IRP Best Practices
Stakeholder Perspectives

Indiana Utility Regulatory Commission

Emerging Issues in IRP

October 17, 2013

Jeremy Fisher, PhD. Principal Associate, Synapse Energy Economics

Synapse Energy Economics

- Analyzes economic and environmental issues in the electric and natural gas industries
- Founded in 1996
- Staff of 30 engineers, scientists, economists and policy experts in Cambridge, MA
- Focuses on electric industry resource planning and ratemaking. Emphasis on environmental compliance costs, role of efficiency and renewables, design and operation of wholesale electricity markets. Experts in computer simulation modeling of long-term demand, supply and prices.
- Provides reports, testimony, litigation and regulatory support
- Clients include energy offices, utility regulators, consumer advocates, environmental organizations and Federal agencies

Structure

IRP Collaboration Experiences

- Other state mechanisms
- Lessons learned

The Stakeholder Perspective of IRP and CPCN

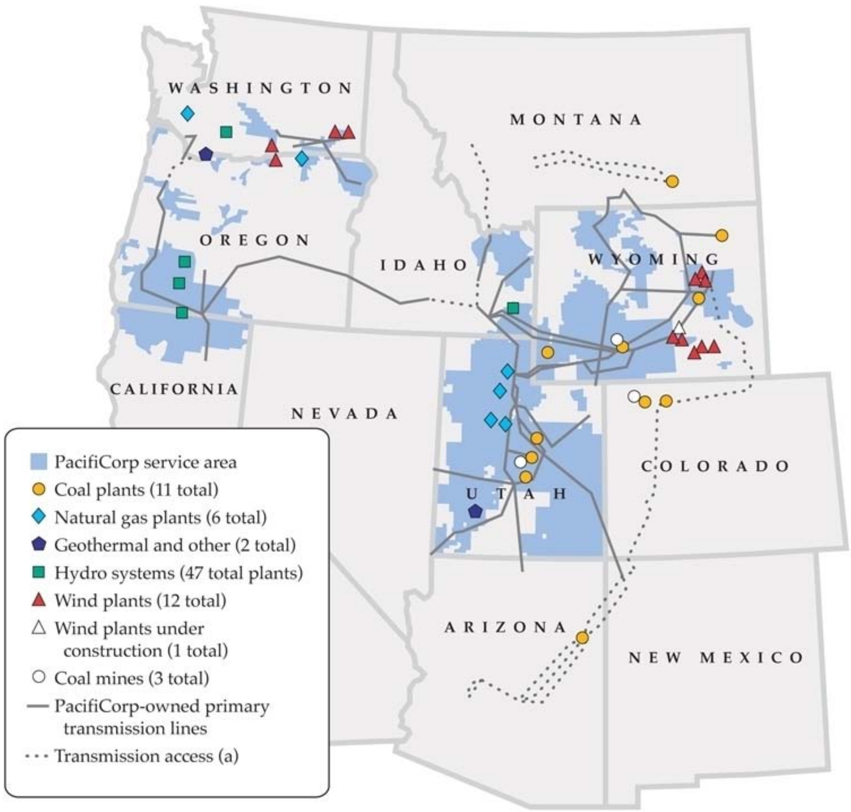
- Purpose of an IRP
- Review of planning assumptions and red flags

Next steps

- Towards a productive collaboration

PacifiCorp (OR, UT, WY, ID, CA, WA)

- Stakeholder process
  - Open to public, staff, consultants
  - Starts one year in advance of triennial IRP, every 3 weeks
  - Meeting content driven by agenda and stakeholder interests
- Responsiveness
  - Comments on meetings summarized and distributed
  - Post-publication formal comment / reply comment
  - Formal oversight in Oregon only
- Docketed proceeding in Oregon with discovery

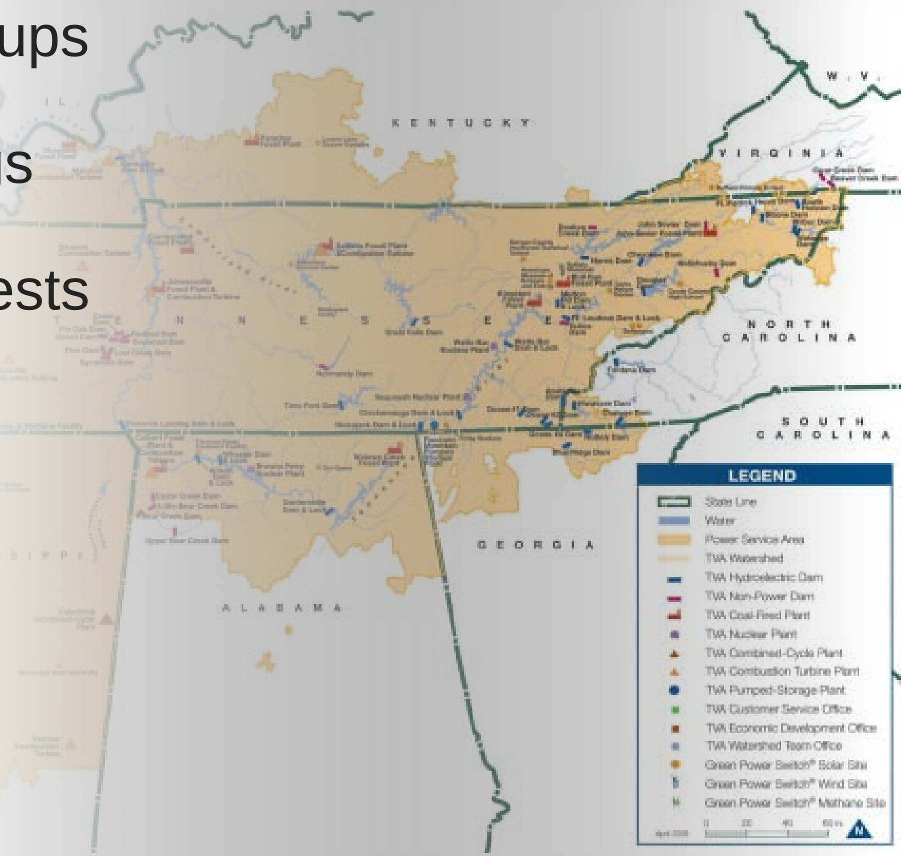


Hawaii Electric Company (HECO)

- Stakeholder process
  - Commission assigns independent evaluator
  - Open to public, staff, consultants
  - Starts one year in advance of triennial IRP, monthly
  - Evaluator presents recommendation to Commission
- Responsiveness
  - Comments and replies posted to evaluator’s website
  - Evaluator keeps Company appraised of current status
  - Formal oversight through evaluator
- Discovery through evaluator

Tennessee Valley Authority (TVA)

- Stakeholder process
  - TVA-selected stakeholder groups
  - Starts one year in advance of triennial IRP, monthly meetings
  - Meeting content driven by agenda and stakeholder interests
- Responsiveness
  - Meeting minutes summarized and distributed
  - No formal reply process
  - No formal oversight
- No discovery process
  - FOIAs processed after 6+ months

