

MEGA
JOULE

Megajoule.org:

**A resource for finding, comparing,
sharing, and reviewing energy estimates**

Max Henrion
& Evan Sherwin

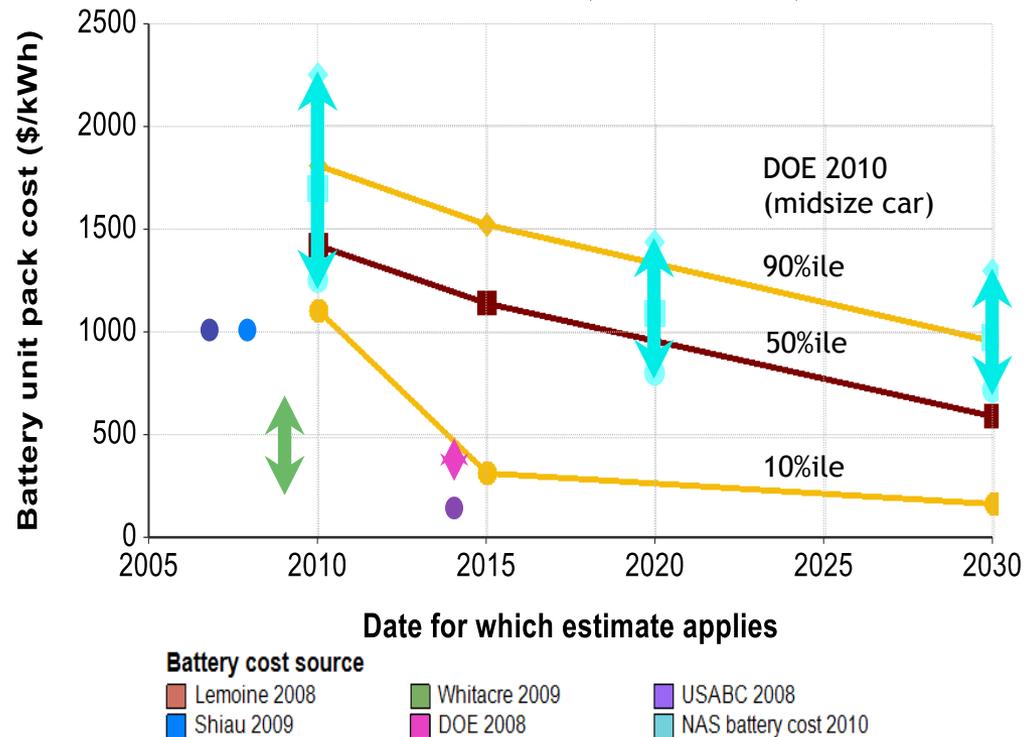


Energy Modeling Forum, Snowmass, July 2012

Why MegaJoule.org?

- There are lots of energy analysts (like us) who spend a lot of time trying to find (or create) credible estimates and projections of the current and future cost and performance of energy technologies.
- Is there a way we could better share and build on each other's work?

Projected costs of Lithium-Ion batteries (\$/KWh)



MegaJoule.org

A wiki for sharing and comparing energy numbers

- An online resource for energy analysts to find, share, and critique estimates, especially of the current and future performance, cost, and GHG emissions of energy technologies.
- Anyone can search, review, download, rate, and comment on estimates.
- Each estimate includes who entered it, assumptions, citations to external sources, dates, and uncertainty, comments, and ratings of quality.

How MegaJoule is *not* like Wikipedia

- **Focus on numbers:** Primary contributions are quantitative estimates of current and future quantities, with supporting assumptions, uncertainty, sources and comments.
- **No anonymity:** Because contributors should take responsibilities for their contributions.
- **You can't edit or delete others' contributions:** But you can rate, comment, and critique them - and add your own estimates.
- **Difference of opinion is OK:** Unlike wikipedia's *Neutral Point of View* (NPOV), it encourages cutting-edge research and multiple differing estimates. Not restricted to what is "generally accepted".
- **Explicit uncertainty:** It encourages explicit statement of uncertainty for all estimates, as standard error, range, or P10, P50, P90 percentiles.

Existing online resources for energy information

- **Wikipedia**
- **Energy Information Administration (EIA):** Annual Energy Outlook (AEO) and other energy data and forecasts.
- **The International Energy Agency (IEA)** (www.iea.org): Global data and forecasts. (Not free.)
- **Open Energy Info** (www.openei.org): DoE/NREL
- **GREET:** Michael Wang (ANL) estimates of automobile fuel efficiency and lifecycle GHG emissions.
- **EBAMM:** The ERG Biofuel Analysis Meta-Model. Focus on comparing numbers for net energy and GHG emission for ethanol from corn.

