Northwest **Power** and **Conservation** Council

February 6, 2018

MEMORANDUM

TO: **Power Committee**

FROM: **Massoud Jourabchi**

SUBJECT: **Review of Load Forecasting Methodology and its linkage to other analytical tools**

BACKGROUND:

Presenter: Massoud Jourabchi

Summary: Load forecasting is a cornerstone of power planning activities at the Council. In this presentation we will re view the enduse forecasting approach used in the Council. We will also show how load forecast is integrated with conservation resource planning and other council analytics.

Relevance: Long-term load forecast is an essential step in development of the Power Plan. As we prepare for the Mid-Term assessment and 8th Plan it is important to revisit the methodology, inputs and outputs from the forecasting model/s.

Workplan: A.3. Forecasting and Economic Analysis

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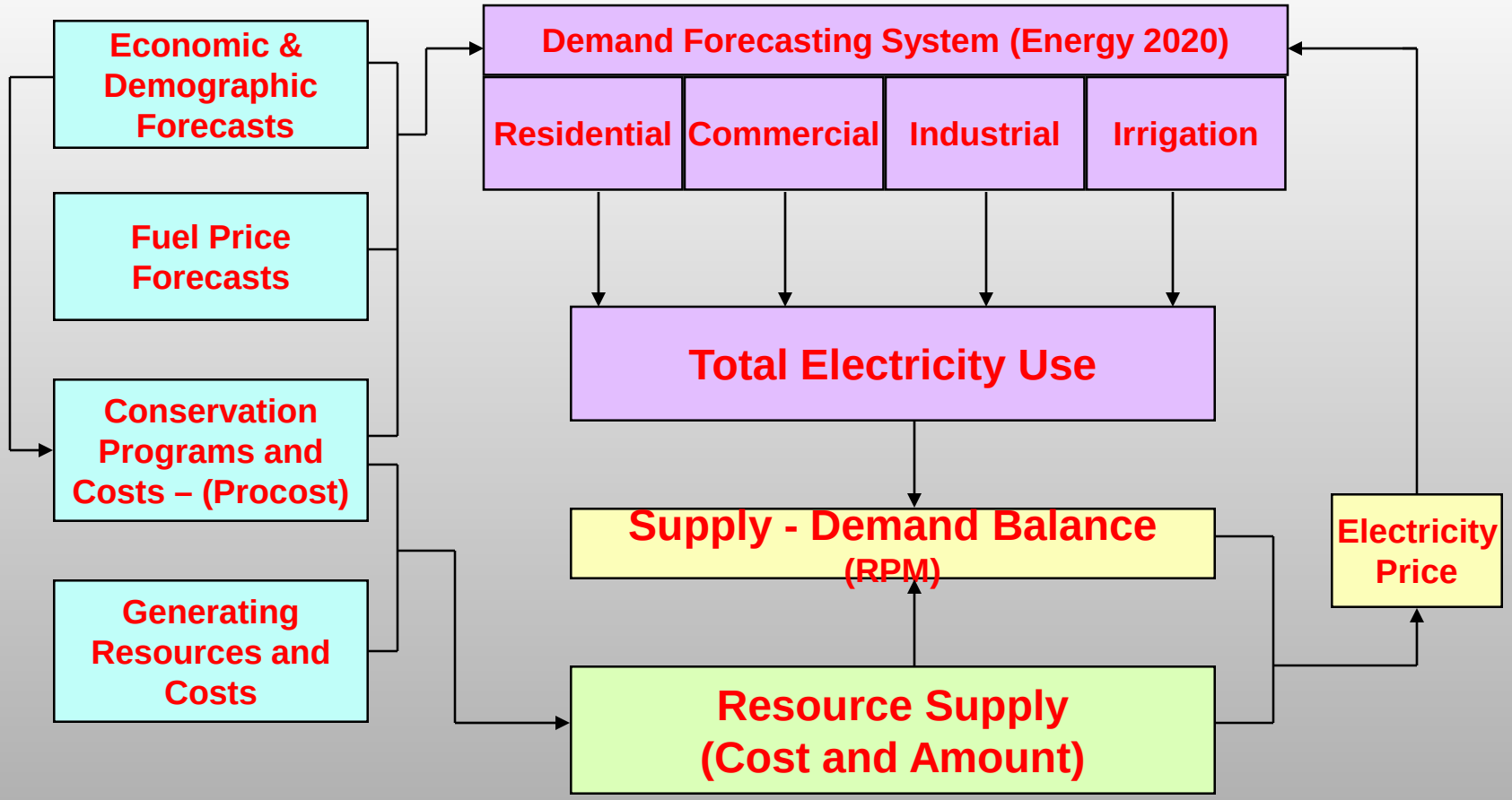
A Review of Load Forecasting and its linkage to other analytical Tools