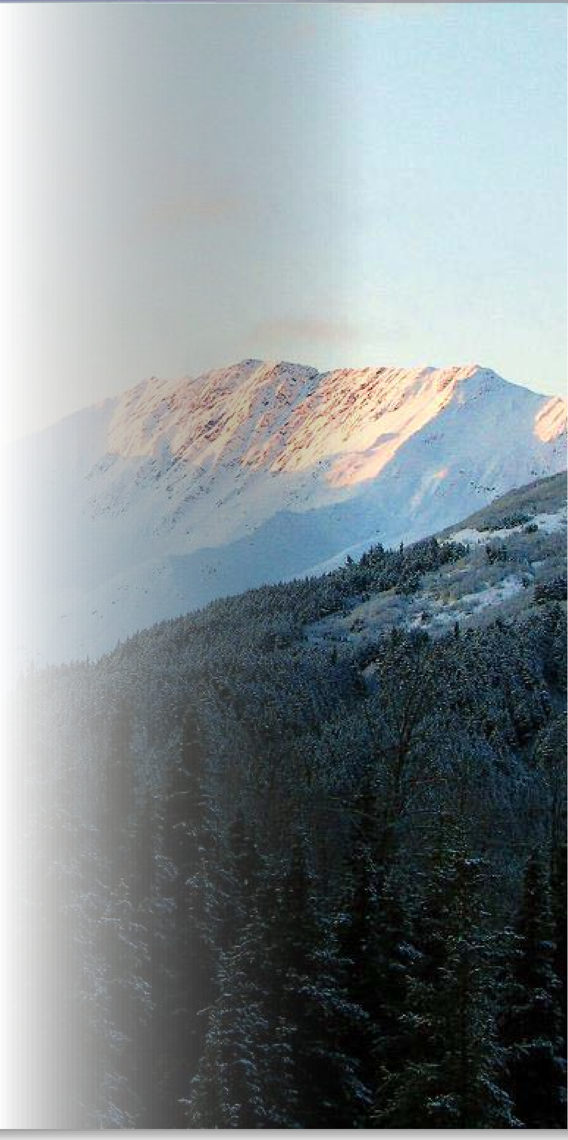


Nebraska Public Power District (NPPD)

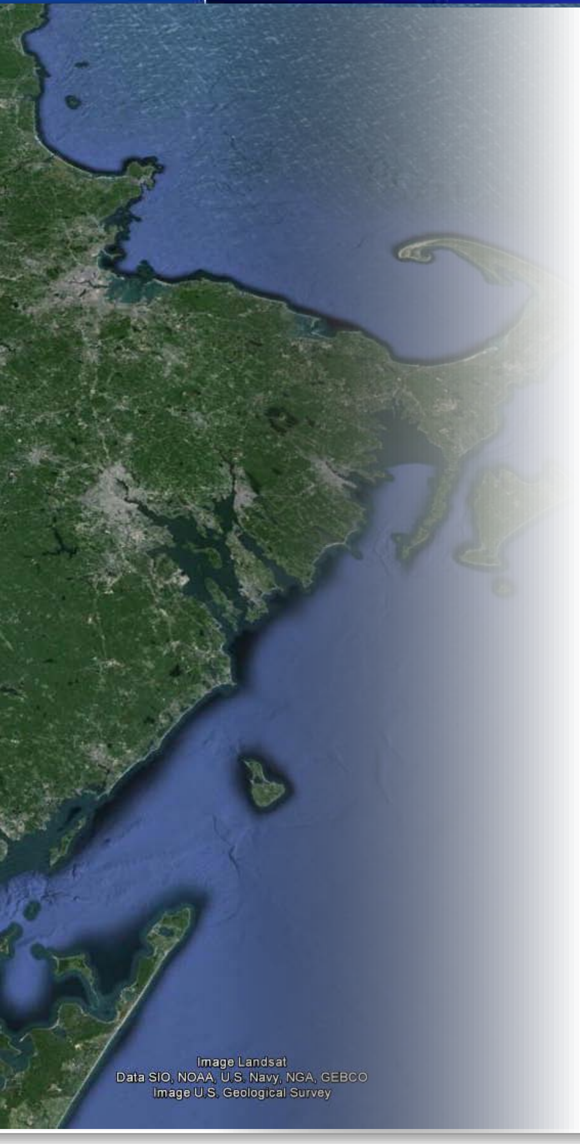
- Stakeholder process
  - No formal process, no oversight
  - Interaction with Company starts after IRP submission
- Responsiveness
  - Company reviews comments, submits off-year IRP update responsive to comments
  - Comments on IRP update incorporated into next IRP, iterative but post-hoc
- Company offered some confidential information via NDAs

Alaska Regional IRP

- Unique circumstance: state mandated & sponsored (AK Energy Authority)
  - To promote cooperation between linked coops
  - Recommendations only, no mandate
  - Guides AK state spending on infrastructure
- Stakeholder process
  - Open to utilities, public, agencies, & consultants
  - Ran for 5 months by B&V
  - Meetings every two weeks
  - Generally used public data only
  - Agenda driven through stakeholders
- Responsiveness
  - B&V responded via comments
- No formal discovery process.
- Little utility buy-in on process or outcome.



Massachusetts, Connecticut, and Rhode Island



- Deregulated
  - No IRP, but EE spending oversight through advisory council
- Stakeholder process
  - Advisory council membership assigned by legislation
  - Technical consultants hired by state to run process and models
  - Program administrators (i.e. utilities) are *ex officio*
  - Stakeholders vote on plan
- Responsiveness
  - Stakeholders run process completely
  - Final recommendations submitted to Commissions
  - Followed by docketed process to process recommendations
- All data and assumptions available to stakeholders

Lessons Learned

Transparency	• IRP requires stakeholder ability to vet assumptions and audit modeling; major input assumptions may not be sufficient
Accountability	• Commission oversight (direct, staff, or evaluator) ensures all parties act in good faith
Responsiveness	• Stakeholder time, effort, and input has no value if there is no response mechanism.
Adaptability	• Outcome is predetermined if assumptions and process are also predetermined

Purpose of an IRP
The Stakeholder Perspective

- Adaptive management
  - Long-term strategy
  - Short-term actions and adjustments

- Information
  - Put all information on the table
  - Put all parties on the same page, no surprises
  - Vet mechanism for making short and long-term decisions

- An IRP is (usually) <u>not</u> a preapproval

Synapse represents various stakeholders in IRP, CPCNs, pre-approvals and other planning cases.

What triggers an in-depth review?

Elements that:

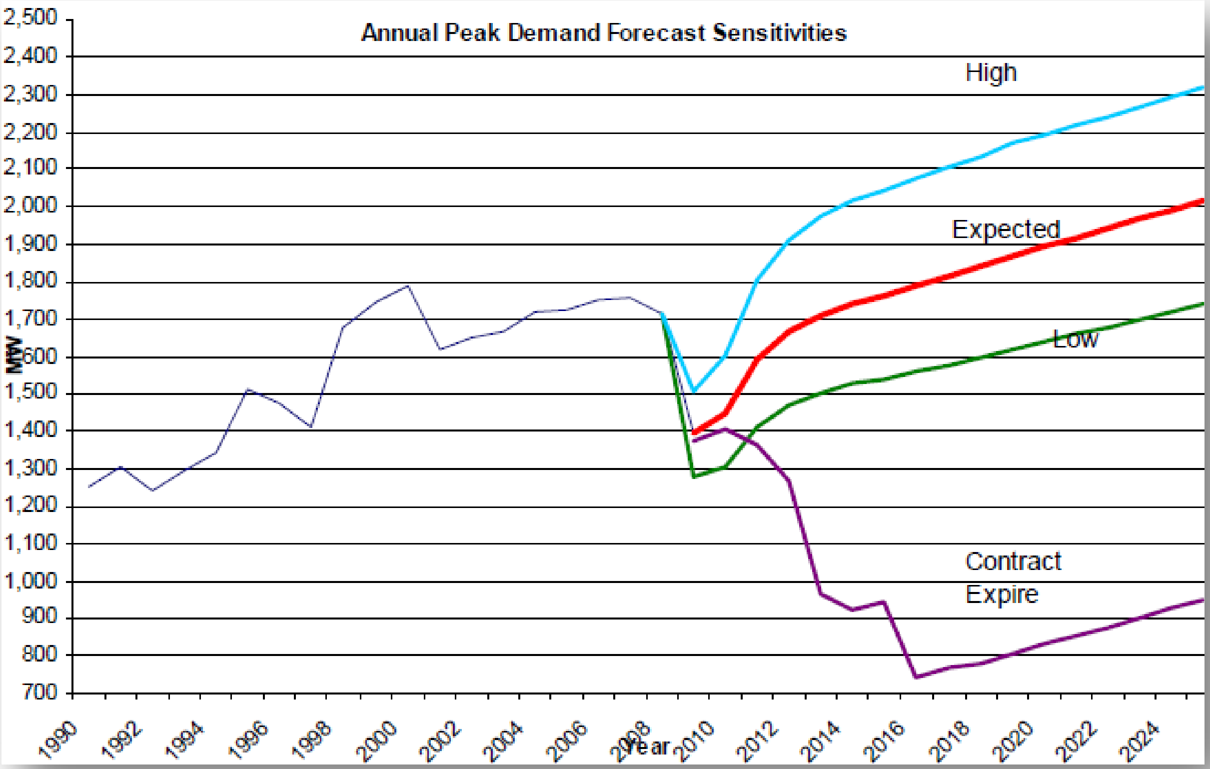
- can affect a planning outcome,
- are complex or non-intuitive, or
- novel.

Load Forecast

How vulnerable is the utility to the departure of a major customer?

Death spiral: Rates go up, major customers depart. Utility has to raise rates to support high fixed costs.

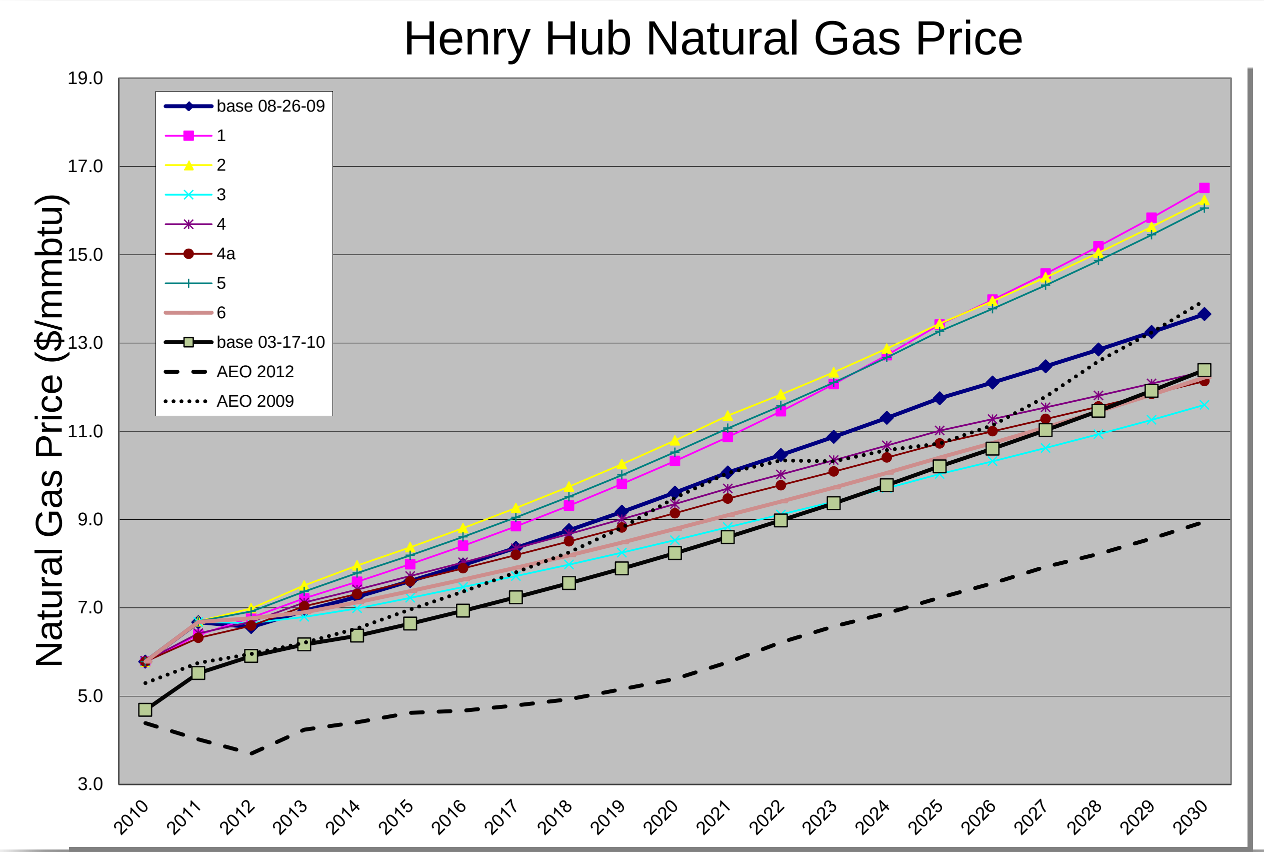
Minnesota Power's 2009 Electric Utility Forecast



Source: Minnesota Power 2009

Commodity Prices

TVA 2012 Internal Planning



Source: TVA 2012

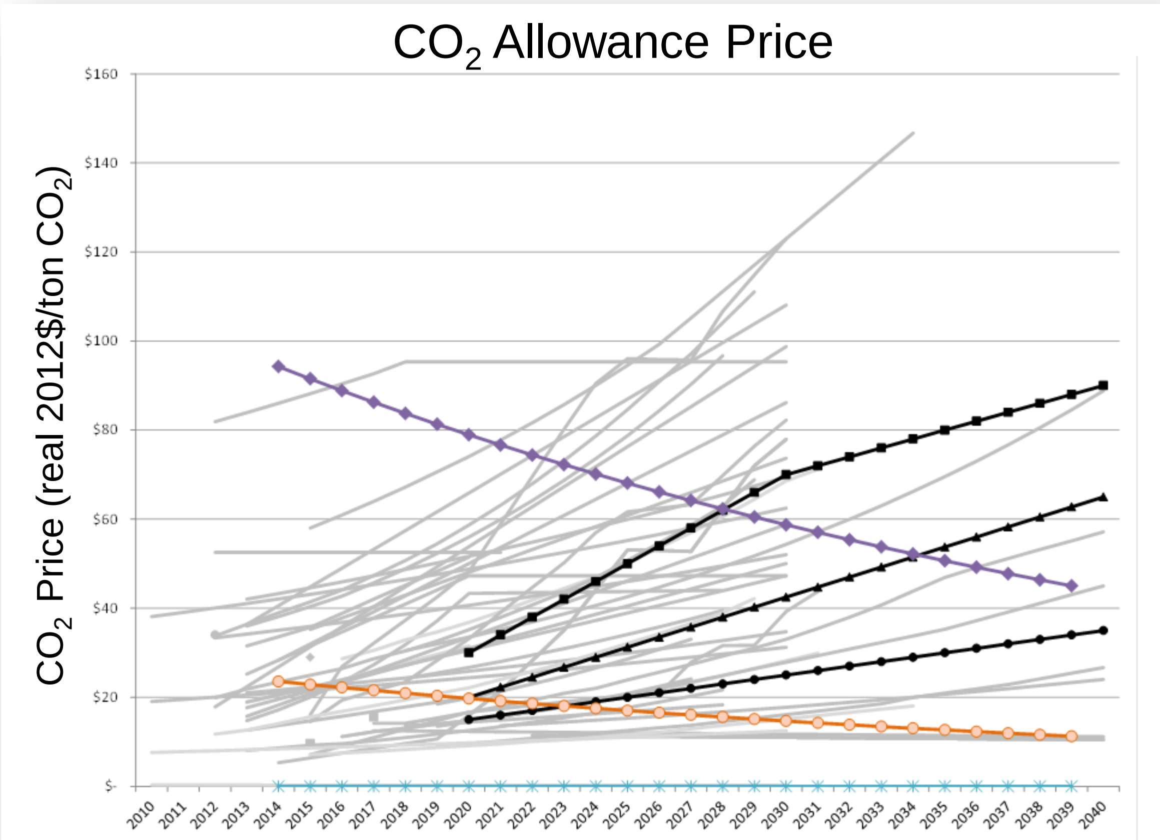
When was the commodity price developed? Is it fresh?

