

Chapter 7 Portfolio Modeling and Intrinsic Results

Update on Portfolio Modeling

The portfolios for the 2007 Plan were constructed and analyzed using the PCI GenTrader Model, first on an intrinsic basis, and then on a stochastic basis. NorthWestern Energy continues to employ GenTrader® as the primary portfolio evaluation and modeling tool in the electric resource planning process. During 2007 new hardware and software upgrades were acquired, tested, and put into use by the Energy Supply Group. As a result of these additions and changes, NorthWestern has substantially improved the overall capability to independently create and execute portfolio simulations.

The modeling capability of the GenTrader® suite of simulation modules is comprehensive. It allows economic unit dispatch logic to be employed in conjunction with complex generation unit definitions to answer questions about economics, uncertainty, risk, and optimization associated with individual generation resources and portfolios. Since 2003, NorthWestern has utilized GenTrader® and its broad range of modeling capability to evaluate generation resources and resource portfolios in the resource procurement planning process.

Inputs for GenTrader® models fall into four categories; 1) Market; 2) Load; 3) Existing Resources; and 4) New Resources. Market inputs are comprised of forward price curves for electricity and fuel (natural gas, coal, and “bio-fuel”). The certainty of the forward market for electricity is complicated by the potential imposition of carbon taxes as a result of greenhouse gas emissions (CO₂) from fossil fuels. Carbon tax cases are explicitly identified and included in market price cases.

The Supply load obligation for the period 2008 through 2027 has been estimated using historical rate class customer counts, historical weather data, and historical rate class energy usage. A detailed description of the data and methods used to create the long-term load forecast is included in sources in Volume 2. Creation of the forecast is a multi-

step process. First, the 20-year forecast of annual Supply energy usage is built. Second, the annual load estimates are converted to hourly load values using test period load shapes provided by the NorthWestern Energy load Research Group. Finally, the hourly load values are formatted and loaded into GenTrader®. The forecast values include losses; however, they exclude projected future energy savings from the DSM program because energy savings is treated as a resource (purchase) for modeling purposes.

Existing resources are the purchase power agreements and generation resources under contract with NorthWestern Energy Supply. The price, term, and quantity for each of these resources have been loaded into the modeling software. New resources are the individual generation units that have been identified, defined, and placed in portfolios with the existing resources for economic evaluation.

The GenTrader® model is designed to perform resource optimization by identifying the most economic alternative for serving load within a portfolio. It is important to recognize and remember that, while the software includes numerous operating input parameters, it is not an operational model from a utility perspective. In some instances, actual unit operations for resources included in the plan may differ from the operating parameters defined and executed for resource evaluation and comparison purposes. One important example of this situation is due to the “perfect” knowledge aspect of the model. During model simulation runs, GenTrader® always has perfect market knowledge for electricity purchases and sales, fuel purchases, and spark spread calculations. Real world unit dispatch decisions do not have the benefit of “perfect” market knowledge resulting in operating decisions and performance that will differ from model results.

Two model types are employed to evaluate resources and resource portfolios in the 2007 resource procurement plan update. They are intrinsic and stochastic models. Each is used to answer different questions about portfolio costs. Intrinsic models have been employed for the initial modeling, evaluation, comparison, and screening of the 50 defined portfolios; including market reference portfolios. Intrinsic models employ “fixed”

forward market curves for electricity and fuel. Results of intrinsic models only provide information about resources and resource portfolios under a single set of market conditions. If run multiple times, an intrinsic model will produce the same results unless input parameters are changed.

Stochastic models introduce risk and uncertainty into the model, and include multiple outcomes as market prices are varied. Implied price volatility for electricity and fuel is the driver for the stochastic studies that causes a distribution and range of portfolio cost outcomes to be created. By evaluating and understanding the distribution of cost outcomes from a stochastic model, it is possible to gain insight and understanding about the risk associated with a resource portfolio. Stochastic model output is not a “guarantee” about the actual economic performance. It does however; provide a disciplined approach to dealing with the risks and uncertainties associated with modern day resource planning decisions.

Intrinsic Portfolios

NorthWestern, considering input from the ETAC, constructed 50 different portfolios which could be modeled and tested in terms of how well the portfolios meet the needs of the electric supply load. There were some overarching objectives in creating the portfolios:

1. Portfolio 1 is a reference case with no additional resources other than the existing that relies strictly upon market to meet future load needs.
2. All other portfolios comply to the Montana RPS standard through the addition of wind resources in an amount to meet the minimum required renewable resources by year.
3. Portfolios are constructed that rely upon only one resource addition to obtain results reflective of that resource only without melding with other resources. It is expected that any preferred portfolio will have a more diverse range of resource options, but the single resource portfolios are useful from an analytical and review perspective.