Massoud Jourabchi

February 13, 2018

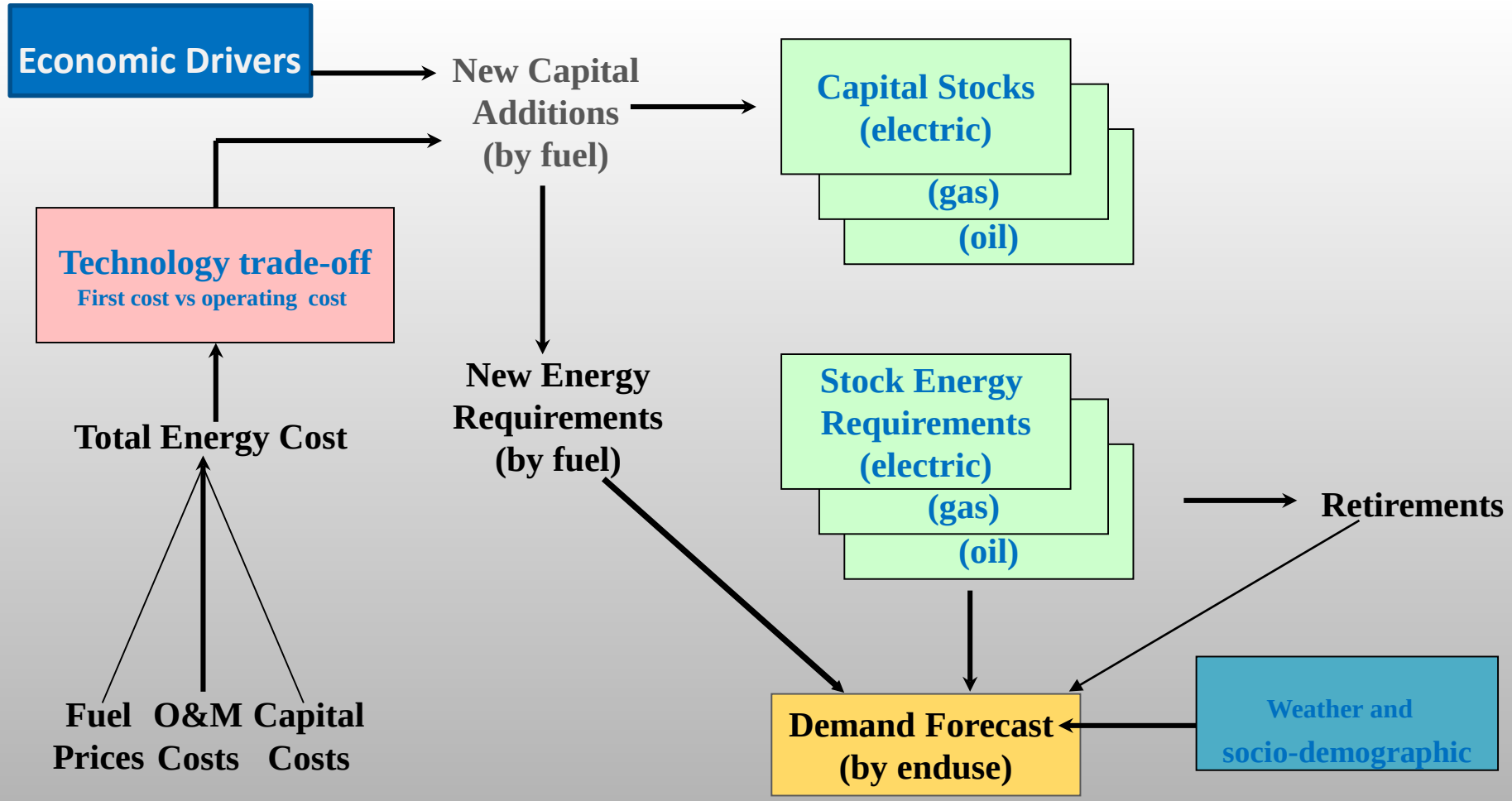
Council's Power Planning Process



Major Factors Influencing Demand

- Long-term factors
  - Economic Activity
  - Energy Prices
  - Technology choices
  - Socio-economic trends
- Short-term factors
  - Temperature conditions (extreme weather)
  - Income