What is the source of the forecast?

How are multiple forecasts considered?

Commodity Prices

Hawaii Electric Company (HECO) 2013 IRP



Source: Hawaii Electric Company, 2013

Review of CO_2 price assumptions are critical.

Does price include "allowances," if so, what assumptions underlie those allowances? Does it rise faster than inflation? Or much, much slower?

Zero is a strong forecast.

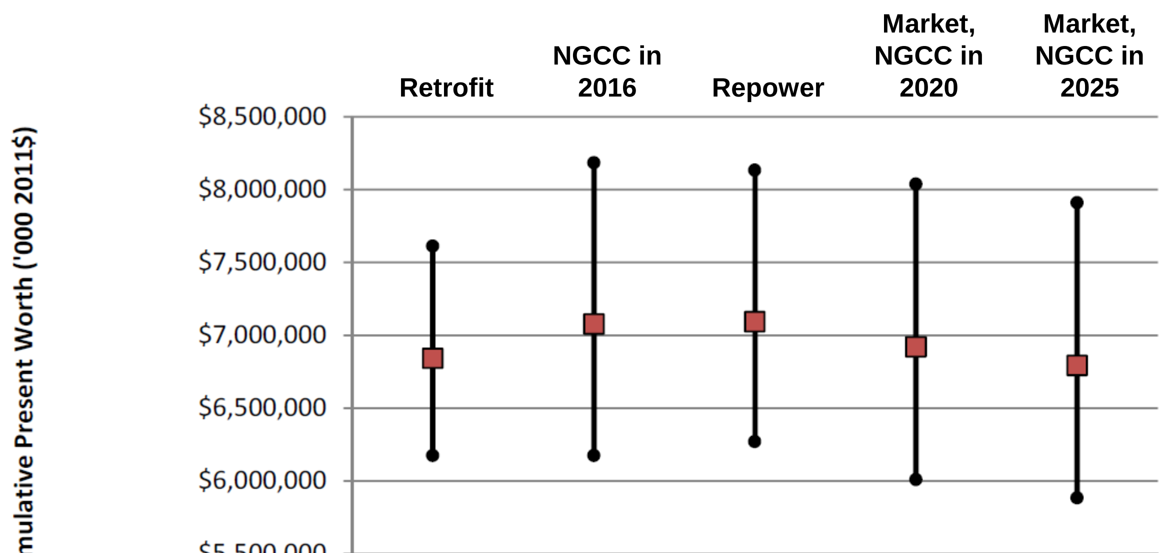
Commodity Price Relationship

"World View" scenarios and stochastic analyses introduce a new form of uncertainty: <u>relationship between variables.</u>

Does analysis outcome depend on this relationship?

What is the basis of that relationship?

KPCo Big Sandy Retrofit Stochastic Analysis



	'BASE' Option #1	Option #2	Option #3	Option #4A	Option #4B
95th % Aurora Risk	7,609,980	8,182,166	8,130,133	8,034,108	7,907,927
Strategist ("Base") Outcome	6,838,879	7,075,297	7,091,182	6,917,767	6,791,587
5th % Aurora Risk	6,171,648	6,172,690	6,268,489	6,008,162	5,881,981

Source: KPCo / AEP (2011)

Commodity Price Relationship

"World View" scenarios and stochastic analyses introduce a new form of uncertainty: <u>relationship between variables.</u>

Does analysis outcome depend on this relationship?

What is the basis of that relationship?

KPCo Big Sandy Retrofit Stochastic Analysis Correlation Variables

Correlations provided by AEP in SCW-1, Table 1-4

	Natural Gas	Coal	Carbon	Power	Demand
Natural Gas	1.00	0.09	(0.23)	0.88	0.66
Coal	0.00	1.00	0.69	0.19	0.74
Carbon	0.00	0.00	1.00	(0.14)	0.50
Power	0.00	0.00	0.00	1.00	0.75
Demand	0.00	0.00	0.00	0.00	1.00

Synapse (for contrast only)

	Natural Gas Price	Coal Price	Carbon Price	Power Price	Demand
Natural Gas Price	1.00	0.11	(0.43)	0.41	(0.15)
Coal Price		1.00	0.67	0.32	0.11
Carbon Price			1.00	(0.43)	0.00
Power Price				1.00	(0.51)
Demand					1.00

Europe	US	Hypothesized

Difference (Company minus Synapse)

