PV Economics

What are we paying for electricity?

What is the price history?

What's the story with PV?

What does the future look like?

How can we change it?

Yearly Consumption, Cost and Price for Three Electric Utilities in Nebraska

LES - Lincoln Electric System

NPPD – Nebraska Public Power District

OPPD – Omaha Public Power Dsitrict

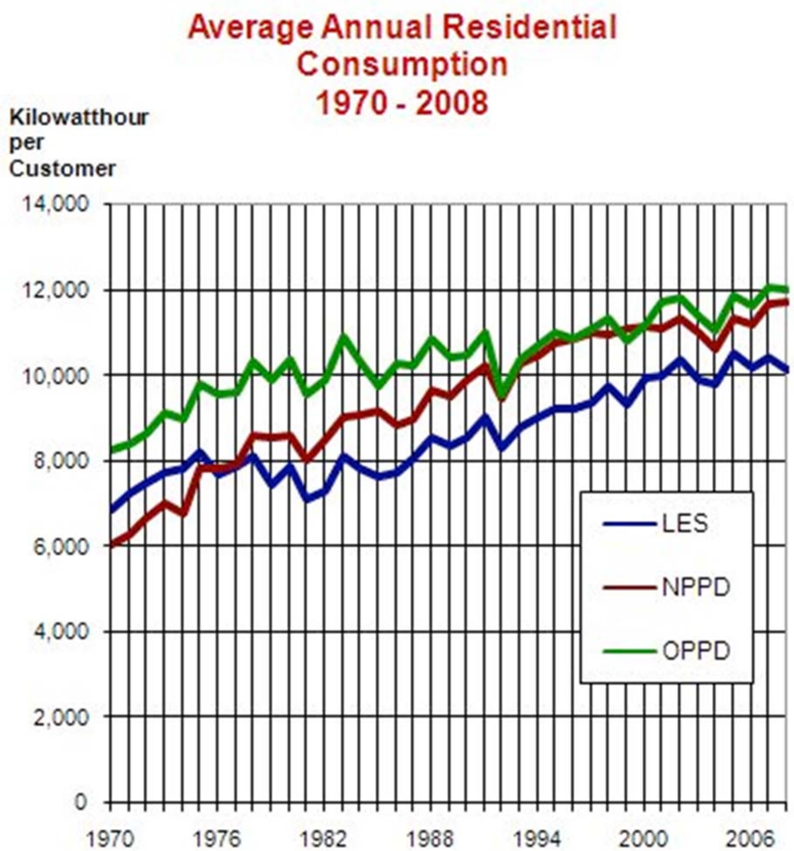
Average Annual Residential Consumption, Cost, and Price
Nebraska's Three Largest Electric Utilities
1970 - 2008

	Consumption (Kilowatthours/Customer)				Cost (Dollar Revenue/Customer)				Price (Price/Kilowatthour)		
Year	LES	NPPD	OPPD	Year	LES	NPPD	OPPD	Year	LES	NPPD	OPPD
1970	6,861	6,077	8,255	1970	$119	$135	$148	1970	$0.017	$0.022	$0.018
1971	7,239	6,333	8,400	1971	$124	$140	$163	1971	$0.017	$0.022	$0.019
1972	7,486	6,697	8,648	1972	$137	$160	$166	1972	$0.018	$0.024	$0.019
1973	7,754	7,059	9,104	1973	$148	$171	$179	1973	$0.019	$0.024	$0.020
1974	7,839	6,784	8,980	1974	$160	$168	$204	1974	$0.020	$0.025	$0.023
1975	8,223	7,842	9,780	1975	$193	$218	$266	1975	$0.023	$0.028	$0.027
1976	7,704	7,857	9,554	1976	$245	$276	$296	1976	$0.032	$0.036	$0.031
1977	7,872	7,959	9,633	1977	$265	$293	$305	1977	$0.034	$0.037	$0.032
1978	8,109	8,636	10,329	1978	$301	$349	$334	1978	$0.038	$0.040	$0.032
1979	7,459	8,572	9,901	1979	$301	$362	$353	1979	$0.040	$0.042	$0.036
1980	7,888	8,610	10,398	1980	$346	$398	$419	1980	$0.044	$0.046	$0.040
1981	7,115	8,055	9,579	1981	$373	$425	$407	1981	$0.052	$0.053	$0.043
1982	7,290	8,528	9,898	1982	$397	$501	$469	1982	$0.055	$0.059	$0.047
1983	8,119	9,053	10,926	1983	$505	$549	$561	1983	$0.062	$0.061	$0.051
1984	7,812	9,103	10,323	1984	$507	$561	$588	1984	$0.065	$0.062	$0.057
1985	7,621	9,221	9,750	1985	$503	$586	$555	1985	$0.066	$0.063	$0.057
1986	7,737	8,878	10,263	1986	$514	$570	$591	1986	$0.067	$0.064	$0.058
1987	8,054	8,996	10,261	1987	$518	$575	$596	1987	$0.064	$0.064	$0.058
1988	8,576	9,689	10,885	1988	$517	$635	$646	1988	$0.060	$0.066	$0.059
1989	8,378	9,554	10,439	1989	$500	$628	$681	1989	$0.060	$0.066	$0.065
1990	8,557	9,896	10,500	1990	$514	$652	$698	1990	$0.060	$0.066	$0.067
1991	9,066	10,277	10,991	1991	$539	$670	$697	1991	$0.059	$0.065	$0.064
1992	8,335	9,463	9,546	1992	$488	$652	$634	1992	$0.059	$0.069	$0.066
1993	8,793	10,284	10,395	1993	$537	$691	$706	1993	$0.061	$0.067	$0.068
1994	9,024	10,508	10,710	1994	$565	$724	$720	1994	$0.063	$0.069	$0.067
1995	9,240	10,764	10,997	1995	$582	$775	$734	1995	$0.063	$0.072	$0.068
1996	9,233	10,894	10,849	1996	$571	$780	$716	1996	$0.062	$0.072	$0.067
1997	9,396	11,025	11,129	1997	$581	$810	$758	1997	$0.062	$0.074	$0.068
1998	9,779	10,957	11,373	1998	$605	$825	$783	1998	$0.062	$0.075	$0.069
1999	9,318	11,132	10,829	1999	$578	$841	$750	1999	$0.062	$0.076	$0.069
2000	9,985	11,154	11,227	2000	$613	$867	$768	2000	$0.061	$0.078	$0.068
2001	10,000	11,105	11,732	2001	$609	$895	$777	2001	$0.061	$0.081	$0.066
2002	10,426	11,336	11,829	2002	$635	$1,015	$805	2002	$0.061	$0.090	$0.068
2003	9,939	11,032	11,381	2003	$625	$1,020	$770	2003	$0.063	$0.093	$0.068
2004	9,816	10,651	11,073	2004	$612	$990	$768	2004	$0.062	$0.093	$0.069
2005	10,550	11,381	11,888	2005	$697	$1,048	$842	2005	$0.066	$0.092	$0.071
2006	10,191	11,221	11,646	2006	$736	$1,036	$860	2006	$0.072	$0.092	$0.074
2007	10,433	11,684	12,076	2007	$747	$1,070	$909	2007	$0.072	$0.092	$0.075
2008	10,176	11,742	12,036	2008	$772	$1,056	$939	2008	$0.076	$0.090	$0.078