Demand Forecast Overview



Tracking Energy Demand

Investments

Production Capacity

Process Energy Requirements

Device Energy Requirements

Energy Demand

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Basic Building Blocks of Long-term Forecasting Model (LTM)

For each enduse in each sector in each state
Demand for energy is determined in part by three factors:

- **Number of Units (A)**
- **Fuel efficiency choices (B)**
- **Fuel choice (C)**

Energy use by an enduse = A * B * C

Number of Units (A)

- Driven by the economic forecast
  - Number of Existing home and their square footage
  - Number of New Homes (Single, Multi, Manuf.)
  - Square footage of existing commercial buildings
  - Square footage of new commercial buildings
  - Level of production from industrial, agricultural and mining firms
  - Income of residential sector
- Source of information: (Global Insight and in-house analysis)
- Review: by State economists and Demand Forecasting Advisory Committee
- Can be updated 5 years.

Fuel Efficiency Choices (B)

- Consumer choice that is critical to the energy decision making process is the Efficiency/capital cost trade-off.

- Trade-off between high up-front costs and high operating cost.
- If a very high efficiency water heater is purchased, the capital cost will be large, however, the operating costs in the future will be lower than with a lower efficiency water heater.

- Source of information: Various sources and studies (LBL, DOE,...)
- Review process : Demand Forecast Advisory Group and In-house
- Frozen efficiency forecast is created by holding the greater of base year efficiency or the federal or state Standard or code induced efficiency.
- Can be updated every five years.

Fuel Choice (C)

Customer trading off one fuel for another on the basis of relative cost of fuels, cost factors considered include:

- Capital Cost
- Operation and maintenance cost
- Non-price factors such as customer preference for one fuel over another
- Availability of fuel

Source of Information:

- Historic retail fuel prices,
- National and regional survey of customer choices (RBSA,CBSA,IFSA, others)
- Calibration demand to 1985-2012 (for the 7th plan)

Review process: Demand Forecast Advisory Group

- Can be updated every 5 years or as regional surveys become available.

Illustrative Example
Demand from Water Heating
in New Homes

Electric water heaters demand in new homes is calculated as:

A. Number of new single family homes: 20,000/yr
B. Baseline Electricity Efficiency: 0.90 Energy Factor = 3600 kWh/yr
C. Fuel share of electric water heaters: 69%

- Electricity Demand for water heating added per year is

  20,000*.69*3600= 49,680 MWH = 5.67 aMW

Similar approach is used for existing homes. Existing homes are tracked over-time and the energy use is reduced each year based on the physical life of the device (i.e., as existing units fail, they are replaced units meeting federal minimum efficiency standards).

Demands for a wide range of Fuels is tracked

- Electric
- Natural Gas
- Propane/butane
- Oil
- Solar (PV)
- Biomass
- Coal
- Diesel
- Ethanol
- Heavy Fuel Oil
- Kerosene
- Light Fuel Oil
- Motor Gasoline
- Naphtha specialties
- Aviation Fuel

Residential Energy Demands

- Economic Categories - Single Family, Multi-family, Manufactured/mobile homes
- Enduse – Space Heating(baseboard, Heat-pump, ductless Heat Pump...) , Water Heating by size, Cooking, Dishwashing, Clothes Washing, Drying, Refrigeration, Freezing, Lighting, Air Conditioning, Entertainment (TV, computers), Other plug loads
- Fuels - Electric, Gas, Coal, Oil, Biomass, Solar (passive and PV) , propane/butane

Commercial Economic Categories

- Large Office
- Medium Office
- Small Office
- Big Box-Retail
- Small Box-Retail
- High End-Retail
- Anchor-Retail
- K-12
- University
- Warehouse
- Supermarket
- Mini-Mart
- Restaurant
- Lodging
- Hospital
- Other-Health
- Assembly
- Other

Commercial Demands

- Enduse – Space Heating, Water Heating, Cooking, Refrigeration, Lighting, Air Conditioning, Ventilation, Plug-loads
- Technologies/fuels – Electric, Gas, Coal, Oil, Biomass, Solar, LPG, Steam

