What is this?

Over the past eight years we at MacroVU have been creating a suite of information murals that support education, discussion, and negotiation on the major issues confronting human management of the planet.

These murals can be used individually or as a collection. They can be printed on paper or displayed on large screens in strategy rooms.

They are created on the computer and can be changed and updated rapidly.

They can be linked with clickable buttons to reveal greater detail or a bigger "helicopter" view.

At this moment 20 info-mural projects have been either completed for clients or in draft form:

What does it contain?

This table is a student assistant created draft in 2007-8. It has not been reviewed and thus should not be further circulated or quoted.

The objective of this exercise was to imagine approximately how many energy production units would have to be produced to address the difficult problem of staying within the 2 degree C. using 450 parts per million of CO2 as an indicator.

We knew it would appear to a very large construction effort for the global industries involved, so we decided to ask an additional question: Do we have the industrial means of production TODAY to accomplish this gigantic tasks within the time limit (starting in 2010)?

Our third objective was to try out a series of graphics that would enable the reader to quickly "see" the size of the task. This is shown in the "Putting it in Perspective" column.

This table should be studied in conjunction with other murals especially the "Rough Costs and Potential Lifespan for Energy Infrastructure" (also a draft). A larger context for both these tables is our info-mural: "One way of looking at possible future climate change pathways."

How do I get updates & revisions and other info-maps in the series?

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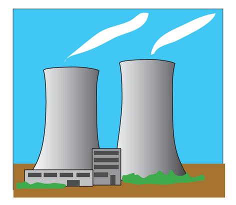
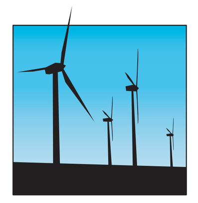
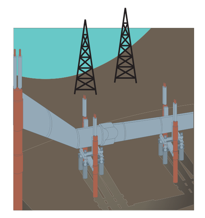
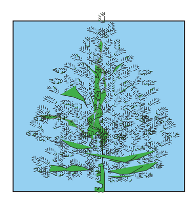
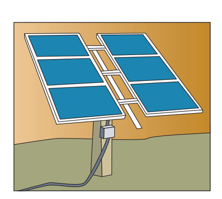
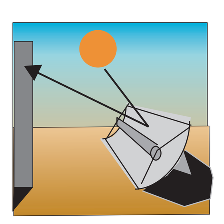
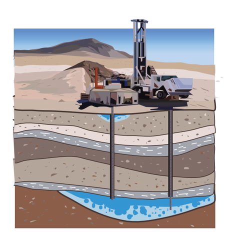
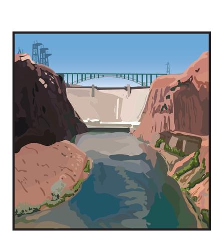
Global Energy Infrastructure Metrics for for 450 ppm Climate Change Scenario

2007

Estimated Number and Total Costs of Low (or No) Emission Power Generation Power Plants (Using IEA Blue Assumptions)

DRAFT - Not reviewed

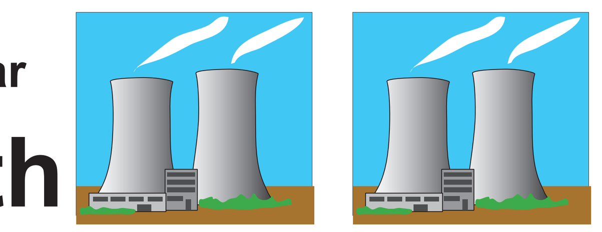
Type of Power Generation Infrastructure		Unit size	Approx. Number Needed Over 40 Years	X Cost per Unit	= Total cost to build (over 40 years)
NUCLEAR POWER PLANTS	 480 to 1,680 GW of new power by 2050. CORRECTIONS NEEDED These cannot be ranges	1,000 MW Power Plant	960 to 1280	Roughly $5 to $13 billion	Approx $4.8 to $16.4 trillion
WIND	 588 to 2,840 GW of new power by 2050.	4 MW Wind Turbine	147,000 to 710,000	Roughly $8 million	Approx $1.2 to $5.7 trillion
CARBON CAPTURE AND STORAGE (CCS)	 CCS techniques used in 30% of all power generation. (coal or gas)	Single Capture Plant	1,200 to 2,200	Roughly $500 million	Approx $620 billion to $1.1 trillion
BIOMASS	 60 to 200 GW of new power by 2050.	50 MW Power Plant	1,200 to 4,000	Roughly $15 million	Approx $18 billion to $60 billion
SOLAR - PV	 460 to 860 GW of new power by 2050.	Square Meter of Solar PV	4,600 to 8,600 million	Roughly $500	Approx $2.3 trillion to $4.3 trillion
SOLAR - Thermal (CSP)	 450 to 800 GW of new power 2050.	250 MW Power Plant	1,800 to 3,200	Roughly $750 million	Approx $1.4 trillion to $2.4 trillion
GEOTHERMAL	 200 to 520 GW of new power by 2050.	100 MW Power Plant	2,000 to 5,200	Roughly $210 million	Approx $1.4 to 2.4 trillion
HYDRO	 Approx. 3,200 GW of new power by 2050.	1 GW Dam plus Power Plant	3200	Roughly $10 billion	Approx $6.0 trillion
					Total: approx $17.7 to $38.4 trillion