The new resource operating costs and parameters were explained and detailed in the preceding chapters. The 50 portfolios developed for analysis in the 2007 Plan are shown in Table 7-1 below:

Table 7-1, Intrinsic Modeling Scenarios

	Portfolio Number	Coal - PV Subcritical	Coal - PV Sub w/ CCS	Coal - PV Supercritical	Coal - PV Super w/ CCS	Coal - IGCC	Coal - IGCC w/ CCS	Gas - CCCT	Gas - CCCT w/ CCS	Gas - CHP	Gas - Oil Sands	Gas - SCCT Frame	Gas - SCCT Aero	Gas - Internal Combustion	Gas - LMs	Generic Regulating Resource	Biomass	Geothermal	Wind	Solar - PV	CAES	Pumped Storage	Total New Resources
<i>Mkt Reference</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Single Resource</i>	2	500	-	-	-	-	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	3	-	500	-	-	-	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	4	-	-	500	-	-	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	5	-	-	-	500	-	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	6	-	-	-	-	500	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	7	-	-	-	-	-	500	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	765
	8	-	-	-	-	-	-	400	-	-	-	-	-	-	-	135	-	-	150	-	-	-	665
	9	-	-	-	-	-	-	-	400	-	-	-	-	-	-	135	-	-	150	-	-	-	665
	10	-	-	-	-	-	-	-	-	600	-	-	-	-	-	135	-	-	150	-	-	-	665
	11	-	-	-	-	-	-	-	-	-	600	-	-	-	-	135	-	-	150	-	-	-	665
	12	-	-	-	-	-	-	-	-	-	-	300	-	-	-	135	-	-	150	-	-	-	565
	13	-	-	-	-	-	-	-	-	-	-	-	300	-	-	135	-	-	150	-	-	-	565
	14	-	-	-	-	-	-	-	-	-	-	-	-	88	-	135	-	-	150	-	-	-	373
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	80	135	-	-	150	-	-	-	365
	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	135	-	-	150	-	-	-	265
<i>Baseload Coal/Gas Combes</i>	17	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	18	-	-	-	250	-	-	-	200	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	19	-	-	-	250	-	-	-	-	200	-	-	-	-	-	135	-	-	150	-	-	-	735
	20	-	-	250	-	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	21	-	-	250	-	-	-	-	200	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	22	-	-	250	-	-	-	-	-	200	-	-	-	-	-	135	-	-	150	-	-	-	735
	23	250	-	-	-	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	24	-	250	-	-	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	25	-	-	-	-	250	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	26	-	-	-	-	-	250	200	-	-	-	-	-	-	-	135	-	-	150	-	-	-	735
	27	-	-	-	-	-	250	200	-	-	-	100	-	-	-	135	-	-	150	-	-	-	635
	28	-	-	-	-	-	250	200	-	-	-	-	100	-	-	135	-	-	150	-	-	-	635
	47	250	-	-	-	-	-	200	-	-	-	100	-	-	-	135	-	-	150	-	-	-	635
	48	250	-	-	-	-	-	200	-	-	-	-	100	-	-	135	-	-	150	-	-	-	635

	Portfolio Number	Coal - PV Subcritical	Coal - PV Sub w/ CCS	Coal - PV Supercritical	Coal - PV Super w/ CCS	Coal - IGCC	Coal - IGCC w/ CCS	Gas - CCCT	Gas - CCCT w/ CCS	Gas - CHP	Gas - Oil Sands	Gas - SCCT Frame	Gas - SCCT Aero	Gas - Internal Combustion	Gas - LMs	Generic Regulating Resource	Biomass	Geothermal	Wind	Solar - PV	CAES	Pumped Storage	Total New Resources
<i>Renewable Options</i>	<i>28</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	105	25	-	-	-	-	-	<i>588</i>
	<i>30</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	105	50	-	-	-	-	-	<i>605</i>
	<i>31</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	105	25	25	-	-	-	-	<i>605</i>
	<i>32</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	115	25	25	50	-	-	-	<i>665</i>
	<i>33</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	115	50	-	50	-	-	-	<i>665</i>
	<i>34</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	50	-	150	-	-	-	<i>785</i>
	<i>35</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	115	50	25	50	-	-	-	<i>626</i>
	<i>36</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	50	25	150	-	-	-	<i>816</i>
	<i>37</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	115	25	25	50	-	-	-	<i>615</i>
	<i>38</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	115	50	25	50	-	-	-	<i>646</i>
	<i>38</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	135	50	25	150	-	-	-	<i>766</i>
	<i>40</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	135	-	-	100	10	-	-	<i>645</i>
	<i>41</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	125	-	-	100	20	-	-	<i>645</i>
	<i>45</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	105	-	50	-	-	-	-	<i>605</i>
	<i>50</i>	-	-	-	-	-	-	400	-	-	-	-	-	-	-	135	-	50	150	-	-	-	<i>735</i>
<i>With</i>	<i>42</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	100	-	<i>835</i>
<i>Air /</i>	<i>43</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	-	100	<i>835</i>
<i>Pump</i>	<i>44</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	135	-	-	150	-	100	100	<i>535</i>
<i>Storage</i>	<i>45</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	115	25	25	50	-	50	-	<i>715</i>
	<i>46</i>	-	-	-	250	-	-	200	-	-	-	-	-	-	-	115	25	25	50	-	-	50	<i>715</i>

