Northwest **Power** and
Conservation Council

April 4, 2017

MEMORANDUM

TO: **Power Committee**

FROM: **Ben Kujala**

SUBJECT: **How RPM Load Inputs are Developed**

BACKGROUND:

Presenter: Massoud Jourabchi and Ben Kujala

Summary: The presentation to the Power Committee at the March meeting focused on the high-level view of the Regional Portfolio Model. This presentation delves deeper into the details focusing on how the load forecast is input and used in the model.

Relevance: The Regional Portfolio Model has been used to inform the resource strategy included in the 5th, 6th and 7th Power Plans.

Workplan: C. Prepare for the 8thPlan

Background: The Regional Portfolio Model was first used by the Council in the Fifth Power Plan. It was developed at the Council by staff. For the Seventh Power Plan, the Council contracted with Navigant to redevelop the model.

More Info: https://www.nwcouncil.org/energy/rpm/home/

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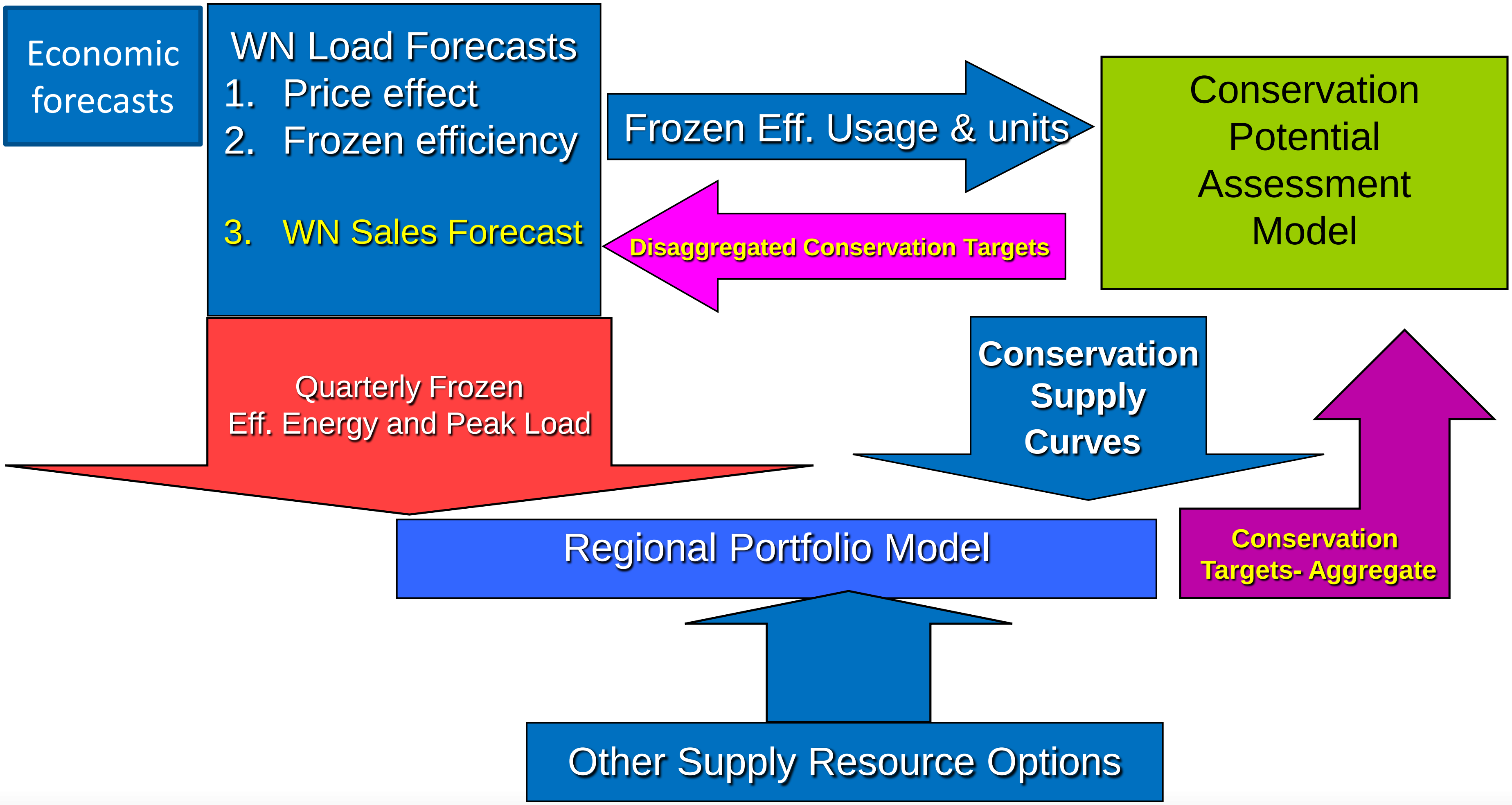
How RPM Load Inputs are Developed

April 2017

Part I:

What Load Forecasts Are Provided to RPM

Load Forecast
Conservation Assessment and Resource Portfolio Model

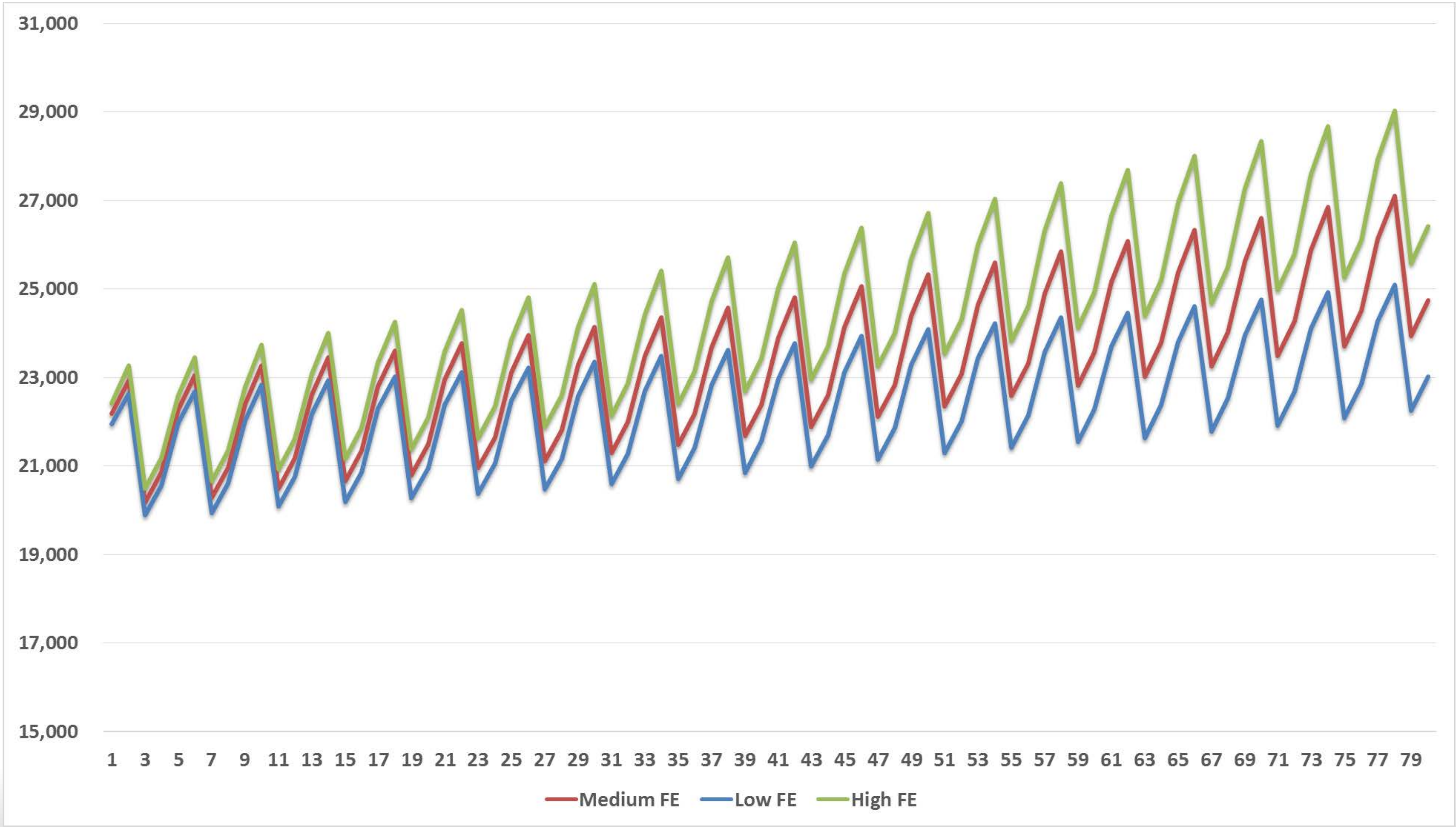


- Forecast of monthly energy and peak loads under “Frozen Efficiency” assumptions are converted to quarterly values and provided to RPM.
- Forecast is provided for 80 quarters, starting with the last quarter of the first year in the plan. For the 7th plan, frozen efficiency forecast for Q4 2015-Q3 2035 was provided.

