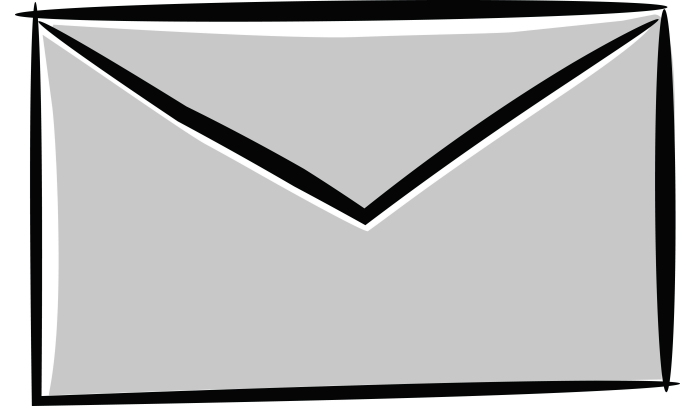
Direct and Indirect

- Heidi Garrett-Peltier - 7 jobs/M\$ [1]
- Luis Mundaca, ARRA - 12 jobs/M\$ [3]
(Renewable Energy only, 2010:Q1)
- CEA ARRA - 4 jobs/M\$
(Clean Energy, 2010:Q2)

[1] Garrett-Peltier (2017)

[3] Mundaca & Richter (2015)

Back of the envelope, please...



Let's consider a \$2 trillion CE investment.
This could yield approx.

> 10 million jobs

Calculation:

one trillion = 1,000,000,000,000 = 1×10^{12}

7 jobs/M\$ x 2×10^{12} x $1\text{M}\$/10^6 \text{ \$}$ = **14 million jobs**

Support for 10 Million Number

- Follows using multiple experts/sources/techniques.
- Here are the details...

Green versus brown

- Estimated 9 clean energy and 2 fossil fuel industry employment multipliers. Calculations were robust.
- \$1 million spending creates 7.49 FTE jobs in renewables, 7.72 in Energy Efficiency (EE).
- Fossil fuel industries support 2.65 FTE jobs per \$1 million spending.
- Uses a “synthetic” industry using using I-O tables. Treats clean energy and EE like any other industry.
- The synthetic industry approach is transparent and easily replicable.

Heidi **Garrett-Peltier**, Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model, *Economic Modelling* 6 (2017) Pages 439-447. <https://doi.org/10.1016/j.econmod.2016.11.012>

(additional content available via a search at: <https://www.peri.umass.edu/>)

Green vs. Brown

Garrett-Peltier (2017)

Energy Source	Direct Jobs per \$ million	Indirect Jobs per \$ million	Total Jobs per \$ million
Oil & natural gas	0.7	1.49	2.20
Coal	1.18	1.92	3.10
Building retrofits	4.55	3.22	7.77
Mass transit/rail	6.16	2.77	8.93
Smart grid	3.66	3.10	6.76
Hydro	4.55	2.98	7.53
Bioenergy	5.22	2.44	7.65
Solar	4.26	2.98	7.24
Wind	4.06	3.46	7.52

- Mass transit and freight railroad industries - six times more direct jobs are generated than for fossil fuel generation.
- After adding in the indirect jobs for the industries that support them, each million dollars of spending shifted from dirty to clean energy or energy efficiency can create a net increase of 5 jobs.
- This is found even before these totals include other induced jobs created in the local economy.

American Recovery and Reinvestment Act

- ARRA – Effective on February 17, 2009.
- A peer-reviewed Swedish Energy Agency analysis brought together various primary sources of literature concerning the performance of renewable energy stimulus programs linked to the ARRA.
- Overall, the results indicate that **stimulus programs have had a positive effect on the renewable energy** sector.
- The development of renewable energy technology was incentivized early in the stimulus, while **more time was needed to train employees for the new jobs** associated with its deployment.

Luis **Mundaca**, Jessika Luth **Richter**, Assessing ‘green energy economy’ stimulus packages: Evidence from the U.S. programs targeting renewable energy, Renewable and Sustainable Energy Reviews, Volume 42, 2015, Pages 1174-1186,

<https://doi.org/10.1016/j.rser.2014.10.060>

<http://www.sciencedirect.com/science/article/pii/S1364032114008855>)

Clean Energy (CE) Categories

- Energy Efficiency
- **Renewable Energy (RE) Generation ✓**
- Grid Modernization
- Advanced Vehicles and Fuels technologies
- Traditional Transit and High-Speed Rail
- Carbon Capture and Sequestration
- **Green Innovation and Job Training ✓**
- **Clean Energy Equipment Manufacturing ✓**
- Other Clean Energy

Mundaca & Richter (2015)

- Utilized U.S. Council of Economic Advisers (CEA) data

ARRA Category	Jobs Created or Supported
Renewable Energy (RE) generation generation	60,400 jobs
Clean Energy manufacturing jobs	1,700 jobs
Green innovation & job training	10,800 jobs
Total Overall	72,900 jobs

- Obligations for Renewable Energy (RE) technologies accounted for approximately **6,046 M\$ U.S.** in the American Recovery and Reinvestment Act (ARRA) through Q1 2010.
- 6,046 Million US\$/72,900 jobs = 82,935 dollars invested per job created or supported.**

Mundaca & Richter (2015) sec. 3.3.1, Job creation, Table 1
(sum the first two columns only)

Calculating **Jobs/M\$** from CEA

ARRA Category	Jobs Created or Supported	Obligations 2010 Q1 (M\$)
Renewable Energy (RE) generation generation	60,400 jobs	2,970
Clean Energy manufacturing jobs	1,700 jobs	61
Green innovation & job training	10,800 jobs	3,015
Total Overall	72,900 jobs	6,046

6,046 Million US\$/72,900 jobs = 82,935 dollars invested per job created or supported (CEA data through Q1 2010).