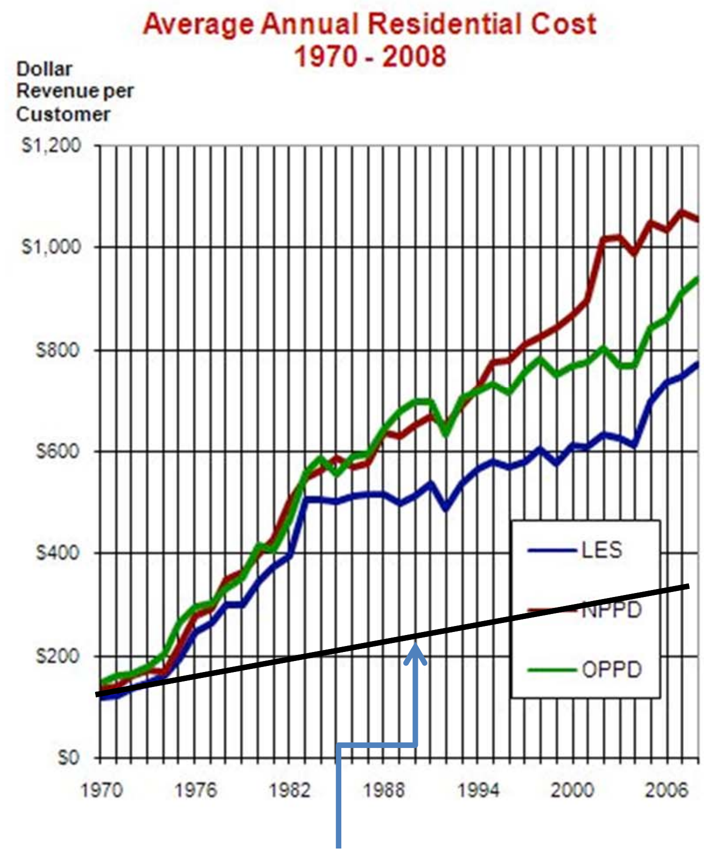
Sources: *Lincoln Electric System Annual Report*, Lincoln Electric System, Lincoln, NE. *Nebraska Public Power District Annual Report*, Nebraska Public Power District, Columbus, NE. *Omaha Public Power District Annual Report*, Omaha Public Power District, Omaha, NE. Nebraska Energy Office, Lincoln, NE.

Notes: Lincoln Electric System (LES). Nebraska Public Power District (NPPD). Omaha Public Power District (OPPD).