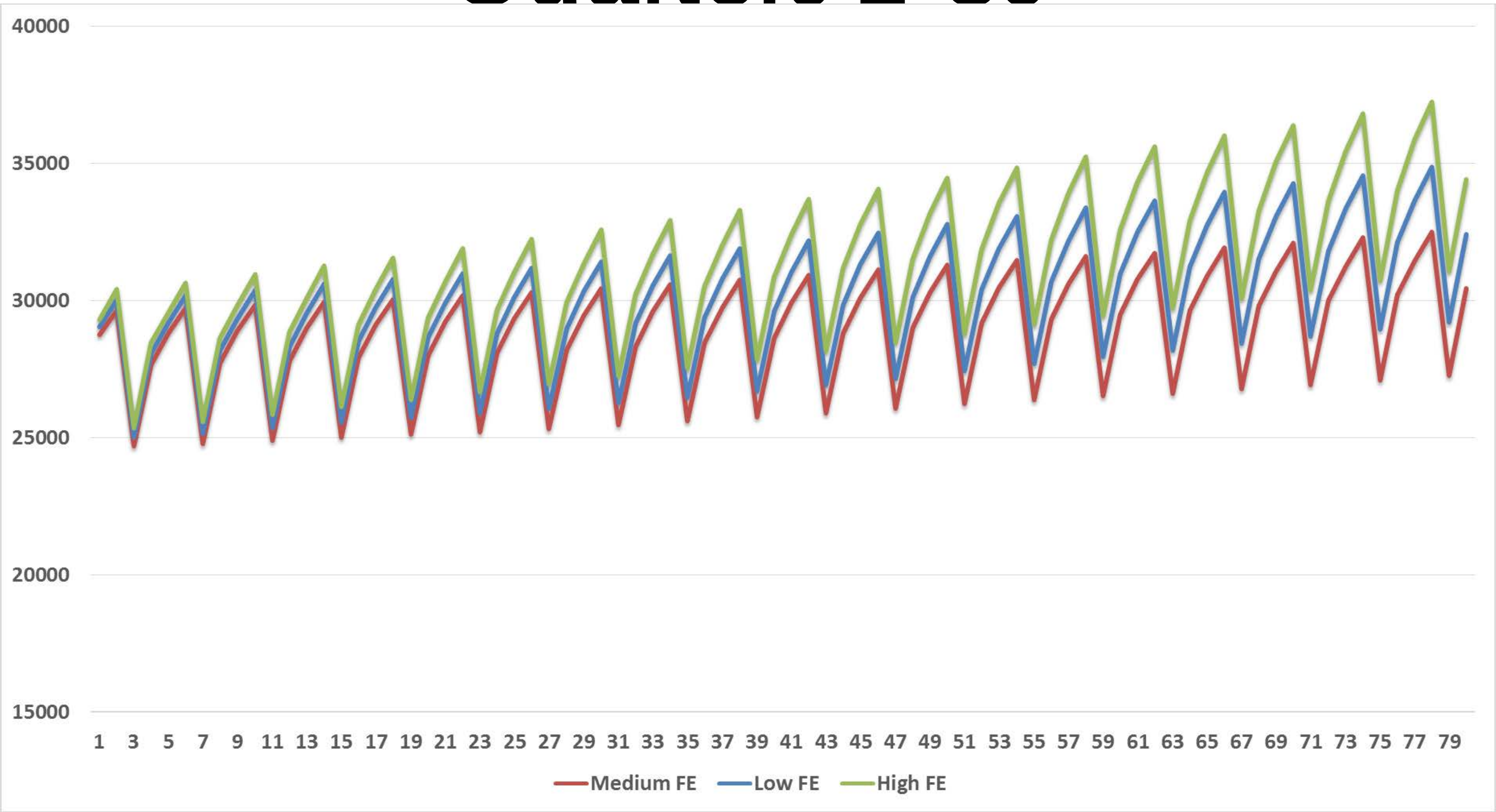
Frozen Efficiency forecast reflects

- Enduse level state of efficiency as of start of the plan, frozen for the duration of plan, except for:
- Known future codes or standards

F.E. Forecast of Loads (aMW) Quarters 1-80



F.E. Forecast of Peak Loads (MW) Quarters 1-80



Part II:

How RPM Expands the Forecasts into "Futures"

Scaling Forecasts

1. Forecasts such as load are input.
2. Factors that scale the input forecast are simulated. These factors are different for each future. The range of the factors is controlled by model parameters.
3. Each "future" is based on applying the factors from that future to the input forecasts.

Electric Load Example

Sample - Stochastic Multiplier

Sample of Stochastic Multiplier

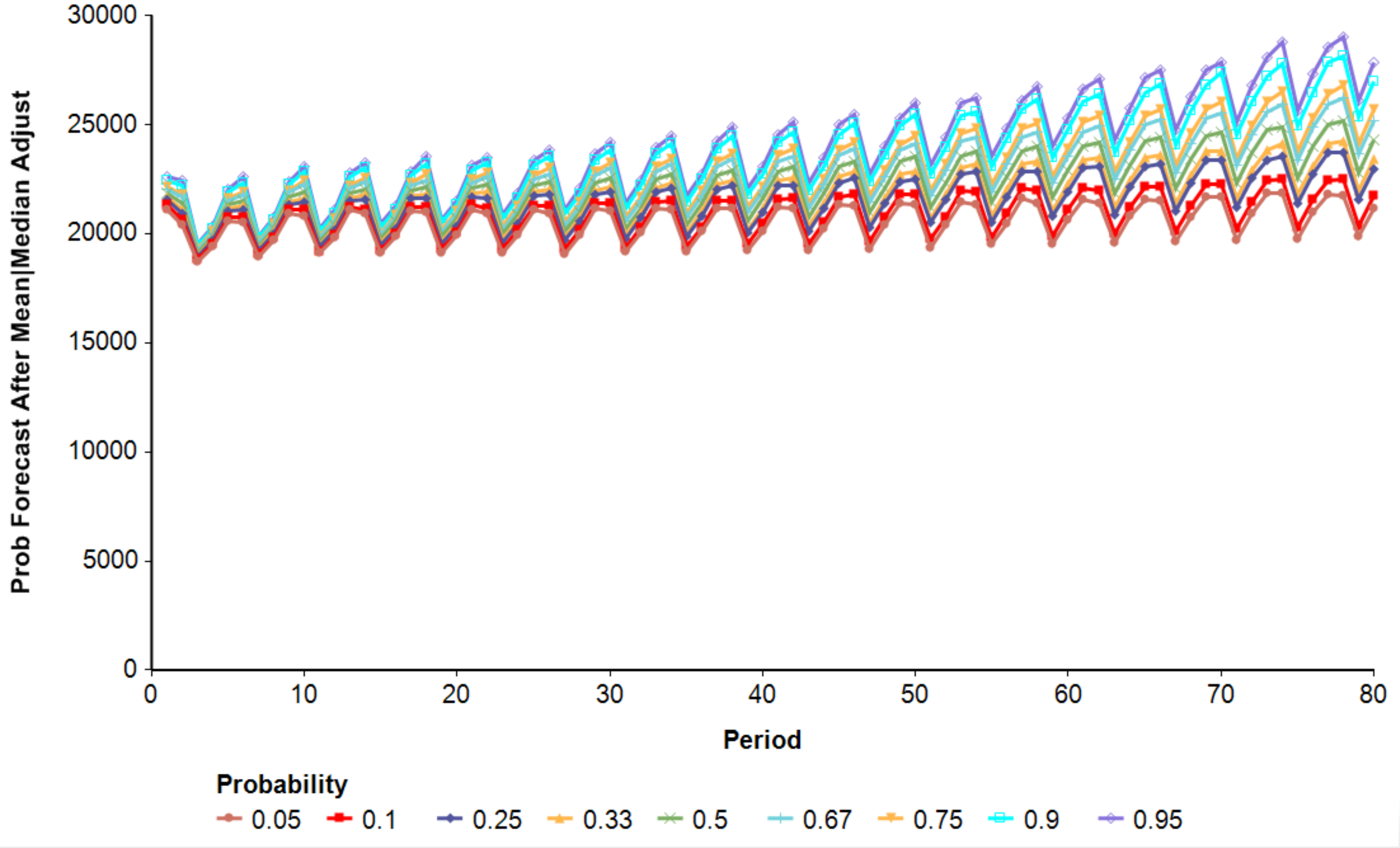
Benchmark Forecast Names: Electric Load Flat (MWa)