Structuring the information:

Record types in knowledge representation

- **Estimates**

- E.g. Energy Storage Cost of Li-Ion battery in 2020 is projected as \$1250/kwh in 2030 by NAS EV Study, 2009

- **Technologies**

- **Energy Conversion Technologies**

- E.g. Photovoltaics, Li-Ion batteries, vehicles

- **Forms of Energy:**

- E.g. Coal, oil, gas, biomass, electricity, hydrogen

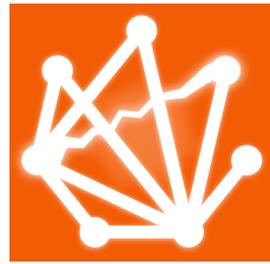
- **Metrics**

- E.g. Cost per power (\$/KW)
Energy storage cost of battery (\$/kwh)

- **Sources**, e.g. NAS EV, 2009, NREL, 2012,

- **Also: Units, Ratings, Comments, Contributors.**

A live demo



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Estimates

Status: More than 100 record(s) found (Search: all Estimates). Click [here](#) to count records.

Page: [First] Next Last Go to page [] Go

Views [] Search []

Search: -TEXT- contains GO

Show All Refine String Context Active Only More Options Saved Search

<input type="checkbox"/>	View Source	Technology	Application	Metric	SI Value	SI Unit	Value Type	Year Applies	Other Assumptions
<input type="checkbox"/>	Baker 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.13	\$/kWh	Estimate	2030	R&D Funding Level = Mid
<input type="checkbox"/>	Baker 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.16	\$/kWh	Estimate	2030	R&D Funding Level = Low
<input type="checkbox"/>	Bosetti 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.08	\$/kWh	Estimate	2030	R&D Funding Level = High
<input type="checkbox"/>	Bosetti 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.1	\$/kWh	Estimate	2030	R&D Funding Level = Mid
<input type="checkbox"/>	Bosetti 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.11	\$/kWh	Estimate	2030	R&D Funding Level = Low
<input type="checkbox"/>	Anadon 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.14	\$/kWh	Estimate	2030	R&D Funding Level = High
<input type="checkbox"/>	Anadon 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.14	\$/kWh	Estimate	2030	R&D Funding Level = Mid
<input type="checkbox"/>	Anadon 2012	Photovoltaic	Utility	Levelized Cost of Electricity	0.16	\$/kWh	Estimate	2030	R&D Funding Level = Low
<input type="checkbox"/>	World Bank 2008 Grid Supply India	Combined Cycle Gas Turbine		System Lifetime	40	y	Estimate	2008	Includes plant renovation and end of life
<input type="checkbox"/>	World Bank 2008 Grid Supply India	Generic Nuclear		System Lifetime	40	y	Estimate	2008	Includes plant renovation and end of life
<input type="checkbox"/>	World Bank 2008 Grid Supply India	Large Hydroelectric		System Lifetime	85	y	Estimate	2008	Includes plant renovation and end of life
<input type="checkbox"/>	AutogasForAmerica 2011	Light-Duty Vehicle: Honda Civic	CNG	Incremental Cost	6,935	\$	Estimate	2012	Baseline: Gasoline. Honda GX, Capital Cost = \$26.050

Example search results for estimates of Photovoltaics: metric = levelized cost of energy)



Estimates Search [Sign In](#)

[Intro](#) [Estimates](#) [Sources](#) [Technologies](#) [Metrics](#) [Graphing](#) [Sign Up](#)

Estimates

Status: 42 record(s) found, 1 pages (Search: Metric~='levelized cost'). Click [here](#) to re-count records.

Views

Search: contains

[Show All](#) Refine String Context Active Only [More Options](#) [Saved Search](#)

<input type="checkbox"/>	View Source	Technology	Application(s)	Metric	SI Value	SI Unit	Value Type	Year Applies	Other Assumptions
<input type="checkbox"/>	Sunshot 2011	Photovoltaic	Commercial	Levelized Cost of Electricity	0.08	\$/kWh	Target	2020	Government target. Original Value = 1.25 \$/Wp
<input type="checkbox"/>	Sunshot 2011	Photovoltaic	Residential	Levelized Cost of Electricity	0.09	\$/kWh	Target	2020	Government target. Original Value = 1.50 \$/Wp
<input type="checkbox"/>	Sunshot 2011	Photovoltaic	Fixed-Axis Utility	Levelized Cost of Electricity	0.06	\$/kWh	Target	2020	Government target. Original Value = 1.00 \$/Wp
<input type="checkbox"/>	Sunshot 2011	Photovoltaic	One-Axis Utility	Levelized Cost of Electricity	0.07	\$/kWh	Target	2020	Government target. Original Value = 1.2 \$/Wp
<input type="checkbox"/>	CAPUC 2011 RPS Q4	Photovoltaic	Grid-Connected	Levelized Cost of Electricity	0.12	\$/kWh	Estimate	2011	Original Value = 0.1246 \$/kWh. Capacity = 0-200+ MW
<input type="checkbox"/>	CAPUC 2011 RPS Q4	Photovoltaic	Grid-Connected	Levelized Cost of Electricity	0.12	\$/kWh	Estimate	2011	Original Value = 0.124 \$/kWh. Capacity = 3-20 MW
<input type="checkbox"/>	CAPUC 2011 RPS Q4	Photovoltaic	Grid-Connected	Levelized Cost of Electricity	0.14	\$/kWh	Estimate	2011	Original Value = 0.1421 \$/kWh. Capacity = 0-3 MW
<input type="checkbox"/>	zecco.com 2012	Photovoltaic	Grid-Connected	Levelized Cost of Electricity	0.12	\$/kWh	Target	2015	Original Value = 13000 \$/Wp
<input type="checkbox"/>	zecco.com 2012	Photovoltaic: Module		Levelized Cost of Electricity	0.07	\$/kWh	Target	2015	Original Value = 7000 yuan/kW
<input type="checkbox"/>	pvinsights.com 2012	Photovoltaic	Grid-Connected	Levelized Cost of Electricity	0.24	\$/kWh	Estimate	2012	High value. Original Value = 3.90 \$/Wp