Current Electricity Generation: Rising Consumption and Revenue



Smaller households, on average, but more consumption

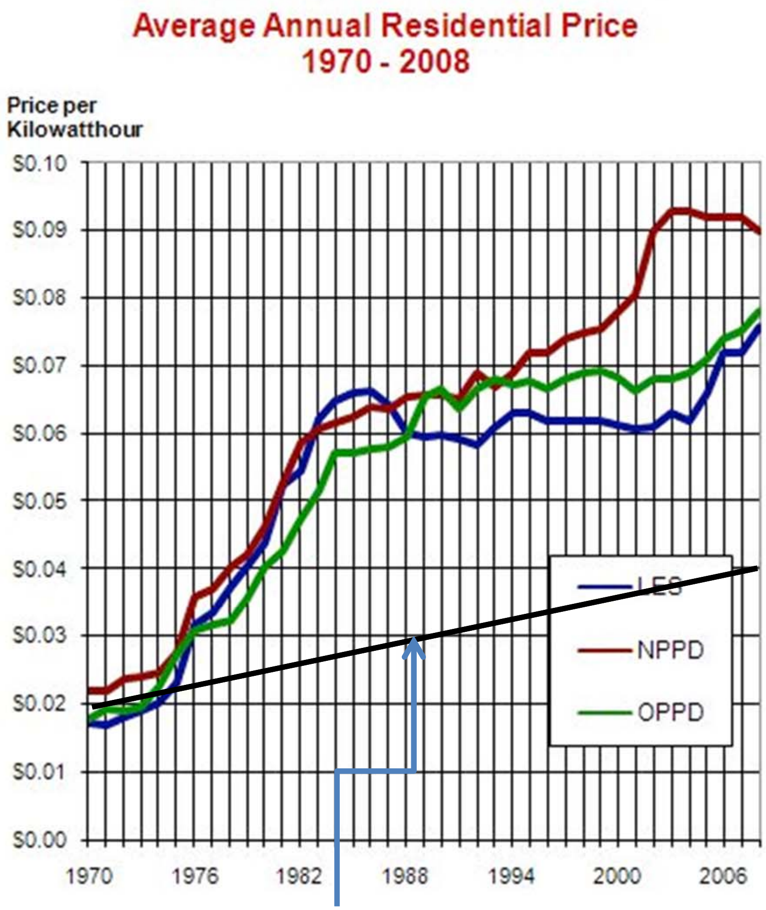


Inflation at 2.5%

(rule of "72")

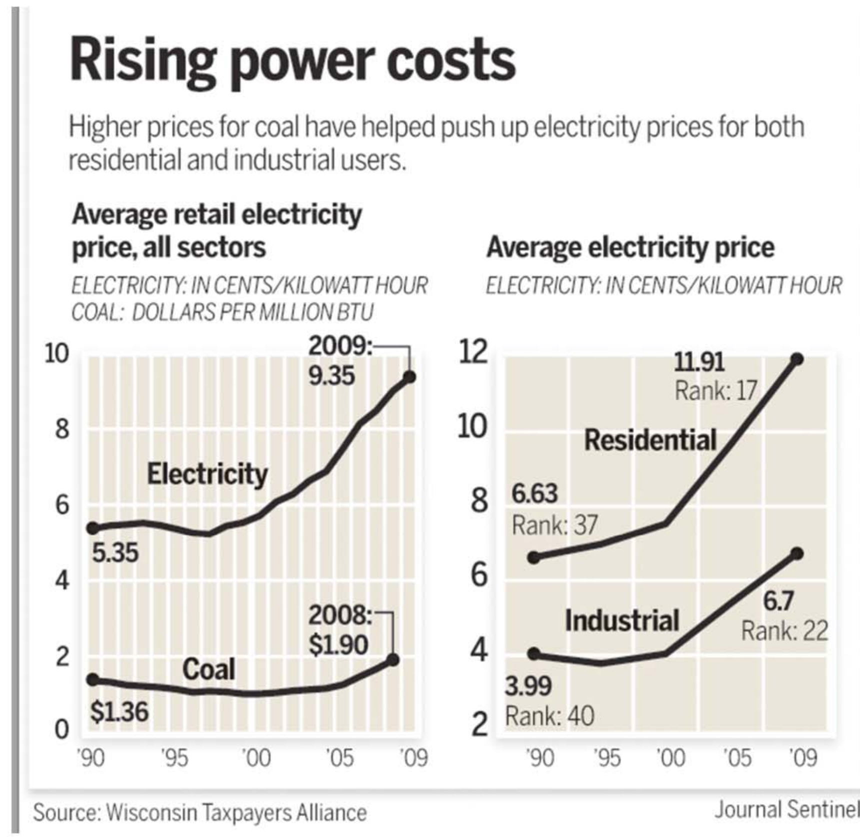
Rising cost of electricity

Nebraska



Inflation at 2.5%

Wisconsin



Data Average Across US

Table 5.3. Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector, 1996 through October 2010

(Cents per Kilowatthour)