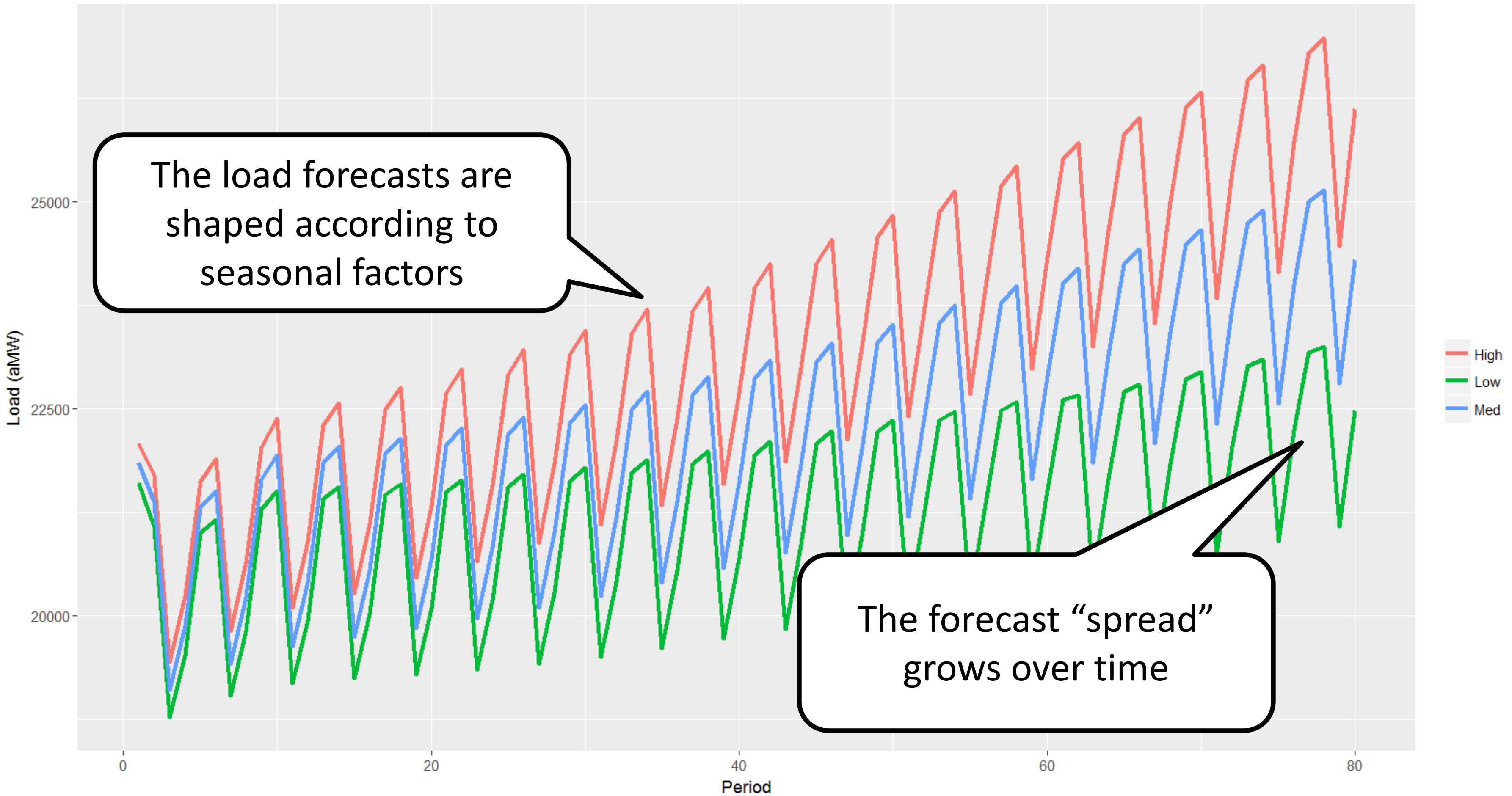
Iteration (Run) ☐ Totals

Period ☐ Totals

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.9949	0.9914	0.9929	0.9949	0.9944	0.9925	0.9924	0.9945	0.995	0.992	0.9936	0.9908	0.9909	0.9875	0.9879	0.9866
2	0.9971	0.9978	0.997	0.9974	1.001	1.002	0.9979	0.9975	0.9956	0.9985	0.9983	0.9965	1.002	0.9951	0.9974	0.9953
3	1.014	1.01	1.009	1.012	1.006	1.009	1.008	1.006	1.007	1.005	1.004	1.006	1.007	1	1.002	1.001
4	1.012	1.013	1.012	1.01	1.009	1.009	1.013	1.012	1.013	1.013	1.016	1.014	1.015	1.017	1.017	1.017
5	1.011	1.013	1.012	1.011	1.015	1.008	1.013	1.012	1.015	1.014	1.013	1.011	1.01	1.014	1.013	1.013
6	1.002	0.9997	1.003	1.002	0.9989	1.002	0.9991	1	0.9989	0.994	0.996	0.995	0.9931	0.9953	0.993	0.9909
7	1.011	1.016	1.014	1.014	1.008	1.008	1.01	1.01	1.01	1.008	1.008	1.009	1.015	1.006	1.008	1.006
8	1	1.001	1.003	1.004	1.004	1.004	1.003	0.9999	1	1.001	1.003	1.002	0.9995	0.9993	1.004	1.005
9	1.007	1.01	1.01	1.013	1.013	1.009	1.01	1.012	1.01	1.004	1.01	1.011	1.013	1.008	1.012	1.011
10	0.9866	0.975	0.9774	0.978	0.9777	0.9708	0.9693	0.9705	0.9743	0.9646	0.9627	0.9622	0.9676	0.9505	0.9563	0.9548
11	1.003	1.001	1	0.9992	0.9967	0.9973	0.9954	0.9962	0.9991	0.9919	0.9945	0.9965	0.9932	0.9933	0.9907	0.9895
12	0.9801	0.9759	0.9732	0.9731	0.9749	0.9657	0.9706	0.9697	0.9718	0.968	0.9664	0.966	0.9698	0.9571	0.9601	0.9613
13	0.9998	1.006	1.006	1.008	1.005	1.003	1.007	1.002	1.006	1.001	1.007	1.004	1.014	1.008	1.01	1.005
14	0.9996	0.993	0.9934	0.9948	0.9903	0.9982	0.9932	0.9921	0.9934	0.992	0.9888	0.9886	0.9845	0.9877	0.9848	0.9837
15	1.001	0.9957	0.9966	0.9946	0.9961	0.9942	0.9916	0.996	0.9921	0.9894	0.9906	0.9884	0.9851	0.9925	0.9871	0.9869
16	0.9929	1.004	0.9992	0.9984	0.9973	0.9998	0.999	1.001	0.999	0.9943	0.9993	0.9986	1.004	1.001	1	0.9975
17	0.9937	0.9961	0.9904	0.9926	0.989	0.9933	0.9958	0.9946	1.001	0.9947	0.9958	0.9966	0.9985	1.001	0.9956	0.9952
18	1.002	1.003	1.001	1.001	1.003	0.9939	1	0.9979	1	0.9882	0.998	0.9959	0.9938	0.9972	0.9935	0.9929