Powered by EnterpriseWizard

Estimate record

Estimate

Capital Cost per Power of Photovoltaic (Fixed-Axis,Utility) in 2010 = 3800.0 \$/kW * Source: [NREL 2012 PV](#)

Details | Source and Contributor | Ratings and Comments | Tags | History

Close

Technology Details

* Is Form of Energy?: No * Selection Method Choose by Classes

* Class: Electricity Generation Subclass: Solar Photovoltaic

* Technology: Photovoltaic Application: [Fixed-Axis](#), [Utility](#)

* Metric: Capital Cost per Power

Estimate Information

* Value: 3,800 * Units: [\\$/kW](#)

* Form of Uncertainty: Mean, Standard Deviation U1: 352

Value Type: Estimate

Context

Year Published: 2012 * Year Applies 2010 Region: USA

Capacity: Page Number(s): Expert(s):

List of Assumptions: [World Bank PV](#)

Other Assumptions: Original Value = 3.80 \$/Wp

ID: 3773

Close

Source record: NREL 2012

 Source 

* Citation: NREL 2012 PV Contributor: [Evan Sherwin](#) Date Created: Mar 19 2012 16:55

Details Abstract and References Contributor Evaluation Estimates Ratings and Comments History

Close

* Title: Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities * Source Type: Report

Author(s): Alan Goodrich, Ted James, and Michael Woodhouse Editor(s):

* Publication Year: 2012 Month Published:

Page Numbers:

URL: www.nrel.gov/docs/fy12osti/53347.pdf

Full Document [PV System Prices and Cost Reduction Opps NREL Feb 2012.pdf](#) Date Accessed:

Publisher

Choose the Publisher: Existing Organization

* Source Organization: [NREL](#) * Organization Type: [Research Institute](#)

* State or Province: [Colorado](#) * Country: [USA](#)

Assumptions

List of Assumptions:

Other Assumptions:

Tags: ID: 130

Close

Source record showing estimates: NREL, 2012

Source

* Citation: NREL 2012 PV Contributor: [Evan Sherwin](#) Date Created: Mar 19 2012 16:55

Details Abstract and References Contributor Evaluation **Estimates** Ratings and Comments History

[Close](#)

Estimates:
Status: 16 record(s) found, 1 pages. Click [here](#) to re-count records

Views Search

<input type="checkbox"/>	View Source	Technology	Application	Metric	SI Value	SI Unit	Value Type	Year Applies	Other Assumptions
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: One-Axis	Capital Cost per Power	1.91	\$/W	Projection	2020	Original Value = 1.91 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: One-Axis	Capital Cost per Power	4.4	\$/W	Estimate	2010	Original Value = 4.4 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: Fixed-Axis	Capital Cost per Power	1.71	\$/W	Projection	2020	Original Value = 1.71 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: Fixed-Axis	Capital Cost per Power	3.8	\$/W	Estimate	2010	Original Value = 3.80 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Commercial	Capital Cost per Power	1.99	\$/W	Projection	2020	Original Value = 1.99 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Commercial	Capital Cost per Power	4.59	\$/W	Estimate	2010	Original Value = 4.59 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Residential	Capital Cost per Power	2.29	\$/W	Projection	2020	Original Value = 2.29 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Residential	Capital Cost per Power	5.7	\$/W	Estimate	2010	Original Value = 5.70 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: One-Axis	Levelized Cost of Electricity	0.12	\$/kWh	Projection	2020	Original Value = 1.91 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: One-Axis	Levelized Cost of Electricity	0.27	\$/kWh	Estimate	2010	Original Value = 4.4 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Utility: Fixed-Axis	Levelized Cost of Electricity	0.1	\$/kWh	Projection	2020	Original Value = 1.71 \$/Wp
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<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Commercial	Levelized Cost of Electricity	0.12	\$/kWh	Projection	2020	Original Value = 1.99 \$/Wp
<input type="checkbox"/>	NREL 2012 PV	Photovoltaic	Commercial	Levelized Cost of Electricity	0.28	\$/kWh	Estimate	2010	Original Value = 4.59 \$/Wp