Putting it into perspective

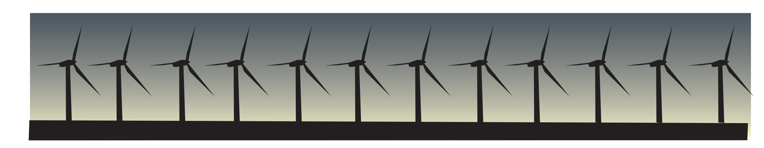
By 2050, to keep emissions below 450 ppm we would need to...

(all numbers are approximations)

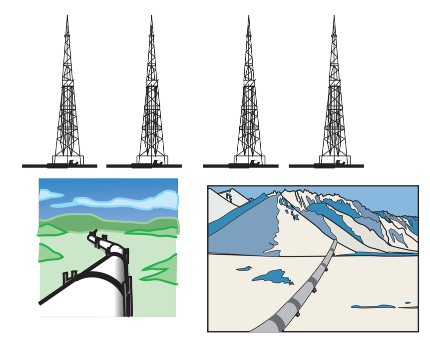
Nuclear: build 2 nuclear plants per month for 40 years



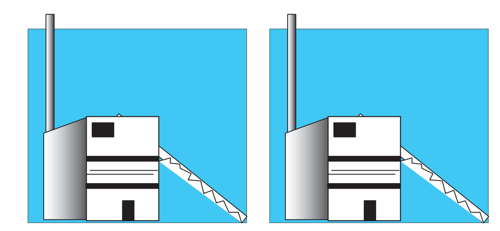
Wind: 12 wind turbines per day for 40 years



CCS: build 4 CCS plants per month plus pipelines for 40 years

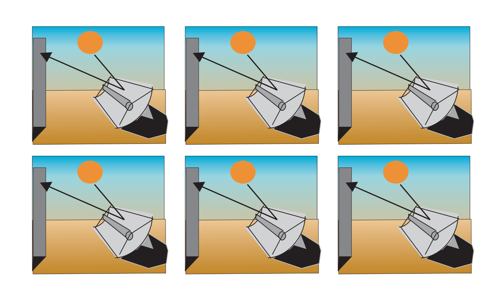


Biomass: build 2 biomass plants per month for 40 years

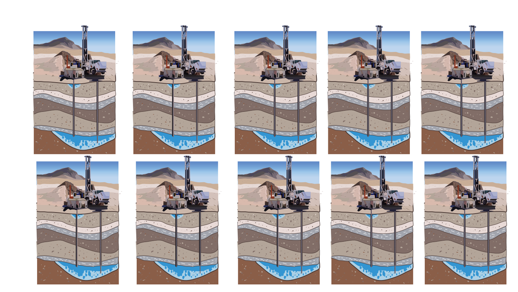


Solar - PV: Install solar PV plants at the rate of 71 football fields per day for 40 years

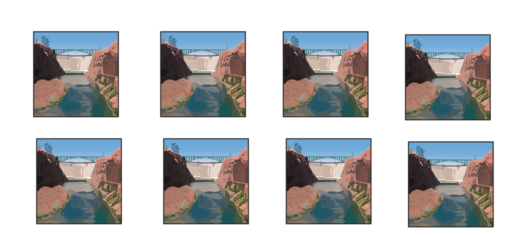
Solar - Thermal (CSP): build 6 solar thermal plants per month for 40 years



Geothermal: drill & build 10 geothermal plants per month for 40 years



Hydro: build 8 dams per month for 40 years



Do we have the means today to accomplish these goals?