19	0.9895	1.001	0.996	0.9922	0.9968	0.9958	0.9974	0.9938	1.002	1.001	0.9973	0.9996	1	1.002	0.9986	0.9984
20	1.002	0.9947	0.9954	0.9968	0.9989	0.9887	0.9955	0.9979	1.001	0.9959	0.9942	0.9976	0.9943	0.9948	0.9945	0.9953
21	0.9934	0.9944	0.995	0.9945	0.998	0.9959	0.9982	0.9965	0.9979	0.9987	0.9989	0.9989	0.9928	0.9977	0.999	0.999
22	1	0.9965	0.9952	0.9948	0.9871	0.9928	0.9885	0.9895	0.9901	0.9799	0.9844	0.9851	0.982	0.981	0.9773	0.9771
23	1.017	1.016	1.015	1.018	1.014	1.014	1.017	1.018	1.02	1.022	1.022	1.021	1.02	1.023	1.026	1.026
24	1.009	1.01	1.011	1.012	1.015	1.015	1.011	1.011	1.009	1.01	1.014	1.013	1.013	1.014	1.015	1.014
25	1.004	1.014	1.011	1.011	1.005	1.016	1.015	1.015	1.014	1.013	1.018	1.02	1.018	1.027	1.021	1.023
26	1.012	1.005	1.008	1.008	1.009	0.997	1.005	1.005	1.007	1.004	1.002	1.003	1.002	0.9949	0.998	0.9989
27	0.986	0.9852	0.9848	0.9845	0.9799	0.9824	0.9817	0.9837	0.9786	0.9849	0.9824	0.9828	0.9822	0.9821	0.9829	0.9792
28	0.9852	0.9911	0.9898	0.9898	0.9879	0.9898	0.9908	0.9897	0.9898	0.9971	0.9913	0.9898	0.9932	0.994	0.9941	0.9933
29	1.022	1.028	1.025	1.027	1.032	1.033	1.031	1.031	1.027	1.036	1.037	1.035	1.032	1.033	1.039	1.037
30	0.9915	1.004	0.999	0.9971	0.9953	1	1.003	1.004	1.001	1.006	1.008	1.007	1.01	1.011	1.012	1.011
31	0.9753	0.9696	0.9673	0.9673	0.9684	0.9607	0.9625	0.9627	0.956	0.9544	0.9555	0.9561	0.9528	0.9521	0.9512	0.9531
32	1.001	0.9991	0.9953	0.9984	0.9947	0.9949	0.9927	0.9905	0.9965	0.9842	0.9903	0.9875	0.9856	0.987	0.9843	0.9838
33	0.9929	0.996	1	1.001	0.998	1.005	1.003	1.008	1.009	1.01	1.01	1.011	1.011	1.017	1.017	1.012
34	1.026	1.026	1.025	1.028	1.026	1.031	1.024	1.028	1.021	1.032	1.028	1.028	1.027	1.025	1.029	1.029
35	0.989	0.9878	0.9896	0.9879	0.9882	0.9874	0.9903	0.9929	0.9931	0.9944	0.9944	0.9935	0.9942	0.987	0.9951	0.9956
36	0.9811	0.9823	0.9859	0.9848	0.9826	0.9883	0.9866	0.9857	0.987	0.9855	0.9842	0.9851	0.9854	0.9845	0.9863	0.9853