Technology record: Photovoltaic



Technology



Full Name: Photovoltaic

Created By: [Evan Sherwin](#)

Date Created: Mar 16 2012 17:23

Details | Estimates | Characterizing Features | Ratings and Comments | History

Close

Classification

* Is Form of Energy?: No * Class: Electricity Generation
* SubClass: Solar Photovoltaic * Name: Photovoltaic

Descriptions

Energy Input: Sunlight Energy Output: Electricity Coproduct:

Description: Generic photovoltaic. The materials and applications are unspecified.

Informational Link:

Tags: ID: 150

Close

Metric record: Levelized cost of electricity

 **Metric**

* Name: Levelized Cost of Electricity Created By: [Evan Sherwin](#) Date Created: Mar 22 2012 22:09

Details | Ratings and Comments | History

Close

Metric Information

* Kind of Unit: Cost per Energy
Standard US Unit: [\\$/kWh](#)

Metric Description

Description: The cost of electricity produces by an electricity generation technology. This cost amortizes capital costs over the lifetime of the plant.
Informational Link: http://en.wikipedia.org/wiki/Levelized_energy_cost

Classes Applicable

* Is Form of Energy? No
Class: Electricity Genera

Unit record:
\$/KWh

 **Unit** 

* Unit Long Form: USD per kilowatt-hour of electricity

Unit | History

Close

* Unit Abbreviation:	\$/kWh	* Kind of Unit:	Cost per Energy
* Unit Type:	Derived	* Base Unit:	\$/GJ
Standard Unit For:	US, SI	1 Unit/1 Base Unit:	277.777778
Description:			
ID:	22		

Close

Graphing tab



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Estimates Search

[Sign In](#)

- Intro
- Estimates
- Sources
- Technologies
- Metrics
- Graphing
- Sign Up

[CLOSE MODEL](#)



Megajoule Graphing

Class: **Electricity Generation**
 SubClass: **Solar Photovoltaic**
 Technology: **Photovoltaic**
 Metric: **Levelized Cost of Electricity**
 Min Year: **2009** Max Year: **2035**
 Applications to Display:
 Sources to Display:
 Estimates to Display:
 Number of Estimates: 27
 Bar Chart - Sorting:
 Bar Chart - Levelized Cost of Electricit... (\$/kWh):
 Graph - Levelized Cost of Electricity: ... (\$/kWh):
 Scatter Plot - Levelized Cost of Electri... (\$/kWh):

Estimates to Display

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3717	<input checked="" type="checkbox"/>	'WEO 2010 Assumptions'	'0.13'	'\$/kWh'	'2020'	'Levelized Cost of Electricity'	'Photovoltaic'
3718	<input checked="" type="checkbox"/>	'WEO 2010 Assumptions'	'0.08'	'\$/kWh'	'2035'	'Levelized Cost of Electricity'	'Photovoltaic'
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3729	<input checked="" type="checkbox"/>	'NREL 2012 PV'	'0.28'	'\$/kWh'	'2010'	'Levelized Cost of Electricity'	'Photovoltaic'
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3731	<input checked="" type="checkbox"/>	'NREL 2012 PV'	'0.23'	'\$/kWh'	'2010'	'Levelized Cost of Electricity'	'Photovoltaic'
3732	<input checked="" type="checkbox"/>	'NREL 2012 PV'	'0.1'	'\$/kWh'	'2020'	'Levelized Cost of Electricity'	'Photovoltaic'
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4053	<input checked="" type="checkbox"/>	'Anadon 2012'	'0.142'	'\$/kWh'	'2030'	'Levelized Cost of Electricity'	'Photovoltaic'
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Bar chart of selected estimates



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Estimates

Search

Sign In

Intro

Estimates

Sources

Technologies

Metrics

Graphing

Sign Up

CLOSE MODEL



Megajoule Graphing

Class: Electricity Generation

SubClass: Solar Photovoltaic

Technology: Photovoltaic

Metric: Levelized Cost of Electricity

Min Year: 2009 Max Year: 2035

Applications to Display:

Sources to Display:

Estimates to Display:

Number of Estimates: 27

Bar Chart - Sorting:

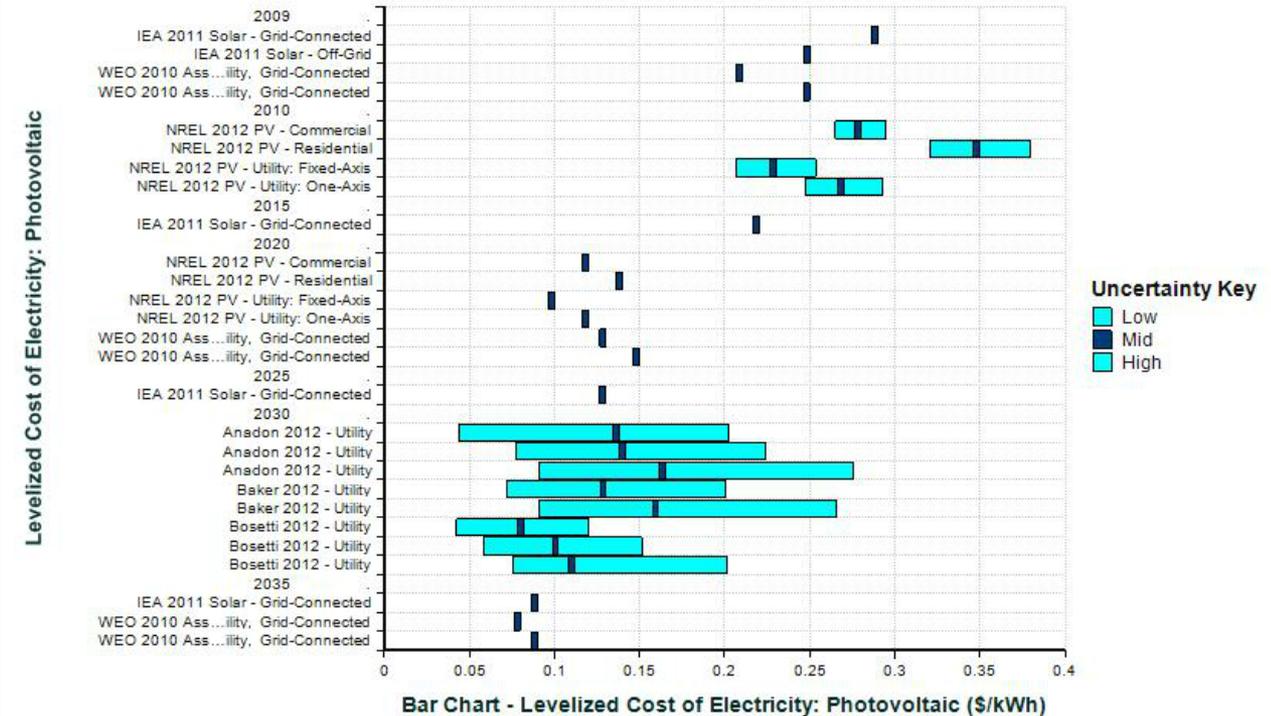
Bar Chart - Levelized Cost of Electricit... (\$/kWh):

Graph - Levelized Cost of Electricity: ... (\$/kWh):

Scatter Plot - Levelized Cost of Electri... (\$/kWh):

Refresh records

Bar Chart - Levelized Cost of Electricity: Photovoltaic (\$/kWh)



Graph of estimates over time



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Estimates Search

Intro Estimates Sources Technologies Metrics Graphing Sign Up

CLOSE MODEL



Megajoule Graphing

Class: Electricity Generation

SubClass: Solar Photovoltaic

Technology: Photovoltaic

Metric: Levelized Cost of Electricity

Min Year: 2009 Max Year: 2035

Applications to Display:

Sources to Display:

Estimates to Display:

Number of Estimates: 27

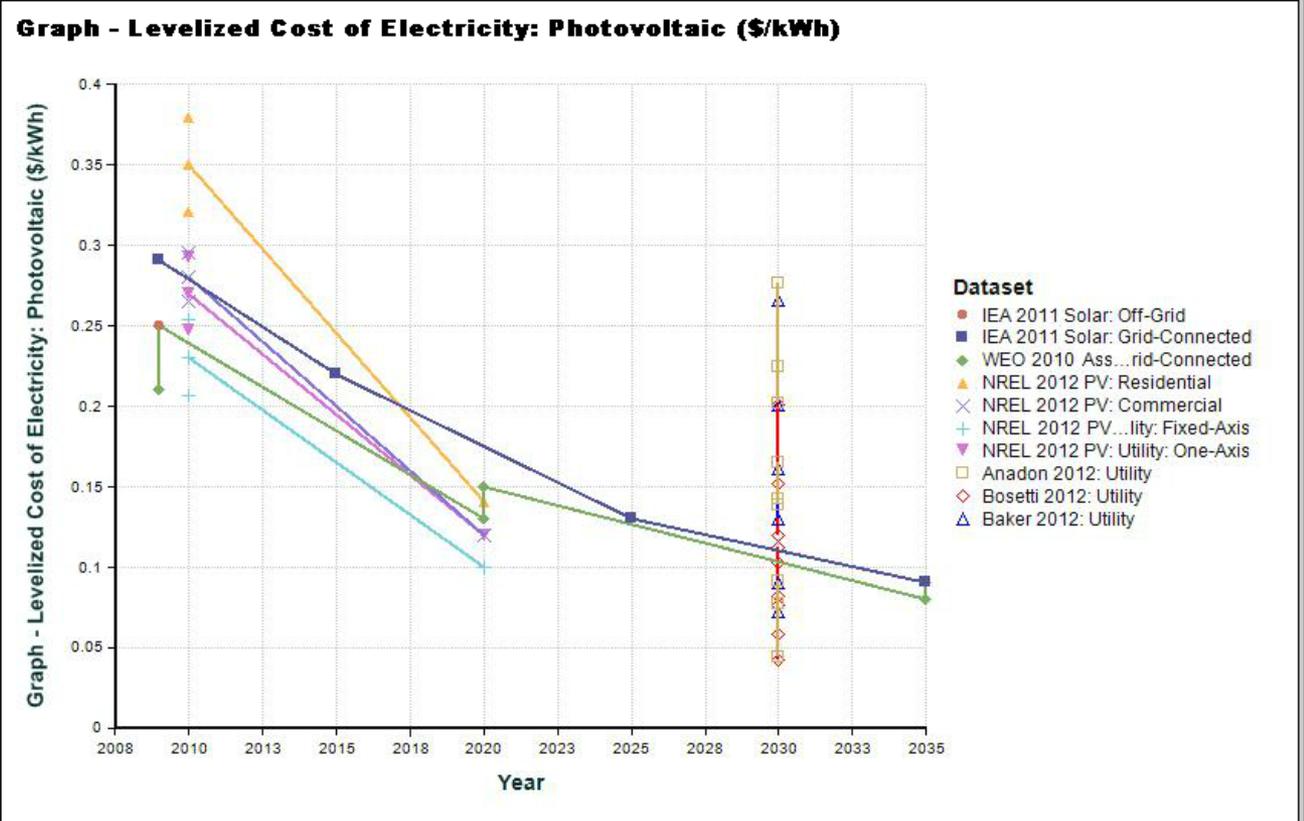
Bar Chart - Sorting:

Bar Chart - Levelized Cost of Electricit... (\$/kWh):

Graph - Levelized Cost of Electricity: ... (\$/kWh):

Scatter Plot - Levelized Cost of Electri... (\$/kWh):

Refresh records



Plot of selected estimates over time



BETA

Estimates

Search

[Sign In](#)

Intro

Estimates

Sources

Technologies

Metrics

Graphing

Sign Up

[CLOSE MODEL](#)



Megajoule Graphing

Class: Electricity Generation

SubClass: Solar Photovoltaic

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Min Year: 2009 Max Year: 2035

Applications to Display:

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Estimates to Display:

Number of Estimates: 27

Bar Chart - Sorting:

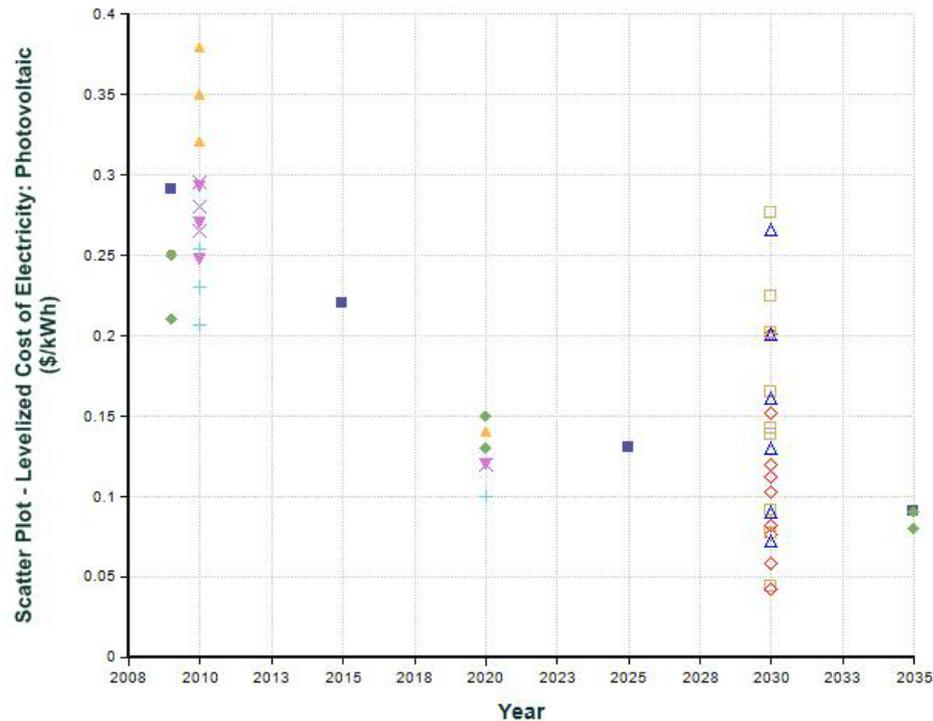
Bar Chart - Levelized Cost of Electricit... (\$/kWh):