Period	Residential	Commercial	Industrial[1]	Transportation[1]	Other	All Sectors
1996	8.36	7.64	4.6	NA	6.91	6.86
1997	8.43	7.59	4.53	NA	6.91	6.85
1998	8.26	7.41	4.48	NA	6.63	6.74
1999	8.16	7.26	4.43	NA	6.35	6.64
2000	8.24	7.43	4.64	NA	6.56	6.81
2001	8.58	7.92	5.05	NA	7.2	7.29
2002	8.44	7.89	4.88	NA	6.75	7.2
2003	8.72	8.03	5.11	7.54	--	7.44
2004	8.95	8.17	5.25	7.18	--	7.61
2005	9.45	8.67	5.73	8.57	--	8.14
2006	10.4	9.46	6.16	9.54	--	8.9
2007	10.65	9.65	6.39	9.7	--	9.13

U.S. Energy Information Administration
Independent Statistics and Analysis

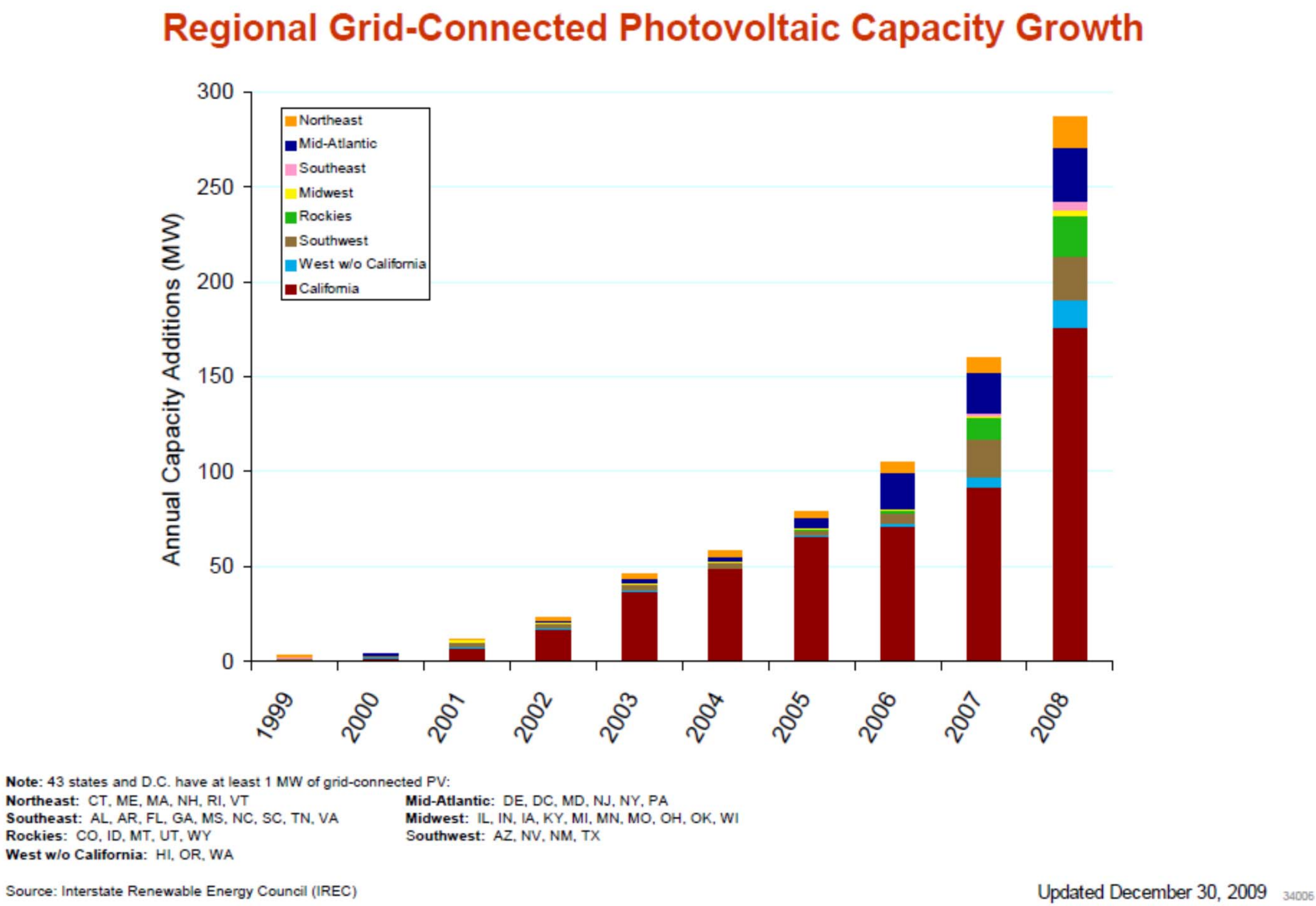
Where Does Our Electricity Come From??