Electric Load Example

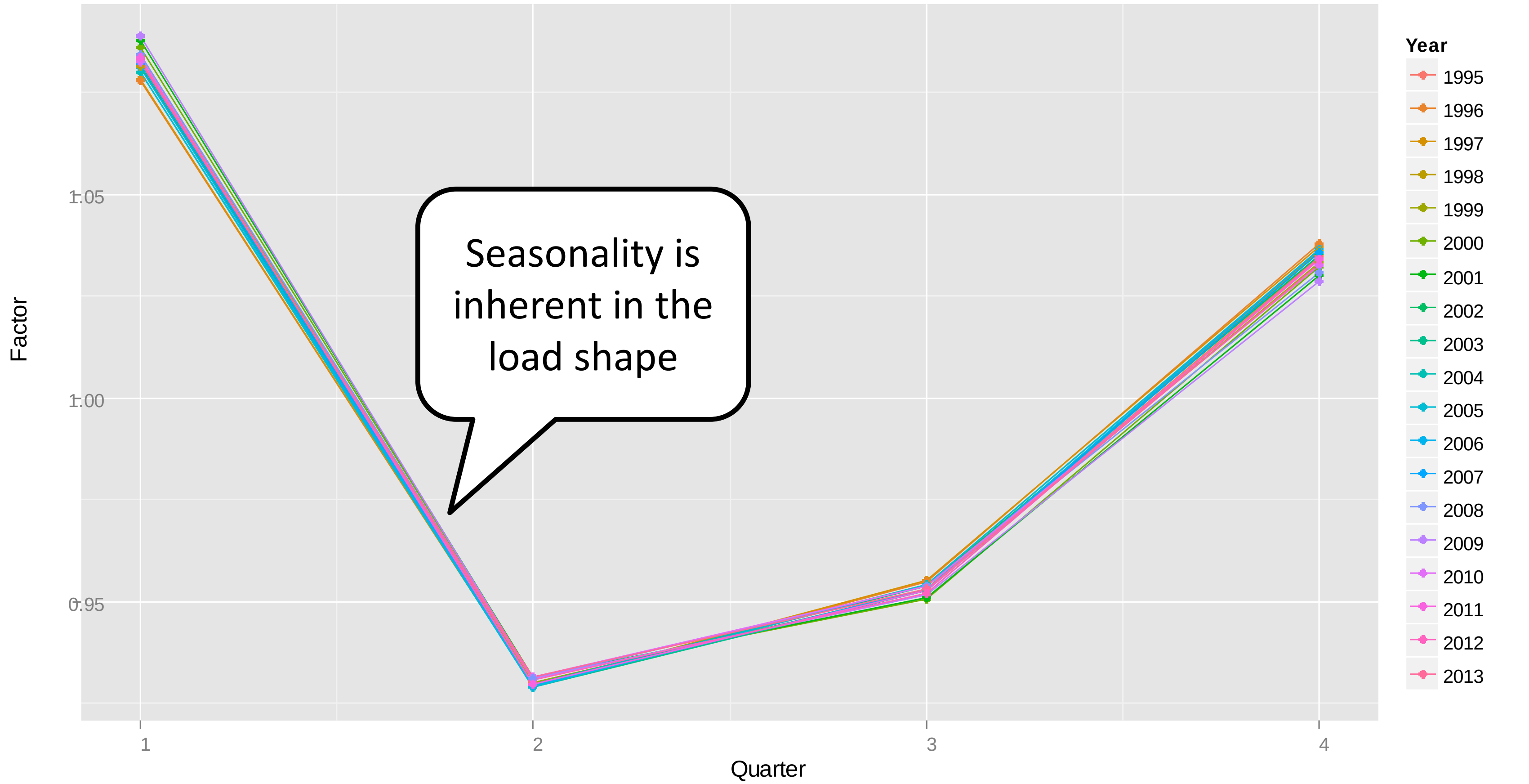


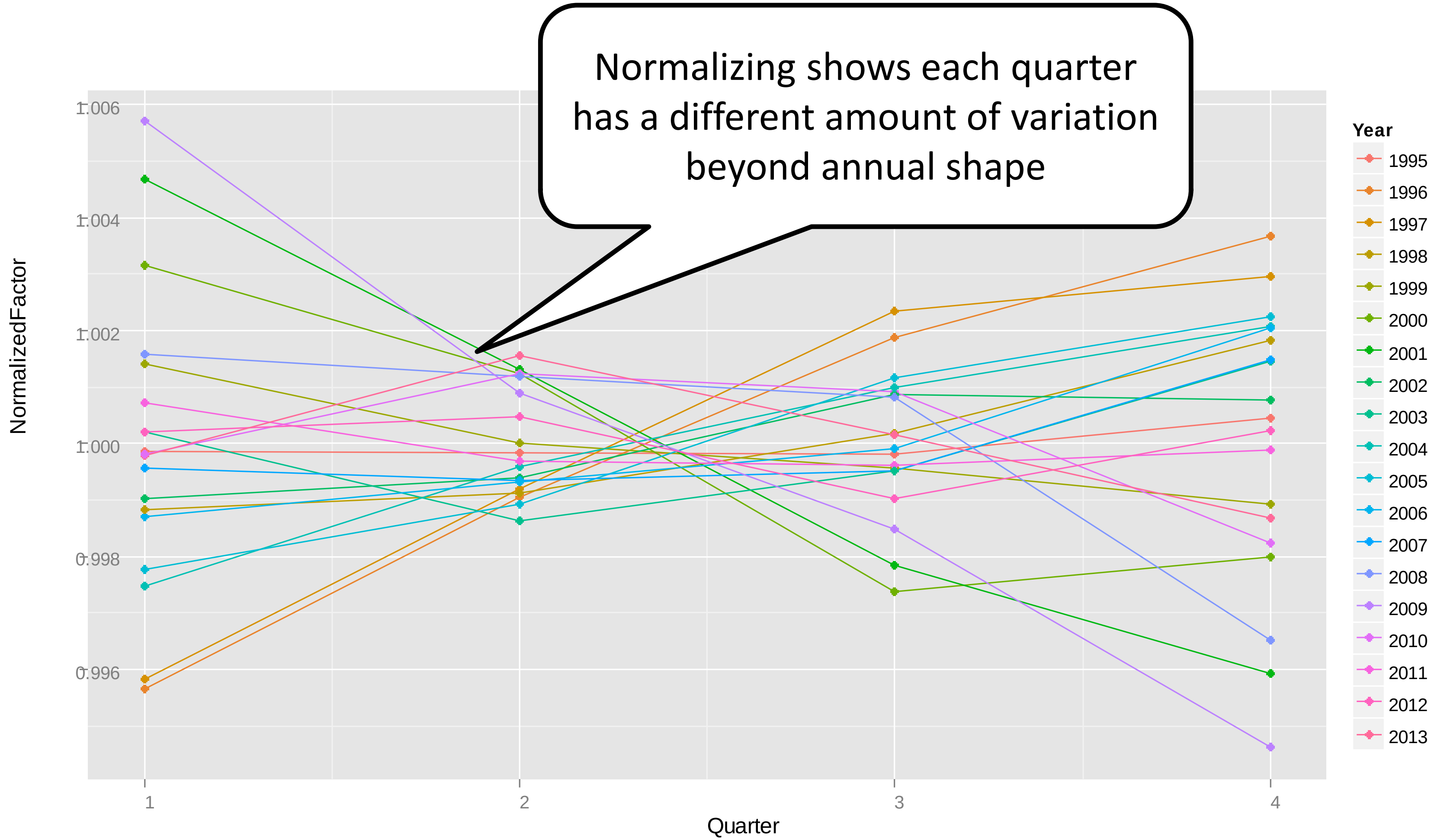

The load forecasts are shaped according to seasonal factors
The forecast "spread" grows over time
Load (aMW)
25000
22500
20000
0
20
40
60
80
Period
High
Low
Med