Graph - Levelized Cost of Electricity: ... (\$/kWh):

Scatter Plot - Levelized Cost of Electri... (\$/kWh):

Refresh records

Scatter Plot - Levelized Cost of Electricity: Photovoltaic (\$/kWh)



Bar chart of capital cost per energy for Lithium Ion batteries



MEGAJOULE

BETA

Estimates

Search

Sign In

Intro

Estimates

Sources

Technologies

Metrics

Graphing

Sign Up

CLOSE MODEL



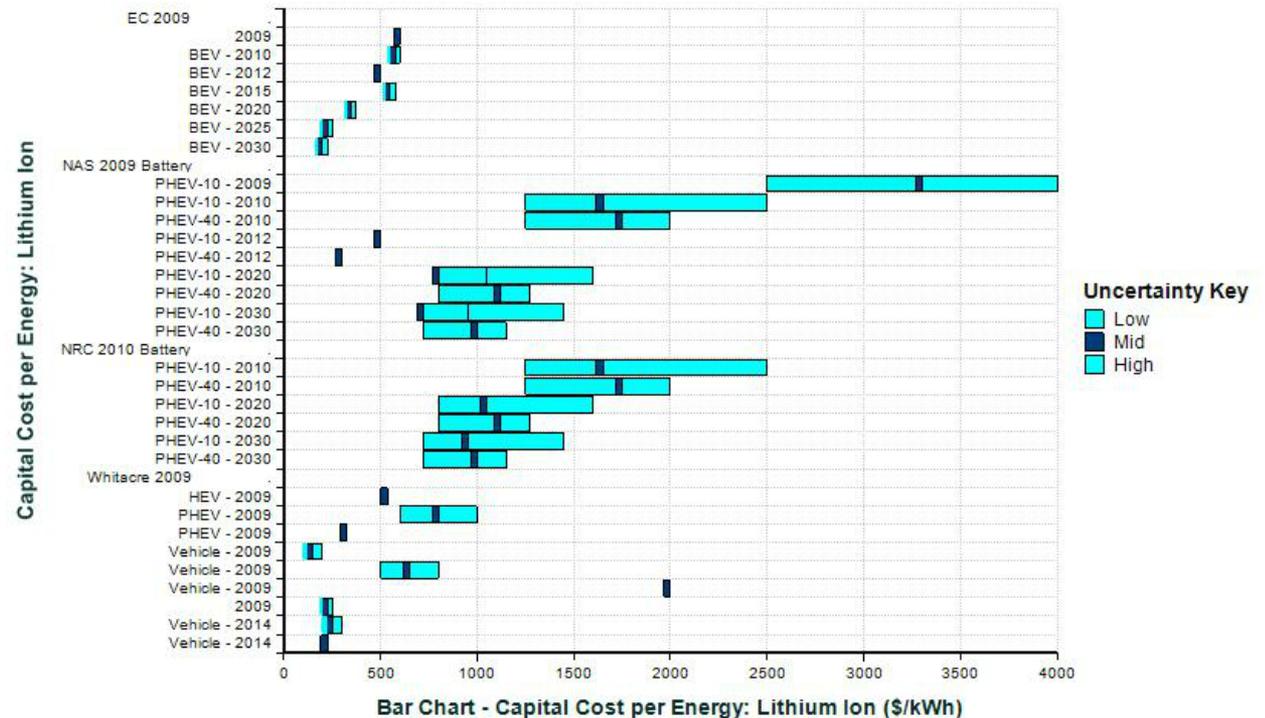
Megajoule Graphing

Class: Energy Storage
 SubClass: Battery
 Technology: Lithium Ion
 Metric: Capital Cost per Energy
 Min Year: 2009 Max Year: 2030

Applications to Display:
 Sources to Display:
 Estimates to Display:
 Number of Estimates: 31
 Bar Chart - Sorting:
 Bar Chart - Capital Cost per Energy: L... (\$/kWh):
 Graph - Capital Cost per Energy: Lithi... (\$/kWh):
 Scatter Plot - Capital Cost per Energy: ... (\$/kWh):

Refresh records

Bar Chart - Capital Cost per Energy: Lithium Ion (\$/kWh)



Capital cost per energy for Li-Ion battery: Bar chart



MEGAJOULE

BETA

Estimates

Search

Sign In

Intro

Estimates

Sources

Technologies

Metrics

Graphing

Sign Up

CLOSE MODEL



Megajoule Graphing

Class:

SubClass:

Technology:

Metric:

Min Year: Max Year:

Applications to Display:

Sources to Display:

Estimates to Display:

Number of Estimates: 31

Bar Chart - Sorting:

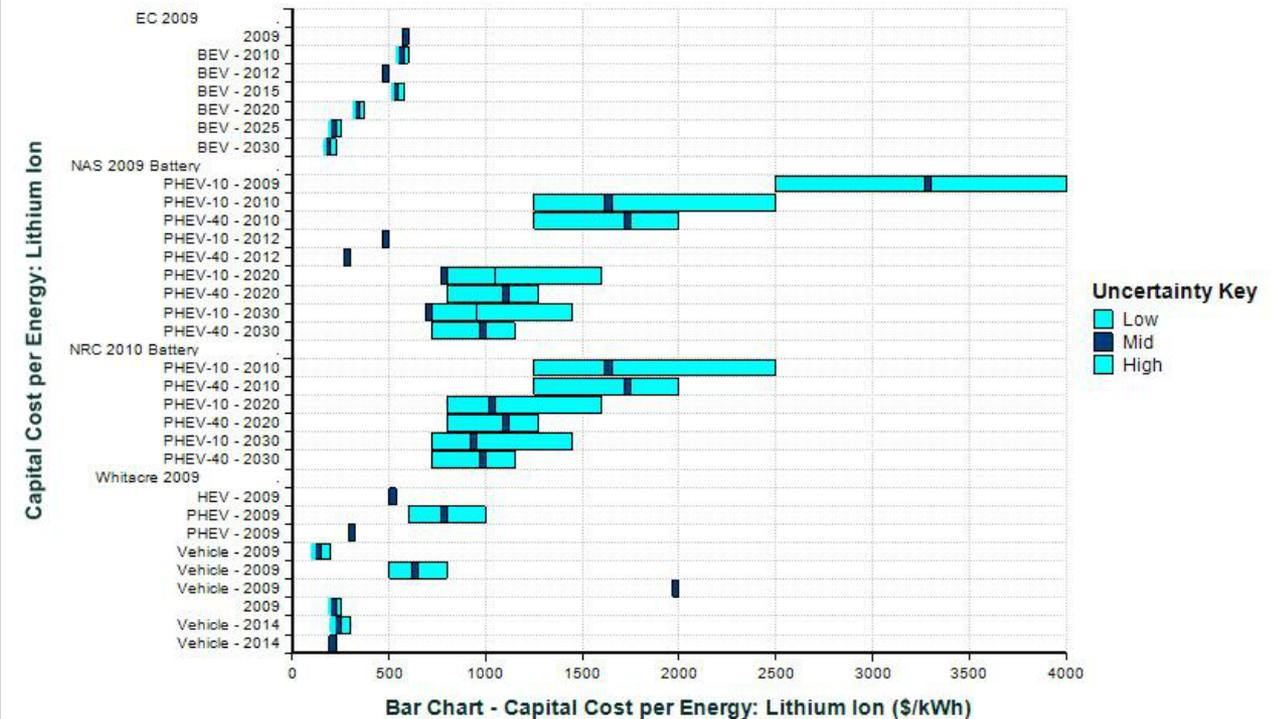
Bar Chart - Capital Cost per Energy: L... (\$/kWh):

Graph - Capital Cost per Energy: Lithi... (\$/kWh):

Scatter Plot - Capital Cost per Energy: ... (\$/kWh):

Refresh records

Bar Chart - Capital Cost per Energy: Lithium Ion (\$/kWh)



Acknowledgments



WHAT IS
MEGAJOULE.ORG?

TOUR

GLOSSARY

RELATED SITES

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GUIDELINES

HOW CAN I HELP?

ACKNOWLEDGEMENTS

DOWNLOAD

INTRODUCTION

Acknowledgements

The Megajoule prototype was made possible with support and seed funding from:



Carnegie Mellon University, Center for Climate Decision Making and the Center Director, Professor Granger Morgan, with funds from the National Science Foundation.



Pacific Northwest National Laboratory, project director Dr Cary Bloyd, with funds from the US Department of Energy, Vehicle Technology Program, Fuel Technologies and its Team Lead, Kevin Stork.



EnterpriseWizard, Inc. and its CEO, Colin Earl, for providing us with their flexible database software on special terms that make it easy for MegaJoule.org to be open and accessible.



Lumina Decision Systems has also supported this work with internal R&D funds.

To sustain the next phase of Megajoule, we are seeking support from a few energy research organizations that will benefit from Megajoule.org. Please contact us if you might be interested. [How can I help?](#)

Next steps for MegaJoule.org

- Prototype is ready for review and testing
 - Search online for relevant estimates
 - Display graphs using the Analytica Cloud Player.
 - Download spreadsheets of selected estimates
 - Sign up as a contributor and add new estimates.
- We are inviting a select group of energy analysts -- including you?
 - To test out the prototype and provide feedback on ease of use and new features
 - To suggest domains for initial content focus
 - To contribute their own estimates, rating, and comments
 - To form a MegaJoule Advisory Group
- Once it is in reasonable shape, we will open it for general release.