Table ES1.B. Total Electric Power Industry Summary Statistics,Year-to-Date 2010 and 2009

January through October Net Generation and Consumption of Fuels			
Items	Total (All Sectors)		
	2010	2009	% Change
Net Generation (thousand megawatthours)			
Coal[1]	1,547,706	1,452,661	6.5
Petroleum Liquids[2]	19,771	23,190	-14.7
Petroleum Coke	11,572	11,253	2.8
Natural Gas[3]	836,660	785,951	6.5
Other Gases[4]	9,358	8,791	6.4
Nuclear	670,630	669,075	0.2
Hydroelectric Conventional	214,515	227,708	-5.8
Other Renewables	136,936	118,019	16
Wood and Wood-Derived Fuels[5]	31,531	29,454	7.1
Other Biomass[6]	15,350	15,263	0.6
Geothermal	12,921	12,367	4.5
Solar Thermal and Photovoltaic[7]	1,195	830	44
Wind	75,939	60,105	26.3
Hydroelectric Pumped Storage	-3,132	-3,914	20
Other Energy Sources[8]	9,429	9,914	-4.9
All Energy Sources	**3,453,444**	**3,302,647**	**4.6**
Consumption of Fossil Fuels for Electricity Generation			
Coal (1000 tons)[1]	818,251	773,213	5.8
Petroleum Liquids (1000 bbls)[2]	33,840	38,905	-13
Petroleum Coke (1000 tons)	4,247	4,195	1.2
Natural Gas (1000 Mcf)[3]	6,534,596	6,097,841	7.2
Consumption of Fossil Fuels for Useful Thermal Output			
Coal (1000 tons)[1]	17,708	16,929	4.6
Petroleum Liquids (1000 bbls)[2]	4,877	6,956	-29.9
Petroleum Coke (1000 tons)	615	827	-25.6
Natural Gas (1000 Mcf)[3]	685,164	678,152	1

U.S. Energy Information Administration
Independent Statistics and Analysis

Figure 1.2 Source: IREC 2009; updated December 30, 2009.



State of Texas Comptroller: Special Report – Assessment of *Direct Federal* Subsidies

http://www.window.state.tx.us/specialrpt/energy/subsidies/

EXHIBIT 28-4
Types of State and Local Financial Energy Subsidies

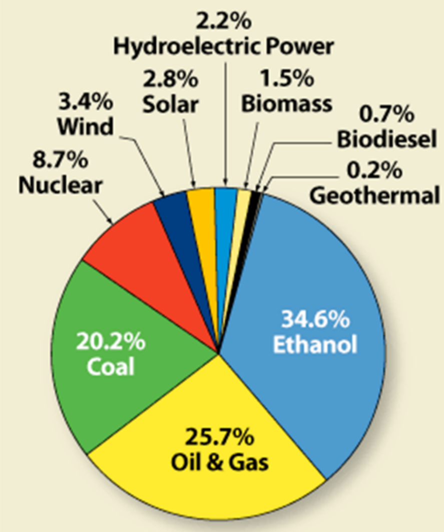
Types of Financial Subsidies	Descriptions	Examples
Taxes	Special tax credits, deductions, exemptions, allowances and property tax incentives	• Tax exemption for oil and gas production for a wellbore certified as non-producing for previous two years • Chapter 312 property tax abatements
Homeowner incentives	Rebates, leasing/lease purchase programs	• Monetary rebate for customers who install solar photovoltaic systems • Program to lease or purchase solar water pumping systems directly from utility company
Direct Spending	Grants compiled of funds received from industry fees and matching general revenue funding	• Fuel Ethanol and Biodiesel Production Incentive Program (sole example in this study)

Source: Texas Comptroller of Public Accounts.

EXHIBIT 28-5

Estimated Percent of Total Federal Subsidies in 2006, Allocated by Fuel Source

Total Federal Subsidies: $13.6 billion



Source: Texas Comptroller of Public Accounts.

View Exhibit 28-5: Estimated Percent of Total Federal Subsidies in 2006, Allocated by Fuel Source, in Table Format.

Indirect Subsidies (costs) *not* include

TOTAL FEDERAL SUBSIDIES BY FUEL SOURCE

The Comptroller's office estimates that the total amount of federal energy subsidies for 2006 was $13.6 billion. Ethanol had the largest share, at $4.7 billion, or 34.6 percent of total subsidies. The share of federal subsidies by fuel source is shown in **Exhibit 28-5**.

It’s all About the “Money”

When everything is included, the real metrics for investment *should* have to do with **value**;

- What are you making?
- Why is it needed by society?
- What are the impacts of making it?
- Or not making it?

Large rai stone money in the village of Gachpar, Yap, Micronesia; the largest are 3 meters in diameter and weigh 4 metric tons (Wikipedia and NPR)

Better, cleaner, less expensive, more “valuable” processes and products

Levelized Cost of Electricity (LCOE), *- from Wikipedia*
a.k.a. Comparing costs of differing types of electricity generation technologies

The cost of electricity generated by different sources measures the cost of generating electricity including initial capital, return on investment, as well as the costs of continuous operation, fuel, and maintenance.

Cost factors [edit]

While calculating costs, several internal cost factors have to be considered[1]. (Note the use of "costs," which is not the actual selling price, since this can be affected by a variety of factors such as subsidies on some energy and sources and taxes on others):

- Capital costs (including waste disposal and decommissioning costs for nuclear energy) - tend to be low for fossil fuel power stations; high for renewables and nuclear; very high for waste to energy, wave and tidal, PV and solar thermal.
- Operating and maintenance costs - tend to be high for nuclear, coal, and waste-to-energy (fly and bottom ash disposal, emissions clean up, operating steam generators) and low for renewables and oil and gas fired peaking units.[citation needed]
- Fuel costs - high for fossil fuel and biomass sources, very low for nuclear and renewables, possibly negative for waste to energy.
- Expected annual hours run - as low as 3% for diesel peakers, 30% for wind, and up to 90% for nuclear.
- Revenue recovered from heat sales can be offset against running costs, and reduce the net costs in the case of Cogeneration (combined heat and power) and District heating schemes.
- Factors such as the costs of waste (and associated issues) and different insurance costs are not included in the following.