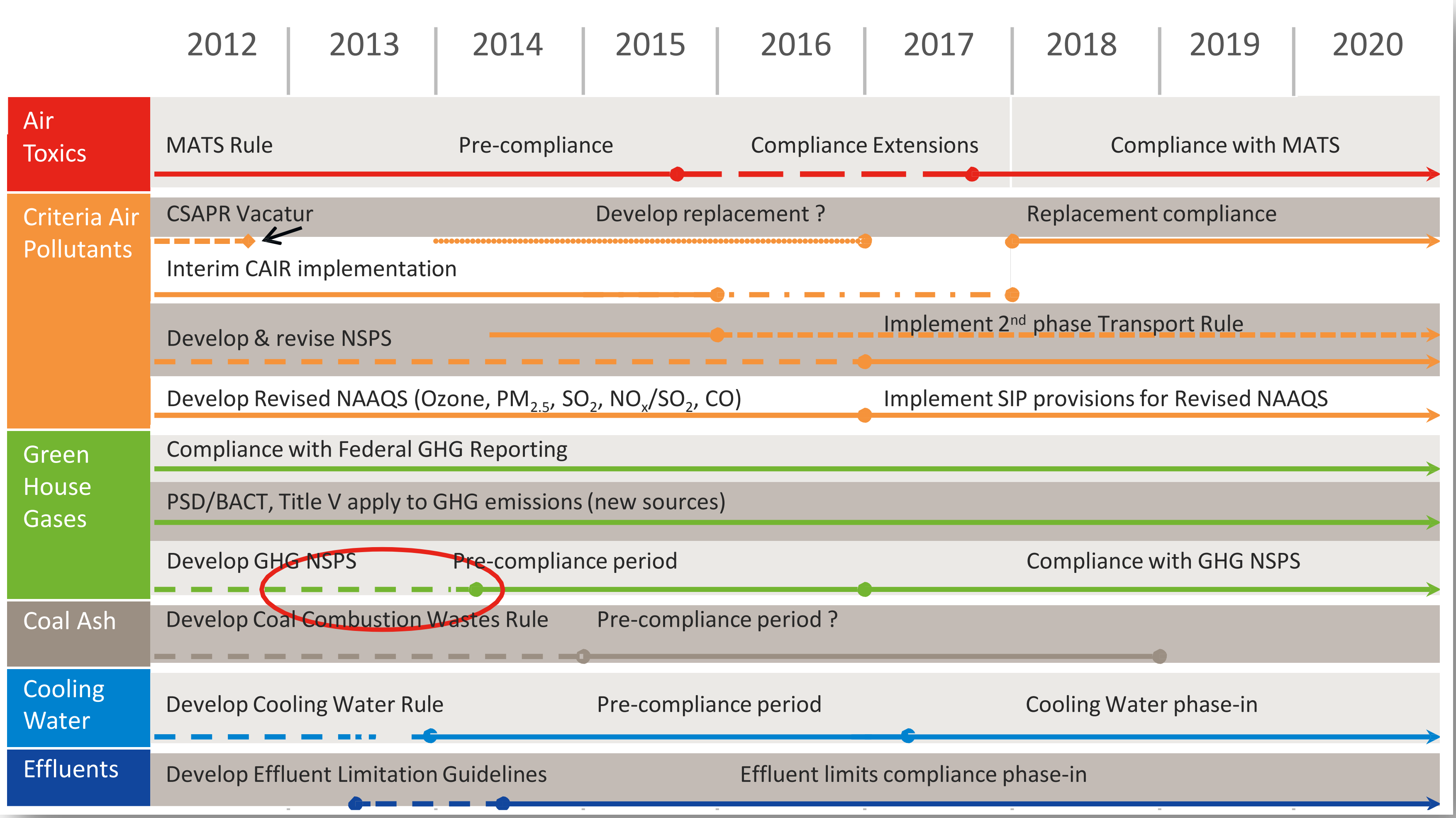
	Natural Gas Price	Coal Price	Carbon Price	Power Price	Demand
Natural Gas Price		-0.03	0.20	0.46	0.81
Coal Price			0.01	(0.14)	0.63
Carbon Price				0.30	0.50
Power Price					1.26
Demand					

Analysis assumed strong relationship between stochastic gas price, power price, and demand.

With these assumptions, any cases with market or gas purchases becomes highly volatile (both upside and downside risk).

Correlations were incorrectly calculated and sourced; result was much lower risk.

Environmental Compliance Obligations



Environmental Compliance Obligations

- Why can't we assume costs for finalized regulations only?

  (i.e. Why should we consider NAAQS, CSAPR 2.0, coal combustion residuals, effluent limitation, cooling water rules or CO_2?)

Ignoring impending regulations assigns them a **zero** dollar cost.

Zero is an **absolute** forecast. It implies **100%** certainty that there will be **no** cost of compliance.

Alternative options include proxy costs or estimates.

Supply-Side Options

- Reasonable diversity of supply options?
  - Range of thermal types/sizes, renewable resources, demand reduction, efficiency, storage?
  - Purchase of existing assets?
  - Partial ownership?
  - Transmission options considered, if viable?
- Source and date of capital estimates. Learning curve for solar and wind?
- Capacity and energy markets included?
- Did the utility consider divesting resources? How?

PacifiCorp 2013 IRP

Table 6.1 - 2013 Supply Side Resource Table (2012$)