Load Risk Model DNA

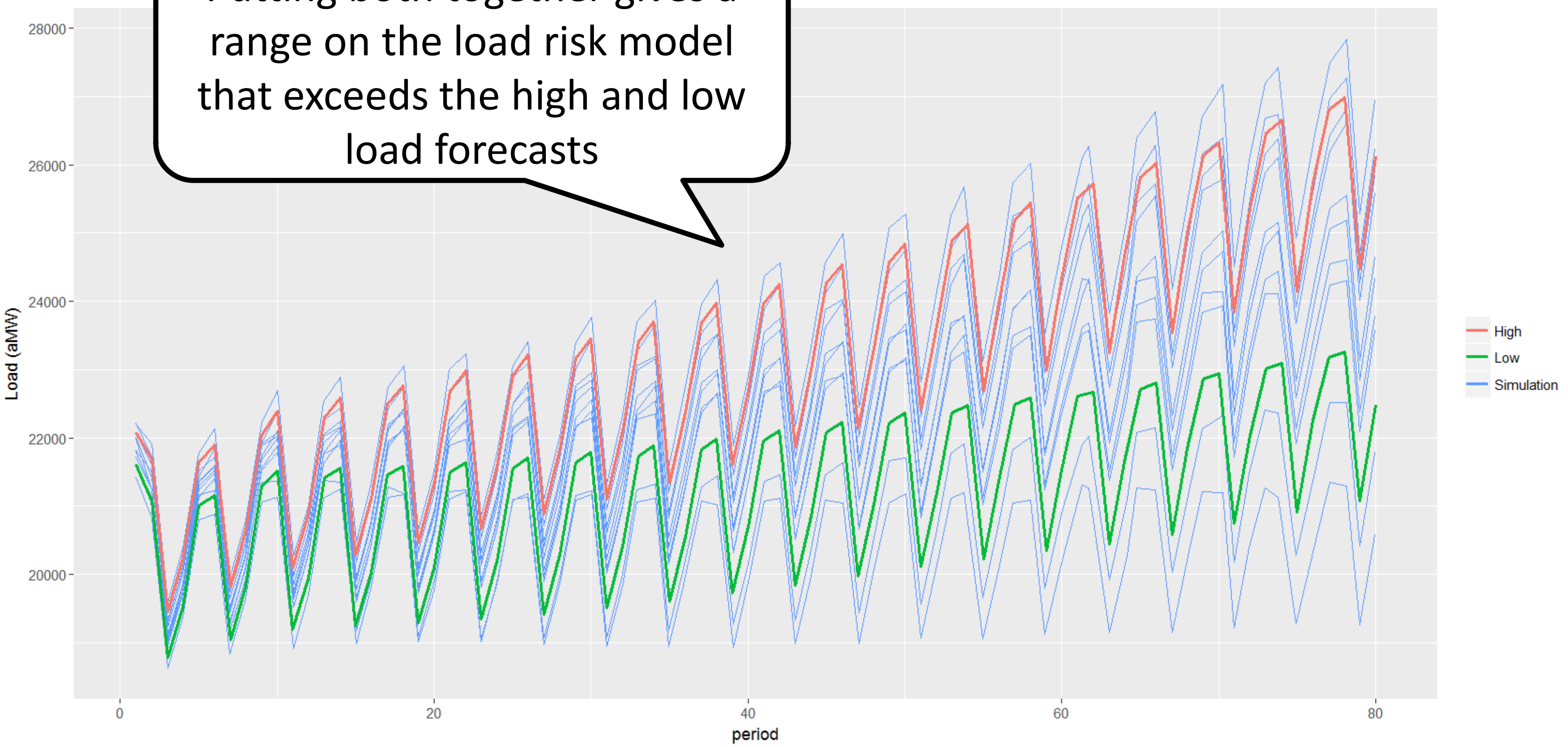
- Annual Trend Factor * Seasonal Factor * Jump Factor * Forecast
  - Annual Trend – varies the long-term economic projection, i.e. the model could select load growth of 2% per year or 0.5% per year
  - Seasonal – effectively makes some quarters more volatile than others, so winter is more likely to have a large load deviation than spring
  - Jump – simulates temporary or permanent deviations in load, e.g. adding a large industrial load

Load Model Example




Normalizing shows each quarter has a different amount of variation beyond annual shape
NormalizedFactor
1.006
1.004
1.002
1.000
0.998
0.996
Quarter
1
2
3
4
Year
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

Putting both together gives a range on the load risk model that exceeds the high and low load forecasts



Extra Slides

Annual Trend Factors

- Controls Annual Spread in RPM
- Of the form:

$$P_{t,i} = e^{\alpha_F \varepsilon_{F,i} + \alpha_L \varepsilon_{L,i}(y_t - y_0) + \alpha_Q \varepsilon_{Q,i}(y_t - y_0)^2}$$

where $y_t = year\ at\ time\ t$; α_F, α_L and α_Q are parameters; and $\varepsilon_{F,i} \sim \varepsilon_{L,i} \sim \varepsilon_{Q,i} \sim N(0,1)$

Seasonal Factors

- Add deviation from annual trends
- Of the form:

$$S_{t,i} = e^{\tau_{q_t,i}}$$

where $\tau_{q_t,i}$ is a normal random variable.