To evaluate the total cost of production of electricity, the streams of costs are converted to a net present value using the time value of money. These costs are all brought together using discounted cash flow here.[2] and here [3].

Another collection of cost calculations is shown here:[4], here [5], and [6], and [7].

BP claims renewables are on a decreasing cost curve, while non-renewables are on an increasing cost curve.[8].

Calculations

[edit]

Levelised energy cost (LEC) is the price at which electricity must be generated from a specific source to break even. It is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital, and is very useful in calculating the costs of generation from different sources.[citation needed]

It can be defined in a single formula as:[9]

$$\mathrm{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

where

- LEC = Average lifetime levelised electricity generation cost
- I_t = Investment expenditures in the year t
- M_t = Operations and maintenance expenditures in the year t
- F_t = Fuel expenditures in the year t
- E_t = Electricity generation in the year t
- r = Discount rate
- n = Life of the system

Typically LECs are calculated over 20 to 40 year lifetimes, and are given in the units of currency per kilowatt-hour, for example AUD/kWh or EUR/kWh or per megawatt-hour, for example AUD/MWh (as tabulated below).[citation needed]

Discount Rate

The **discount rate** can mean

- an interest rate a central bank charges depository institutions that borrow reserves from it, for example for the use of the Federal Reserve's discount window.
- the same as interest rate; the term "discount" does not refer to the common meaning of the word, but to the meaning in computations of present value, e.g. net present value or discounted cash flow
- the *annual effective discount rate*, which is the annual interest divided by the capital including that interest; this rate is lower than the interest rate; it corresponds to using the value after a year as the nominal value, and seeing the initial value as the nominal value minus a discount; it is used for Treasury Bills and similar financial instruments

From Wikipedia....

Net Present Value

NPV in decision making

[edit]

NPV is an indicator of how much value an investment or project adds to the firm. With a particular project, if R_t is a positive value, the project is in the status of discounted cash inflow in the time of t. If R_t is a negative value, the project is in the status of discounted cash outflow in the time of t. Appropriately risked projects with a positive NPV could be accepted. This does not necessarily mean that they should be undertaken since NPV at the cost of capital may not account for opportunity cost, *i.e.* comparison with other available investments. In financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected.

If...	It means...	Then...
NPV > 0	the investment would add value to the firm	the project may be accepted
NPV < 0	the investment would subtract value from the firm	the project should be rejected
NPV = 0	the investment would neither gain nor lose value for the firm	We should be indifferent in the decision whether to accept or reject the project. This project adds no monetary value. Decision should be based on other criteria, e.g. strategic positioning or other factors not explicitly included in the calculation.

From Wikipedia....

Net Present Value (cont.)

Formula

[edit]

Each cash inflow/outflow is discounted back to its present value (PV). Then they are summed. Therefore NPV is the sum of all terms,

$$\frac{R_t}{(1+i)^t}$$

where

t - the time of the cash flow

i - the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk.)

R_t - the net cash flow (the amount of cash, inflow minus outflow) at time *t*. For educational purposes, R_0 is commonly placed to the left of the sum to emphasize its role as (minus) the investment.

The result of this formula if multiplied with the Annual Net cash in-flows and reduced by Initial Cash outlay will be the present value but in case where the cash flows are not equal in amount then the previous formula will be used to determine the present value of each cash flow separately. Any cash flow within 12 months will not be discounted for NPV purpose.[2]

From Wikipedia....

A corporation must decide whether to introduce a new product line. The new product will have startup costs, operational costs, and incoming cash flows over six years. This project will have an immediate (t=0) cash outflow of $100,000 (which might include machinery, and employee training costs). Other cash outflows for years 1–6 are expected to be $5,000 per year. Cash inflows are expected to be $30,000 each for years 1–6. All cash flows are after-tax, and there are no cash flows expected after year 6. The required rate of return is 10%. The present value (PV) can be calculated for each year:

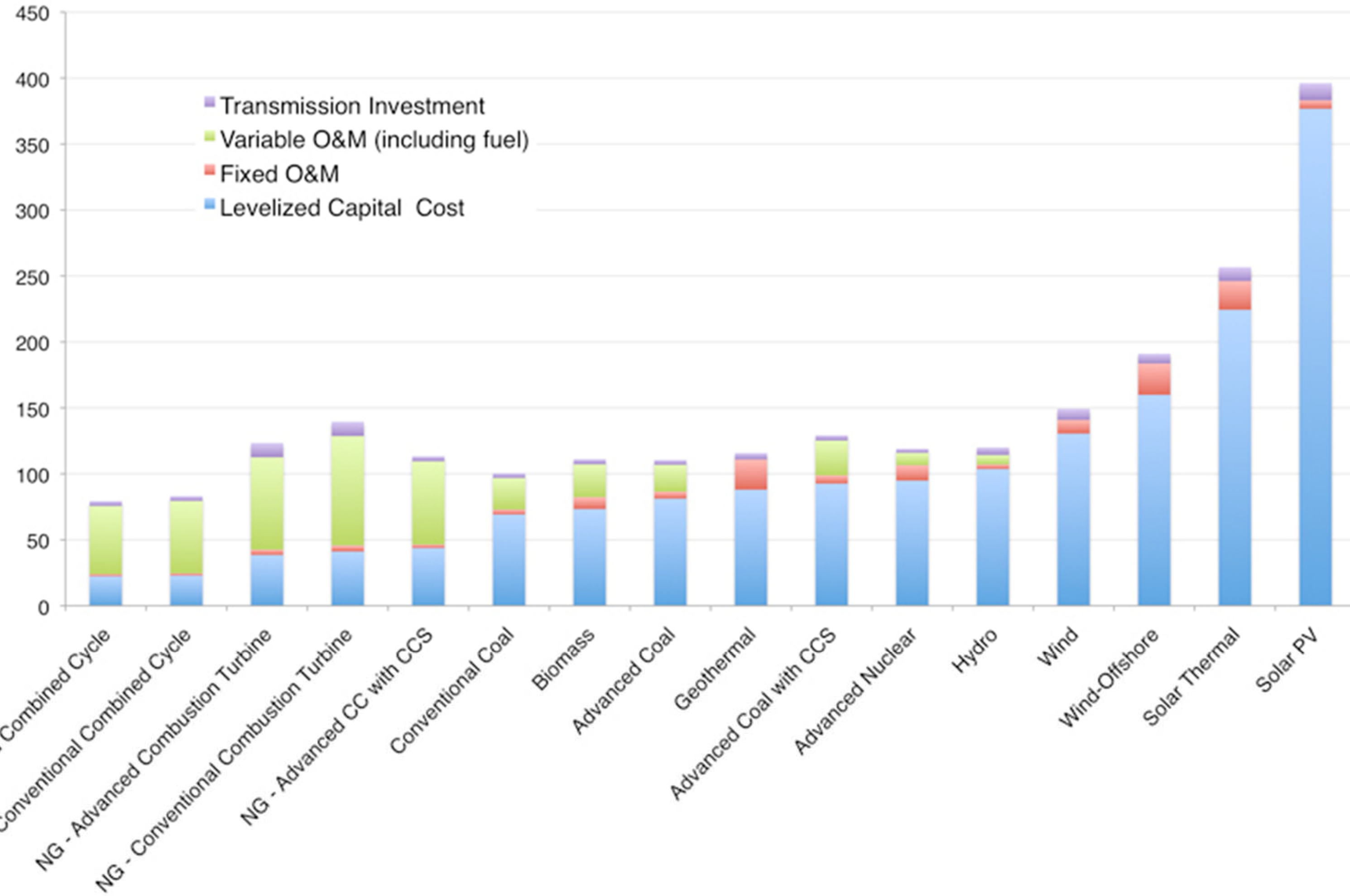
Year	Cash flow	Present value
T=0	$\frac{-100,000}{(1+0.10)^0}$	-$100,000
T=1	$\frac{30,000-5,000}{(1+0.10)^1}$	$22,727
T=2	$\frac{30,000-5,000}{(1+0.10)^2}$	$20,661
T=3	$\frac{30,000-5,000}{(1+0.10)^3}$	$18,783
T=4	$\frac{30,000-5,000}{(1+0.10)^4}$	$17,075
T=5	$\frac{30,000-5,000}{(1+0.10)^5}$	$15,523
T=6	$\frac{30,000-5,000}{(1+0.10)^6}$	$14,112

- The sum of all these present values is the net present value. Since the NPV is greater than zero, it would be better to invest in the project than to do nothing, and the corporation should invest in this project if there is no mutually exclusive alternative project with a higher NPV
- Subsidies need be includes in the cash flow analysis

Sum, after six years, i.e. NPV of the project, is $8,881.52 ✔

Estimated Levelized Cost of New Electricity Generating Technologies in 2016

($2008/megawatt hour)



Source: Energy Information Administration, Annual Energy Outlook 2010, http://www.eia.doe.gov/oiaf/aeo/electricity_generation.html

IER INSTITUTE FOR ENERGY RESEARCH

California levelized energy costs for different generation technologies (2007)

Technology	Cost (USD/MWh)
Advanced Nuclear	67
Coal	74-88
Gas	313-346
Geothermal	67
Hydro power	48-86
Wind power	60
Solar	116-312
Biomass	47-117
Fuel Cell	86-111
Wave Power	611

Note that the above figures incorporate tax breaks for the various forms of power plants. Subsidies range from 0% (for Coal) to 14% (for nuclear) to over 100% (for solar).

Estimated Levelized Cost of New Generation Resources, 2016.