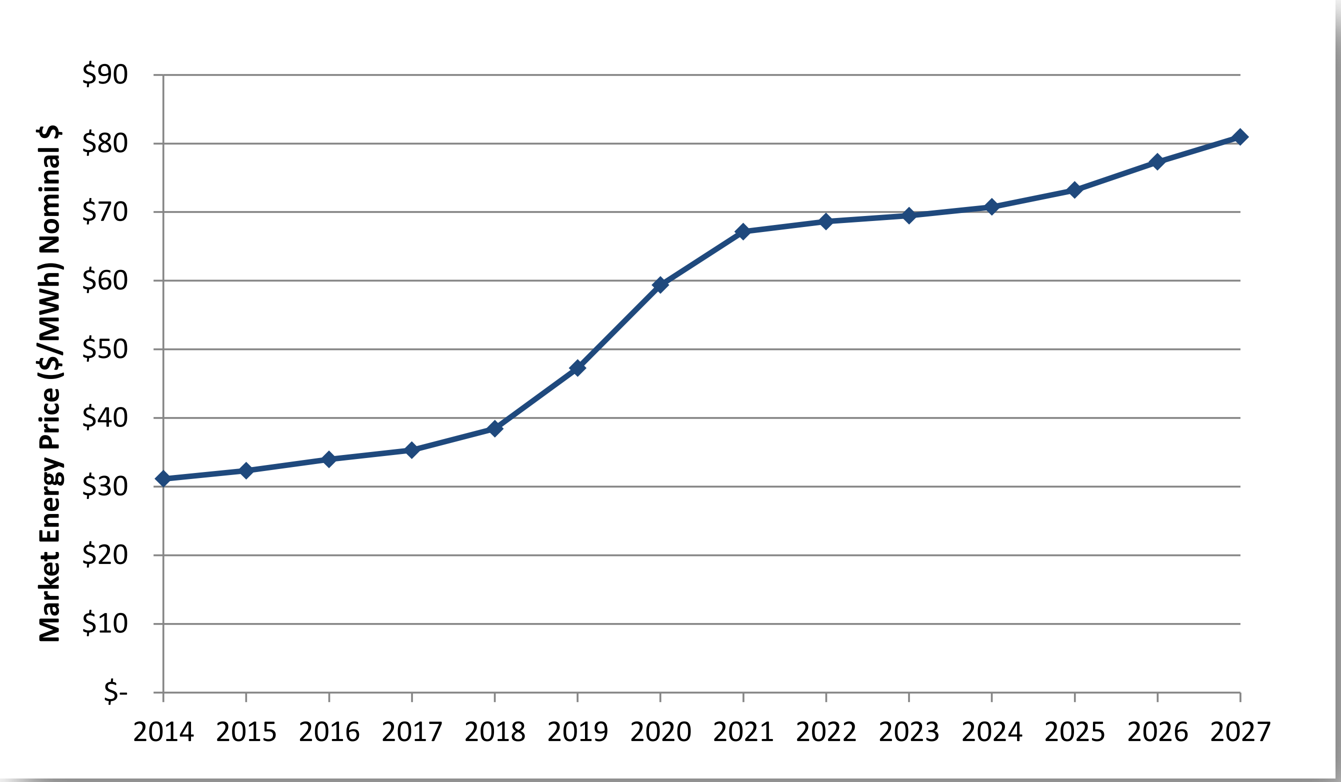
Description		Resource Characteristics				Costs			Operating Characteristics				Environmental			
Fuel	Resource	Elevation (AFSL)	Net Capacity (MW)	Commercial Operation Year	Design Life (yrs)	Base Capital ($/KW)	Var O&M ($/MWh)	Fixed O&M ($/KW-yr)	Average Full Load Heat Rate (HHV Btu/KWh)/Efficiency	EFOR (%)	POR (%)	Water Consumed (Gal/MWh)	SO2 (lbs /MMBtu)	NOx (lbs /MMBtu)	Hg (lbs /TBTu)	CO2 (lbs /MMBtu)
Natural Gas	SCCT Aero x3, ISO	0	163	2016	30	1,081	3.50	9.88	9,739	2.6	3.9	56	0.0006	0.018	0.255	118
Natural Gas	Intercooled SCCT Aero x1, ISO	0	102	2016	30	1,004	2.92	15.23	8,867	2.9	3.9	78	0.0006	0.018	0.255	118
Natural Gas	SCCT Frame "F" x1, ISO	0	203	2016	35	679	8.46	7.73	9,950	2.7	3.9	10	0.0006	0.018	0.255	118
Natural Gas	IC Recips x6, ISO	0	117	2016	30	1,204	7.40	15.61	8,447	2.5	5.0	5	0.0006	0.018	0.255	118
Natural Gas	CCCT Dry "F", 2x1, ISO	0	609	2017	40	995	2.11	6.13	6,738	2.5	3.8	11	0.0006	0.007	0.255	118
Natural Gas	CCCT Dry "F", DF, 2x1, ISO	0	138	2017	40	522	0.08	0.00	8,482	0.8	3.8	11	0.0006	0.007	0.255	118
Natural Gas	CCCT Dry "G/H", 1x1, ISO	0	372	2017	40	971	2.53	10.70	6,866	2.5	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 1x1, ISO	0	48	2017	40	612	0.08	0.00	8,262	0.8	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", 2x1, ISO	0	746	2017	40	959	2.44	5.61	6,743	2.5	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 2x1, ISO	0	96	2017	40	600	0.07	0.00	8,105	0.8	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", Adv 1x1, ISO	0	439	2018	40	931	2.20	9.13	6,495	2.5	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", DF, Adv 1x1, ISO	0	43	2018	40	486	0.08	0.00	8,611	0.8	3.8	11	0.0006	0.008	0.255	118
Natural Gas	Intercooled SCCT Aero x1	1,500	99	2016	30	1,034	2.99	15.67	8,839	2.9	3.9	80	0.0006	0.018	0.255	118
Natural Gas	SCCT Frame "F" x1	1,500	197	2016	35	699	8.71	7.97	9,950	2.7	3.9	20	0.0006	0.018	0.255	118
Natural Gas	IC Recips x 6	1,500	112	2016	30	1,253	7.63	16.31	8,447	2.5	3.8	5	0.0006	0.030	0.255	118
Natural Gas	CCCT Dry "F", 2x1	1,500	583	2016	40	1,039	2.18	6.43	6,738	2.5	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "F", DF, 2x1	1,500	138	2016	40	522	0.08	0.00	8,482	0.8	3.8	11	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", 2x1	1,500	715	2017	40	1,000	2.54	5.86	6,773	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 2x1	1,500	96	2017	40	600	0.07	0.00	8,135	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", Adv 1x1	1,500	425	2018	40	962	2.27	9.43	6,495	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", DF, Adv 1x1	1,500	43	2018	40	486	0.08	0.00	8,611	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	SCCT Aero x3	4,250	144	2016	30	1,225	3.89	11.11	9,739	2.6	3.9	58	0.0006	0.018	0.255	118
Natural Gas	Intercooled SCCT Aero x1	4,250	91	2016	30	1,127	3.23	16.97	8,867	2.9	3.9	80	0.0006	0.018	0.255	118
Natural Gas	SCCT Frame "F" x1	4,250	181	2016	35	762	9.48	8.67	9,950	2.7	3.9	20	0.0006	0.018	0.255	118
Natural Gas	IC Recips x6	4,250	103	2016	30	1,368	8.15	18.39	8,447	2.5	5.0	5	0.0006	0.030	0.255	118
Natural Gas	CCCT Wet "F", 2x1	4,250	545	2017	40	1,104	2.87	8.58	6,666	2.5	3.8	200	0.0006	0.007	0.255	118
Natural Gas	CCCT Wet "F", DF, 2x1	4,250	89	2017	40	490	0.32	0.00	7,901	0.8	3.8	200	0.0006	0.007	0.255	118
Natural Gas	CCCT Dry "F", 1x1	5,050	255	2017	40	1,253	2.57	13.94	6,815	2.5	3.8	9	0.0006	0.007	0.255	118
Natural Gas	CCCT Dry "F", DF, 1x1	5,050	48	2017	40	546	0.08	0.00	8,518	0.8	3.8	9	0.0006	0.007	0.255	118
Natural Gas	CCCT Dry "F", 2x1	5,050	523	2017	40	1,159	2.42	7.14	6,738	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "F", DF, 2x1	5,050	138	2017	40	522	0.08	0.00	8,482	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", 1x1	5,050	320	2017	40	1,129	2.94	12.45	6,866	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 1x1	5,050	48	2017	40	612	0.08	0.00	8,262	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", 2x1	5,050	640	2017	40	1,118	2.82	6.55	6,743	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 2x1	5,050	96	2017	40	600	0.07	0.00	8,105	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", Adv 1x1	5,050	380	2018	40	1,075	2.54	10.54	6,495	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", DF, Adv 1x1	5,050	43	2018	40	486	0.08	0.00	8,611	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	SO Fuel Cell	4,500	5	2018	20	2,090	0.03	8.82	8,061	3	2	2	0.0006	0	0.255	118
Natural Gas	Intercooled SCCT Aero x1	6,500	86	2016	30	1,189	3.39	17.91	8,867	2.9	3.9	80	0.0006	0.018	0.255	118
Natural Gas	SCCT Frame "F" x1	6,500	172	2016	35	804	10.00	9.13	9,950	2.7	3.9	20	0.0006	0.018	0.255	118
Natural Gas	IC Recips x6	6,500	96	2016	30	1,469	8.60	19.03	8,447	2.5	5.0	5	0.0006	0.0295	0.255	118
Natural Gas	CCCT Dry "G/H", 2x1	6,500	617	2017	40	1,159	2.92	6.80	6,743	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "G/H", DF, 2x1	6,500	96	2017	40	600	0.07	0.00	8,105	0.8	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", Adv 1x1	6,500	368	2018	40	1,110	2.62	10.88	6,495	2.5	3.8	9	0.0006	0.008	0.255	118
Natural Gas	CCCT Dry "J", DF, Adv 1x1	6,500	43	2018	40	486	0.08	0.00	8,611	0.8	3.8	9	0.0006	0.008	0.255	118
Coal	SCPC with CCS	4,500	526	2032	40	5,410	6.71	69.22	13,087	5	5	1,004	0.009	0.070	0.022	20.5
Coal	SCPC without CCS	4,500	600	2027	40	2,992	0.96	40.65	9,106	4.6	4	600	0.005	0.070	0.022	205.4
Coal	IGCC with CCS	4,500	466	2032	40	5,238	11.28	55.78	10,823	8	7	394	0.009	0.050	0.333	20.5
Coal	IGCC without CCS	4,500	560	2027	40	3,734	8.39	42.45	8,734	8	7	361	0.013	0.059	0.333	205.4
Coal	PC CCS retrofit @ 500 MW	4,500	-139	2029	20	1,188	6.20	74.52	14,372	5	5	1,004	0.005	0.070	1.200	20.5
Coal	SCPC with CCS	6,500	692	2032	40	6,126	7.26	64.29	13,242	5	5	1,004	0.009	0.070	0.022	20.5
Coal	SCPC without CCS	6,500	790	2027	40	3,388	1.27	37.71	9,214	4.6	4	600	0.005	0.070	0.022	205.4
Coal	IGCC with CCS	6,500	456	2032	40	5,931	13.52	60.76	11,047	8	7	394	0.009	0.050	0.333	20.5
Coal	IGCC without CCS	6,500	548	2027	40	4,228	10.06	46.24	8,915	8	7	361	0.013	0.059	0.333	205.4
Coal	PC CCS retrofit @ 500 MW	6,500	-139	2029	20	1,345	6.71	69.22	14,372	5	5	1,004	0.005	0.070	1.200	20.5
Geothermal	Blundell Dual Flash 90% CF	4,500	35	2016	40	4,795	0.98	118.49	na	5	5	1453	0	0	0	0
Geothermal	Greenfield Binary 90% CF	4,500	43	2018	40	5,916	0.98	187.85	na	5	5	1453	0	0	0	0
Geothermal	Generic Geothermal PPA 90% CF	4,500	30	2016	20	n/a	110.00	n/a	na	5	5	1453	0	0	0	0
Wind	2.3 MW turbine 29% CF WA	1,500	100	2017	25	2,365	0.00	33.11	0	Included with CF		0	0	0	0	0
Wind	2.3 MW turbine 29% CF UT	4,500	100	2017	25	2,304	0.00	33.11	0	Included with CF		0	0	0	0	0
Wind	2.3 MW turbine 35% CF WY	6,500	100	2017	25	2,138	0.65	33.11	0	Included with CF		0	0	0	0	0
Wind	2.3 MW turbine 40% CF WY	6,500	200	2017	25	2,257	0.65	33.11	0	Included with CF		0	0	0	0	0
Solar	PV Thin Film 21% CF	4,500	2	2014	25	3,476	0.00	51.50	na	Included with CF		0	0	0	0	0
Solar	PV Poly-Si Fixed Tilt 22% CF	4,500	2	2014	25	3,153	0.00	51.50	na	Included with CF		0	0	0	0	0
Solar	PV Poly-Si Single Tracking 25% CF	4,500	2	2014	25	3,810	0.00	67.00	na	Included with CF		0	0	0	0	0
Solar	PV Poly-Si Fixed Tilt 28% CF	4,500	50	2015	25	2,952	0.00	27.81	na	Included with CF		0	0	0	0	0
Solar	PV Poly-Si Single Tracking 33% CF	4,500	50	2015	25	3,176	0.00	32.55	na	Included with CF		0	0	0	0	0
Solar	CSP Trough w Natural Gas	4,500	100	2015	30	5,072	0.00	64.00	11,750	Included with CF		725	0	0	0	0
Solar	CSP Tower 24% CF	4,500	100	2015	30	4,831	0.00	64.00	na	Included with CF		725	0	0	0	0
Solar	CSP Tower Molten Salt 30% CF	4,500	100	2015	30	5,796	0.00	64.00	na	Included with CF		750	0	0	0	0
Water	Hydrokinetic/Wave 40% CF	0	100	2024	20	5,539	0.00	166.17	na	na	na	0	0	0	0	0
Biomass	Forestry Byproduct	1,500	5	2017	30	3,334	0.96	40.65	10,017	5.06	4.4	660	0.1	0.2	0.4	205
Storage	Pumped Storage	4,500	1,000	2022	50	3,000	4.30	4.30	77.5%	3	1.9	0	0	0	0	0
Storage	Lithium Ion Battery	4,500	10	2015	20	8,712	0.00	27.40	91.0%	3	1.9	0	0	0	0	0
Storage	Sodium-Sulfur Battery	4,500	10	2015	20	4,400	0.00	27.40	72.5%	0.3	0	0	0	0	0	0
Storage	Vanadium RedOx Battery	4,500	10	2015	20	5,530	0.00	36.53	70.0%	2	0	0	0	0	0	0
Storage	Advanced Fly Wheel	4,500	10	2015	20	2,406	0.00	96.24	85.0%	2	0	0	0	0	0	0
Storage	CAES	4,500	557	2017	30	1,751	22.51	33.80	83.5%	3.5	3.5	0	0.001	0.011	0.255	118
Nuclear	Advanced Fission	4,500	2,236	2025	40	7,093	2.04	88.75	10,710	7.7	7.3	767	0	0	0	0
Nuclear	Modular Reactor	4,500	25	2030	40	3,390	1.02	44.38	10,710	7.7	7.3	767	0	0	0	0