Jobs/M\$

6,046 Million US\$/72,900 jobs = 82,935 dollars invested per job created or supported.

$$1/(82,935 \text{ \$/job}) \times 10^6 \text{ \$/1M\$} = 12.06 \text{ jobs/M\$}$$

Caveats and Cautions

- Mundaca & Richter (2015) tabulated CEA jobs data through **Q1 2010 only**.
- This is for for ARRA Renewable Energy (RE) only, not all *Clean Energy*.

Council of Economic Advisers

- All Clean Energy (CE), which includes Renewable Energy
- Table 10 - CE appropriations = 94.8 billion \$, obligations = 51.3 billion \$ and outlays = 19.9 billion \$ through **2010:Q2**.
- Table 12 - CE ***jobs saved or created*** by public investment outlays = **190,700** (2010:Q2).
- Table 15 - CE: **46.0 billion \$** direct cost to government.
Results in approx. **4 jobs/M\$**.

CEA, The economic impact of the American Recovery and Reinvestment Act of 2009. Fourth quarterly report, July 14, 2010. Available via:
https://obamawhitehouse.archives.gov/files/documents/cea_4th_arra_report.pdf

Jobs/M\$ from CEA (model)

ARRA Category	Jobs	M\$	Jobs/M\$
2010 Q1 – Renewable Energy Generation, CE Manufacturing, and Green Innovation & Job Training	72,900 (b)	6,046 (a)	12.06
2010:Q1 - All CE Categories	187,400 (b)	39,754 (a)	4.7
2010:Q2 - All CE Categories	190,700 (c)	51,300 (a)	3.7

(a) obligations

(b) direct, indirect and induced (supported)

(c) saved or created

A Bonus

- Specific Example from Ref. [2]...
- Future Work:
 - Extend this to specific states and relevant & specific projects within those states.



**Thank you
Greg P. Smestad, Ph.D.**

Putting renewables and energy efficiency to work

U.S. Vestas Wind Plant (example)

228 MW_p

500 Jobs in Development & Installation (5 years) 2500 job-years

Divided by 25 years 100 jobs

Divided by 228 MW_p 0.44 jobs/MW_p

Divided by 35% Capacity Factor 1.25 jobs/MW_a

40 O&M jobs (20 years) 800 job-years

Divided by 25 years 32 jobs

Divided by 228 MW_p 0.140 jobs/MW_p

Divided by 35% Capacity Factor 0.4 jobs/MW_a

Max Wei, Shana Patadia, Daniel M. **Kammen**, Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?, Energy Policy 38 (2010) Pages 919–931.

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[1] Heidi **Garrett-Peltier**, Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model, *Economic Modelling* 6 (**2017**) Pages 439-447.

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[2] Max **Wei**, Shana **Patadia**, Daniel M. **Kammen**, Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?, *Energy Policy* 38 (**2010**) Pages 919–931.

<https://doi.org/10.1016/j.enpol.2009.10.044>

[3] Luis **Mundaca**, Jessika Luth **Richter**, Assessing ‘green energy economy’ stimulus packages: Evidence from the U.S. programs targeting renewable energy, *Renewable and Sustainable Energy Reviews* 42 (**2015**) Pages 1174-1186.

<https://doi.org/10.1016/j.rser.2014.10.060>

For table 1 of the above, the numbers are in the 3rd, not the 4th, CEA quarterly report. It's therefore early in the stimulus. Author email: jessika.richter@iiiee.lu.se

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<https://www.rewiringamerica.org/jobs-report>

GLOSSARY OF BUDGET TERMS

Budgetary resources--Budgetary resources comprise new budget authority, unobligated balances of budget authority, direct spending authority, and obligation limitations.

Direct spending--Direct spending, sometimes called mandatory spending, is a category of outlays from budget authority provided in law other than appropriations acts, entitlement authority, and the budget authority for the food stamp program. (Cf. discretionary appropriations.)

Loan guarantee--A loan guarantee is any guarantee, insurance, or other pledge with respect to the payment of all or a part of the principal or interest on any debt obligation of a non-Federal borrower to a non-Federal lender. The term does not include the insurance of deposits, shares, or other withdrawable accounts in financial institutions. (Cf. direct loan.)

Obligations--Obligations are binding agreements that will result in outlays, immediately or in the future. Budgetary resources must be available before obligations can be incurred legally.

Obligated balances--These are amounts that have been obligated but not yet outlaid. Unobligated balances are amounts that have not been obligated and that remain available for obligation under law.

Outlays--Outlays are the measure of Government spending. They are payments to liquidate obligations (other than the repayment of debt), net of refunds and offsetting collections. Outlays generally are recorded on a cash basis, but also include cash-equivalent transactions, the subsidy cost of direct loans and loan guarantees, and interest accrued on public issues of Treasury debt.

GLOSSARY OF BUDGET TERMS

Job-year--one person employed for one year. Sum of the average jobs created per year over the total number of years. Job-years represent all jobs supported by direct spending agency outlays and the estimated cost of tax provisions.