Plant Type	Capacity Factor (%)	U.S. Average Levelized Costs (2008 $/megawatthour) for Plants Entering Service in 2016				
		Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85	69.2	3.8	23.9	3.6	100.4
Advanced Coal	85	81.2	5.3	20.4	3.6	110.5
Advanced Coal with CCS	85	92.6	6.3	26.4	3.9	129.3
Natural Gas-fired						
Conventional Combined Cycle	87	22.9	1.7	54.9	3.6	83.1
Advanced Combined Cycle	87	22.4	1.6	51.7	3.6	79.3
Advanced CC with CCS	87	43.8	2.7	63.0	3.8	113.3
Conventional Combustion Turbine	30	41.1	4.7	82.9	10.8	139.5
Advanced Combustion Turbine	30	38.5	4.1	70.0	10.8	123.5
Advanced Nuclear	90	94.9	11.7	9.4	3.0	119.0
Wind	34.4	130.5	10.4	0.0	8.4	149.3
Wind – Offshore	39.3	159.9	23.8	0.0	7.4	191.1
Solar PV	21.7	376.8	6.4	0.0	13.0	396.1
Solar Thermal	31.2	224.4	21.8	0.0	10.4	256.6
Geothermal	90	88.0	22.9	0.0	4.8	115.7
Biomass	83	73.3	9.1	24.9	3.8	111.0
Hydro	51.4	103.7	3.5	7.1	5.7	119.9

Source: Energy Information Administration, Annual Energy Outlook 2010, December 2009, DOE/EIA-0383(2009)

LCOE for PV (From K. Zweibel, "Terawatt Challenge for PV")

Appendix 1. Calculating Levelized Energy Cost from System $/Wp DC Costs

Table A-1. Conversion of $1/Wp (DC) to ¢/kWh (fixed flat plates) *without* O&M

	Average Location (e.g., Kansas City)	**Below Average (Maine or Seattle)**	**Above Average (Phoenix or Albuquerque)**
Sunlight (kWh/m2-yr) and capacity factor (= 0.8*sunlight/(8760)	1700 kWh/m2-yr 15.5%	1300 kWh/m2-yr 12%	2300 kWh/m2-yr 21%
Levelized Energy Cost (¢/kWh)	5.9 ¢/kWh	7.7 ¢/kWh	4.4 ¢/kWh

Using this table, one can estimate the LEC of any system (assuming the same set of financial and other terms) by merely multiplying the system $/Wp by the proper number, above (e.g., a $5/Wp system would be 5 times more than the ¢/kWh level in Table A1) and then adding in the O&M, which is usually very small (about 0.1 ¢/kWh for a fixed flat plate).

The LEC values in Table 1 were calculated using the standard formula for amortization of cost over time, assuming the system is financed through a loan matched to the lifetime of the system.

LEC = (ICCx1000xCRF)/(CFx8760)+O&M, where

ICC = Installed Capacity Cost ($/Wp DC),

CRF = Capital Recovery Factor = (i*(i+1)^n)/((i+1)^n-1),

CF = AC Capacity Factor (0.8*sunlight/8760 hours, reduced by 20% losses to go from DC to AC),

O&M = Operation and Maintenance ($/kWh),

i = interest rate,

n = system lifetime (i.e., how many years to amortize cost of system over).

Assumptions are: O&M=$0.001/kWh, i=7%, n=30 (no tax credits and no accelerated depreciation); for these, CRF = 0.081.

For comparison, the LEC for an Advanced Combined Cycle Plant is currently 5.6 ¢/kWh at a capacity factor of 50% and 7.6 ¢/kWh at a capacity factor of 25%, under the following assumptions: Plant size = 400 MWe, Heat Rate = 6422 Btu/kWh, Capital Cost = $599/kWe, Fixed O&M = $10.34/kWyr, Variable O&M = 2.07 mil/kWh, Burner Tip Gas Price = $5/MMBtu, 20 year IRR @ 12%, 15 year Dept @ 6%.

FSLR Sets Module Efficiency Record

Zacks Equity Research | Zacks – Tue, Jan 17, 2012 2:30 PM EST

- First Solar Inc. (Nasdaq:FSLR - News) announced it set a new world record for cadmium-telluride (CdTe) photovoltaic (PV) solar module efficiency, achieving 14.4% total area efficiency. The U.S. Department of Energy's National Renewable Energy Lab (NREL) confirmed the record, which eclipsed the prior record of 13.4%, which was also set by First Solar.

- Earlier, in December 2011, First Solar updated its long-term module efficiency goal of 14.5%–15.0% average efficiency for its modules by the end of 2015. The average efficiency of First Solar modules increased from 11.4% in 2010 to 11.7% in 2011 and is expected to reach 12.7% in the fourth quarter of 2012.

Helping Solar Help Us....

Compendium of Best Practices

SHARING LOCAL AND STATE SUCCESSES IN ENERGY EFFICIENCY AND RENEWABLE ENERGY FROM THE UNITED STATES

Lead Authors and Researchers:
Maria Ellingson (Alliance to Save Energy)
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APRIL 2010

A COLLABORATIVE REPORT BY:

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