Load Model Example

- Seasonal factor only impacts volatility not the shape
- Historic load must be adjusted for DSIs
- Seasonal shapes can be estimated from the adjusted historic load

The factor only depends on the quarter since

it is of the form

$$S_{t,i} = e^{\tau q_{t,i}}$$

Jump Factors

- Controls temporary deviations from the annual trend, i.e. jumps
- Of the form:

$$J_{t,i} = e^{I_{\{\beta_i < y_t - y_0 < \beta_i + \omega_i\}} \xi_i - I_{\{\beta_i + \omega_i < y_t - y_0 < \beta_i + \omega_i + e^{\xi_i}\}} \xi_i / \gamma}$$

where β_i and ω_i and ξ_i are all uniform random variables and γ is a scaling factor.

Load Model Example

- Estimate factors using simple linear regression

That is, if H_t, M_t and L_t are the high, medium and low load forecasts respective then use regression to find a, b and c in

$$\ln(H_t/M_t) = a + b(y_t - y_0) + c(y_t - y_0)^2 + \epsilon$$

Load Model Example

We want a value where the probability of exceeding it is .85, which is the probability associated with the high load forecast. Since we have normality

$$\Pr\left[{}^{\alpha_L}/_{20} * \varepsilon_{L,i} < {}^{\alpha_L}/_{20} * z_{.85}\right] = .85$$

Thus we set

$$b = {}^{\alpha_L}/_{20} * z_{.85}$$

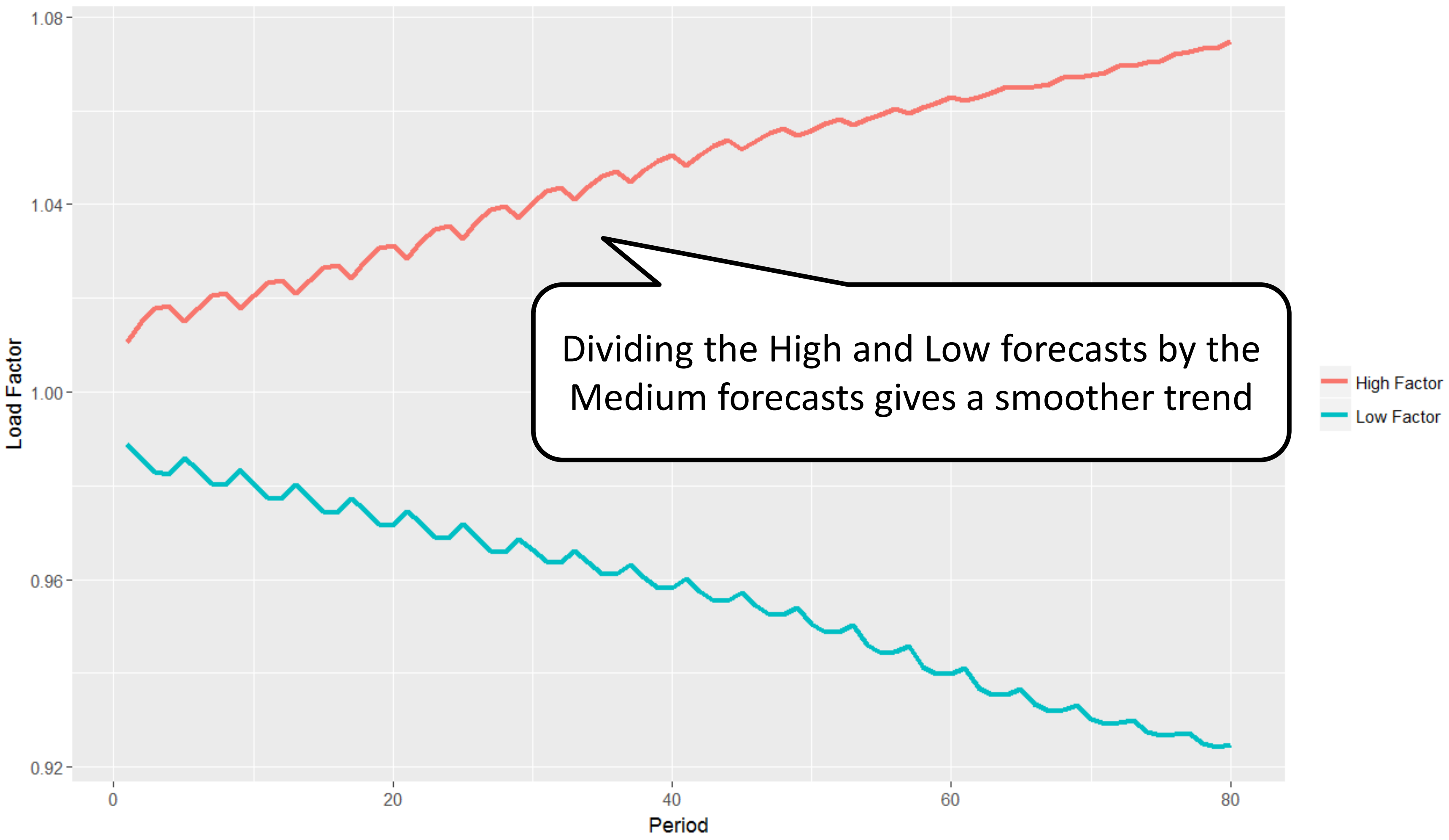
Which implies

$$\alpha_L = {}^{20b}/_{z_{.85}}$$

This gives $\alpha_F = .0102$, $\alpha_L = .0632$ and $\alpha_Q = .0221$

Load Model Example

- Factors grow through time relatively smoothly by year
- Combining inputs, some context and RPM parametric assumptions (mostly log-normal assumptions) allows for estimating parameters for the model
- Load high/low forecast **directly** informs the risk model


1.08
1.04
1.00
0.96
0.92
Load Factor
0
20
40
60
80
Period
Dividing the High and Low forecasts by the Medium forecasts gives a smoother trend
High Factor
Low Factor