Nuclear. In the 1980s a new nuclear power plant went on line every 17 days on average. Assuming each new power plant was at least 2 GW, and keeping pace with the 1980's average, we would surpass our goal in less than 40 years.

Wind. It is reported that GM has the capacity to make 1 car every 2 minutes. Based on that statistic, it seems plausible that just GM and Ford combined could potentially produce 1 wind turbine every 5 minutes. The estimated need is only 2 every hour. Additionally, over 70 million motor vehicles were manufactured in 2008. If it took the equivalent of 2 cars to manufacture 1 wind turbine we would only need ~2% of the automotive industry capacity for a single year to accomplish this goal.

CCS. The 502 mile Cortez CO2 pipeline was built in less than two years. Assuming all CCS equipped power plants will, on average, require only 50 miles of pipe, it would only take 11 crews to construct all 110,000 miles of pipe in less than 40 years. As stated in the Geothermal section, there is more than enough drilling capacity to meet both the Geothermal drilling needs and our CCS drilling needs while barely putting a dent into current oil and gas drilling operations.

Biomass. In 2005 it was estimated that the U.S. alone could sustainably produce 1.3 billion tons of dry biomass material. This amount of biomass material equates to approximately 150 GW of power per year. This is three quarters of the way to our 200 GW goal. it is only the United States contribution, and there are no technical hurdles, This amount of biomass usage would have no effect on the current agricultural usage. It would also have no effect on the current timber activities. This is based on a study funded by the DOE and the U.S. Department of Agriculture.

Solar – Photovoltaic. In Q3 of 2009 world solar cell manufacturing capacity is expect to be 17 GW, and is expect to surge to 42 GW by 2013. Conservatively assuming about half the expected growth, 22 GW by 2013, we would still easily make our current 40 year goal of 860 GW of new solar PV. Assuming the 42 GW, 2013 estimate is correct we would meet our goal by as early as 2033.

Solar – Thermal. An average beverage can production line can produce ~2400 cans per minute; that's well over 1 billion cans per year. It has been estimated that the manufacturing of ~1 billion cans per year is equivalent to ~2 GW of solar thermal power per year. American can producers manufacture approximately 100 billion beverage cans per year alone. It would only take 8 years of American can production to meet our 40 year goal.

Geothermal. Saskatchewan province in Canada drilled over 4000 new oil and gas wells alone in 2008. In 1999 the world drilled well over 17,000 new wells and over 95 million feet of holes; that was only for oil and was considered to be a very down year. Assuming only 1% of the 1999 year wells would be viable geothermal equivalents; in approximately 30 years we would have all of the necessary drilling to meet this goal.

Hydroelectric. World cement usage in 2008 was ~2.8 billion tons. A Hoover Dam size hydroelectric plant uses approximately 900,000 tons of cement. To build 1600 Hoover Dam size plants (2.08 GW each) we would need ~1.44 billion tons of cement. That's only half of the world's usage for one year, and we have 40+ years to build these. Yearly that means that we would need less than 2% of the world's cement usage to accomplish this goal.

Sources / Notes

The estimates for needed new infrastructure and on the IEA Blue scenario. www.iea.org The IEA used 450 parts per million limit on greenhouse gas emissions for the Blue scenario. The estimates for costs are based on various sources listed below:

Nuclear Regulatory Commission www.nrc.gov (nuclear)
Energy Information Administration www.eia.doe.gov (many)
Toronto Star www.thestar.com (report on current bids for nuclear plant)
American Wind Energy Association www.awea.org
Vindmolleindustrien www.windpower.org
Windustry www.windustry.org
Belfer Center for Science and International Affairs belfer.ksg.harvard.edu (carbon capture)
OREGON.gov www.oregon.gov (biomass)
Government of Alberta Agriculture and Rural Development www1.agric.gov.ab.ca (biomass)
Center for Global Development www.cgdev.org (solar csp)
National Renewable Energy Laboratory www.nrel.gov (geothermal)
Geothermal Energy Association www.geo-energy.org
World Commission on Dams www.dams.org

Acknowledgements

The section "Do we have the means today to accomplish these goals?" was inspired by Griffith, Saul, "The Game Plan" slide notes release 1.0, March 13 2008
Appreciation to intern Maurice Evans for calculations and Shay Lurie for some illustrations

DRAFT 1 SKETCH

Status The ideas presented here are unreviewed, first draft. Therefore, please do not reproduce or quote.

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