The portfolios were then run on an intrinsic basis to determine which portfolios met the default load requirements in an economic fashion without incorporating the volatility of the market prices. The intrinsic runs were performed with scenarios for the three market projections combined with the three carbon projections. Figure 7-1 below is representative of the combinations that were analyzed using the PCI model on an intrinsic basis:

Figure 7-1, Intrinsic Modeling Scenarios

		Market		
		Low	Medium	High
Carbon Tax	Low		X	
	Medium	X	X	X
	High		X	

Intrinsic Results

The PCI results were then reviewed to determine the overall costs of the whole portfolio under the five scenarios reviewed for the 50 portfolios. An overall summary of the portfolio’s relative merit is obtained by reviewing their 20-year levelized blend. For each modeling run, the top 15 portfolios, in terms of lowest levelized cost, are shaded. The results are summarized Table 7-2 below.

Table 7-2, 20-Year Levelized Portfolio Costs (top 15 shaded)

	New Res	Levelized Cost (\$/MWh)				
		Basecase	Low Mkt	High Mkt	Low CO2	High CO2
PF1		56.24	46.19	70.59	55.24	56.28
PF2	785	53.94	53.94	63.44	57.15	70.53
PF3	785	63.99	59.56	72.04	64.28	66.91
PF4	785	55.82	55.47	64.96	58.72	71.34
PF5	785	69.05	64.54	77.02	69.27	71.6
PF6	785	57.76	56.95	66.44	60.26	71.62
PF7	785	67.07	62.69	74.49	67.19	68.91
PF8	685	58.86	52.64	71.26	60.47	64.68
PF9	685	60.76	53	71.36	61.09	61.74
PF10	885	61.41	55.32	73.29	62.65	67.17
PF11	885	61.13	54.62	73.38	62.53	67.85
PF12	585	58.93	49.89	72.63	58.35	59.31
PF13	585	60.96	52.13	74.76	60.54	61.55
PF14	373	57.17	48.2	70.88	56.64	57.62
PF15	365	56.62	47.62	70.33	56.07	57.04
PF16	285	55.73	46.68	69.42	55.14	56.1
PF17	735	65.37	58.59	74.14	65.22	68.14
PF18	735	65.55	58.77	74.19	65.49	66.67
PF19	735	65.3	58.49	74.51	65.2	67.45
PF20	735	60.24	54.06	68.11	59.88	68.01
PF21	735	60.42	54.24	68.16	60.16	66.54
PF22	735	60.17	53.95	68.48	59.87	67.31
PF23	735	59.48	53.29	67.35	59.1	67.14
PF24	735	62.88	56.1	71.65	62.72	65.79
PF25	735	60.98	54.79	68.85	60.65	68.15
PF26	735	64.31	57.67	72.88	64.17	66.8
PF27	835	65.38	58.74	73.95	65.24	67.87
PF28	835	66.11	59.48	74.66	65.96	68.61
PF47	835	60.55	54.22	68.56	60.1	68.21
PF48	835	61.28	54.96	69.28	60.82	68.95
PF29	580	66.16	58.87	75.57	66	68.93
PF30	605	66.76	59.79	75.68	66.61	69.53
PF31	605	66.65	59.37	76.06	66.5	68.4
PF32	665	66.59	59.53	75.67	66.44	68.34
PF33	665	66.7	59.96	75.29	66.55	69.47
PF34	785	66.59	60.29	74.51	66.43	69.35
PF35	690	67.2	60.45	75.78	67.05	68.95
PF36	810	67.08	60.78	75	66.93	68.83
PF37	615	62.13	53.58	72.79	61.9	64.88
PF38	640	62.73	54.5	72.9	62.5	65.48
PF39	760	62.62	54.83	72.12	62.38	65.36
PF40	645	60.94	52.33	71.74	60.71	64.68
PF41	645	60.92	52.32	71.68	60.68	64.68
PF49	605	66.54	58.94	76.44	66.38	67.26
PF50	735	61.89	53.49	72.39	61.66	63.62
PF42	835	66.1	59.25	74.85	65.95	68.87
PF43	835	66.1	59.25	74.85	65.95	68.87
PF44	935	66.83	60.04	75.42	66.68	69.6
PF45	715	66.96	59.93	75.95	66.8	69.72
PF46	715	66.96	59.93	75.95	66.8	69.73