Market Prices

Energy market price forecasts guide value of existing resources and consumer risk of loss.

Are prices reasonable and consistent?

Midwest Utility "A" Rate Case



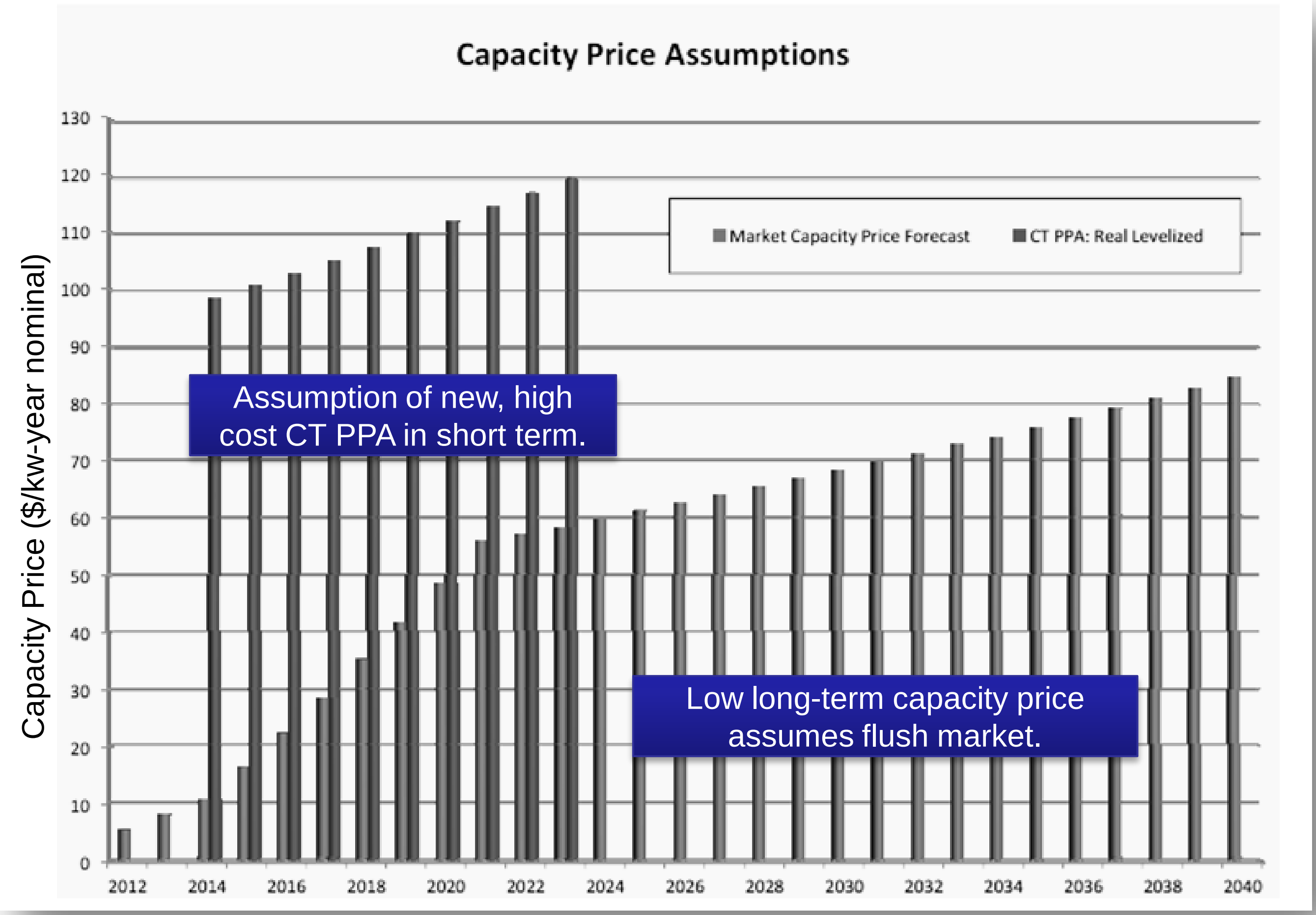
Source: Midwest Utility "A", 2012

Market Prices

Capacity prices are company's estimate of risk of "going short".

Assumed payments for capacity can overwhelm an analysis.

Midwest Utility "B" CPCN



Source: Midwest Utility "B", 2012

Optimization

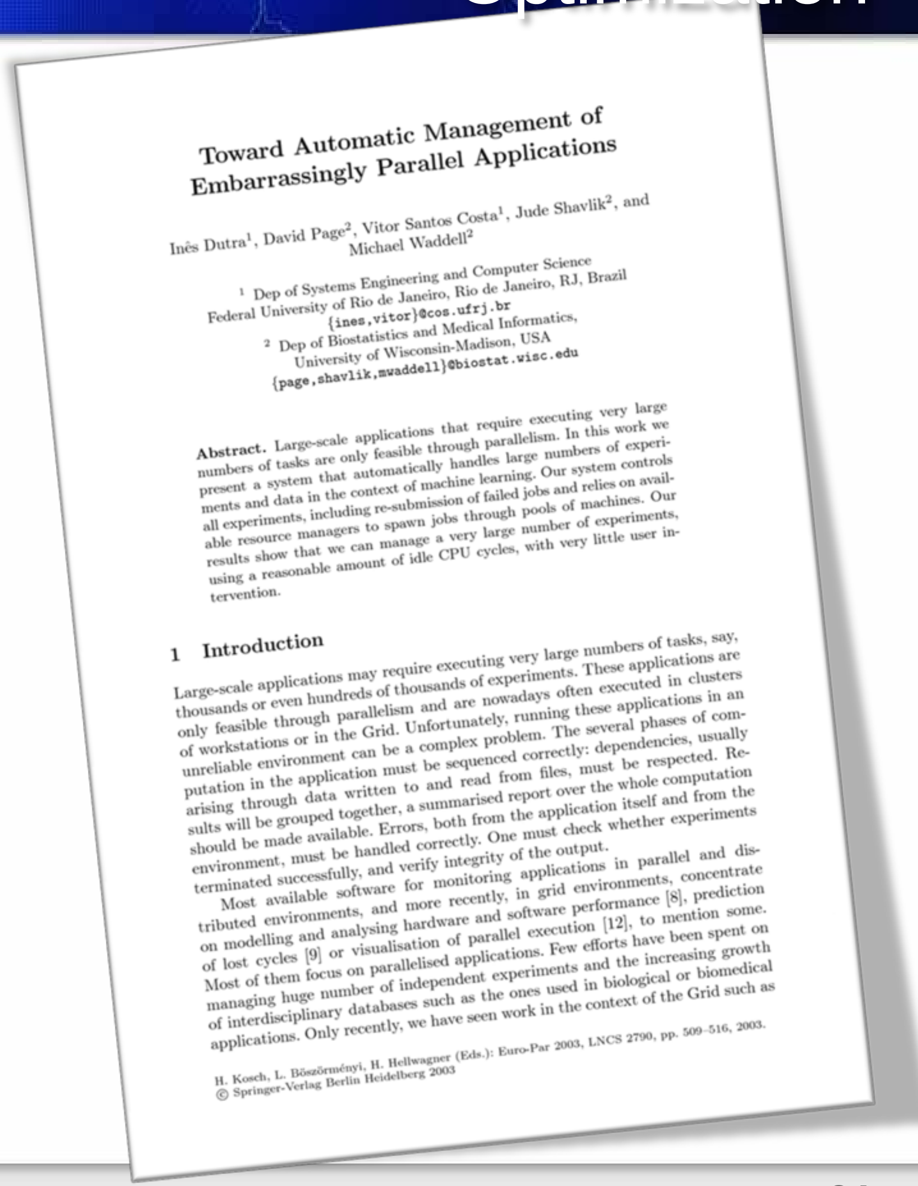
- Was every reasonable portfolio combination considered?
- What was excluded, and why?
- Was every commodity price combination and regulatory requirement considered, or just a limited selection?

Large number of unknown variables results in large number of runs.

(i.e. low-mid-high range on gas prices, coal prices, CO_2 prices, and environmental stringency results in 81 scenarios.)

Modeling one-off scenarios is <u>embarrassingly parallel</u>.

Incremental cost of computing power pales in comparison to annual investments.



Toward Automatic Management of Embarrassingly Parallel Applications

Inês Dutra[1], David Page[2], Vitor Santos Costa[1], Jude Shavlik[2], and Michael Waddell[2]

[1] Dep of Systems Engineering and Computer Science
Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil
{ines,vitor}@cos.ufrj.br
[2] Dep of Biostatistics and Medical Informatics,
University of Wisconsin-Madison, USA
{page,shavlik,mwaddell}@biostat.wisc.edu

Abstract. Large-scale applications that require executing very large numbers of tasks are only feasible through parallelism. In this work we present a system that automatically handles large numbers of experiments and data in the context of machine learning. Our system controls all experiments, including re-submission of failed jobs and relies on available resource managers to spawn jobs through pools of machines. Our results show that we can manage a very large number of experiments, using a reasonable amount of idle CPU cycles, with very little user intervention.

1 Introduction

Large-scale applications may require executing very large numbers of tasks, say,
thousands or even hundreds of thousands of experiments. These applications are
only feasible through parallelism and are nowadays often executed in clusters
of workstations or in the Grid. Unfortunately, running these applications in an
unreliable environment can be a complex problem. The several phases of com-
putation in the application must be sequenced correctly: dependencies, usually
arising through data written to and read from files, must be respected. Re-
sults will be grouped together, a summarised report over the whole computation
should be made available. Errors, both from the application itself and from the
environment, must be handled correctly. One must check whether experiments
terminated successfully, and verify integrity of the output.
Most available software for monitoring applications in parallel and dis-
tributed environments, and more recently, in grid environments, concentrate
on modelling and analysing hardware and software performance [8], prediction
of lost cycles [9] or visualisation of parallel execution [12], to mention some.
Most of them focus on parallelised applications. Few efforts have been spent on
managing huge number of independent experiments and the increasing growth
of interdisciplinary databases such as the ones used in biological or biomedical
applications. Only recently, we have seen work in the context of the Grid such as

H. Kosch, L. Böszörményi, H. Hellwagner (Eds.): Euro-Par 2003, LNCS 2790, pp. 509–516, 2003.

Participant Roles in Productive IRP Planning

Utility

- Continuously improve planning
- Responsive to stakeholder concerns
- Transparent as often as possible
- Use stakeholder input as a process audit

Stakeholders

- Engage seriously, and at a technical level
- Realistic expectations

Staff/PUC

- Provide backstop and/or recourse for transparency, concerns
- Guide priorities