A further simplification was achieved by weighting each of the scenarios to produce a combined single weighted average levelized price of the portfolio. Since all the combinations from Figure 7-2 were not run, the weightings were adjusted to weight the High CO₂ scenario more than it would have otherwise been weighted if all scenarios were weighted equally. If the five runs were weighted equally, the variations in market forecasts and variations in carbon costs adders would result in a 20% weighting for each of the five scenarios. While this would weight the low and high carbon cost scenarios each at 20% and the low and high market scenarios at the same level, it seems that the higher CO₂ cost adders are becoming more and more probable all the time. Since it is difficult to similarly assess the likelihood of the various market scenarios, the high carbon adder scenario was weighted at 30% and the basecase was weighted at 30%. The high market was assigned the standard 20%, while the low carbon and low market cases were each assigned 10%. This weighting produced the results in Table 7-3 below.

Table 7-3, Weighted Average 20-Year Level Costs

	New Res	Weighted Cost (\$/mwh)	Rank
PF1		-58.02	2
PF2	785	-61.14	6
PF3	785	-66.06	28
PF4	785	-62.56	8
PF5	785	-70.98	50
PF6	785	-63.82	19
PF7	785	-68.68	45
PF8	685	-62.62	9
PF9	685	-62.43	7
PF10	885	-65.03	26
PF11	885	-65.09	27
PF12	585	-60.82	5
PF13	585	-62.97	11
PF14	373	-59.1	4
PF15	365	-58.53	3
PF16	285	-57.62	1
PF17	735	-67.26	33
PF18	735	-66.93	30
PF19	735	-67.1	31
PF20	735	-63.49	16
PF21	735	-63.16	12
PF22	735	-63.32	14
PF23	735	-62.7	10
PF24	735	-64.81	25
PF25	735	-64.05	20
PF26	735	-66.09	29
PF27	835	-67.16	32
PF28	835	-67.89	34
PF47	835	-63.77	18
PF48	835	-64.5	22
PF29	580	-68.13	38
PF30	605	-68.66	44
PF31	605	-68.31	40
PF32	665	-68.21	39
PF33	665	-68.56	43
PF34	785	-68.35	41
PF35	690	-68.75	47
PF36	810	-68.54	42
PF37	615	-64.21	21
PF38	640	-64.75	24
PF39	760	-64.54	23
PF40	645	-63.34	15
PF41	645	-63.32	13
PF49	605	-67.96	35
PF50	735	-63.65	17
PF42	835	-67.98	36
PF43	835	-67.98	37
PF44	935	-68.68	46
PF45	715	-68.87	48
PF46	715	-68.87	49

Intrinsic Analysis Conclusions

The intent of the intrinsic runs is to determine portfolio and resource performance under specific and fixed market conditions and to narrow the number of portfolios to a more manageable number for the more detailed stochastic review. Upon technical review of the GenTrader® model's new capability, it was determined that the number of portfolios did not need to be reduced as much as was originally thought. Therefore, only Portfolios 42-46, which were clearly not cost competitive, were excluded from the stochastic modeling. There are a few conclusions that are drawn from the intrinsic runs:

1. Overall, the conventional coal plants were more cost effective than the new technology coal incorporating carbon capture and sequestration. This relative performance resulted in the addition of portfolios 47 and 48 combining conventional coal units with natural gas units.
2. The smaller natural gas peaking units appeared to have performed better than the larger frame units.
3. In terms of renewable portfolios, the geothermal unit option performed well. This result, combined with the added benefits of a baseload output profile and better long-term fuel certainty than the biomass plants led to the addition of portfolios 49 and 50.
4. Intrinsic model results were used to verify that base inputs such as load, DSM, wind energy production schedule, term energy purchase contracts, and other base inputs common to all portfolios were being treated properly in all models.