Industrial Economic Categories

- Food & Tobacco
- Textiles
- Apparel
- Lumber
- Furniture
- Paper
- Printing
- Chemicals
- Petroleum Products
- Rubber
- Leather
- Stone, Clay, etc.
- Primary Metals
- DSI aluminum
- Fabricated Metals
- Machines & Computer
- Electric Equipment
- Transport Equipment
- Other Manufacturing
- Mining
- Data Centers
- Agriculture (Irrigation)

Industrial Demands

- Enduse – Process Heat, Motors, Other Substitutable, Misc.
- Cogeneration
- Feedstocks
- Technologies/fuels – Electric, Gas, Coal, Oil, Biomass, Solar, Propane/butane, Steam

Transportation Demands

- Economic Categories
  - Passenger
  - Freight
  - Off Road
- Enduse – Transport

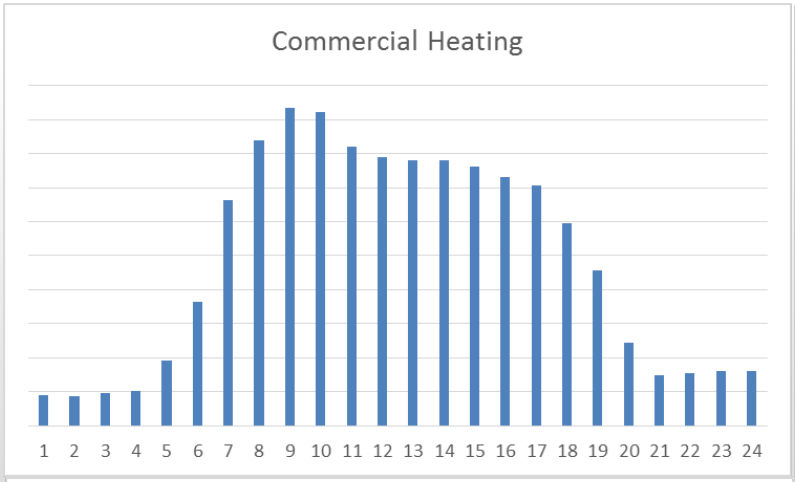
Transportation Technologies

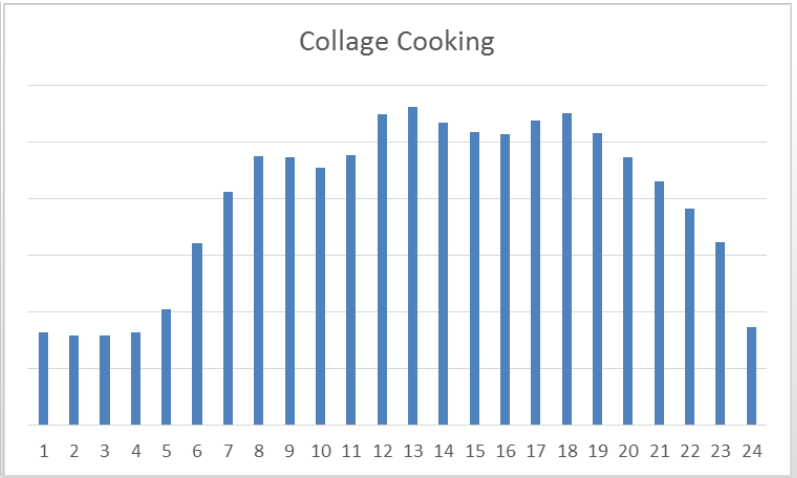
- Light Propane
- Light CNG
- Light Electric
- Light Ethanol
- Light Gasoline-electric hybrids
- Light Hybrid Diesel
- Light Fuel Cell Gasoline
- Light Fuel Cell CNG
- Light Fuel Cell Hydrogen
- Medium Propane
- Medium CNG
- Medium Ethanol
- Medium Hybrid Gasoline
- Medium Hybrid Diesel
- Medium Fuel Cell Gasoline
- Medium Fuel Cell CNG
- Medium Fuel Cell Hydrogen
- Heavy Propane
- Heavy CNG
- Heavy Ethanol
- Heavy Hybrid Gasoline
- Heavy Hybrid Diesel
- Heavy Fuel Cell Gasoline
- Heavy Fuel Cell CNG
- Heavy Fuel Cell Hydrogen

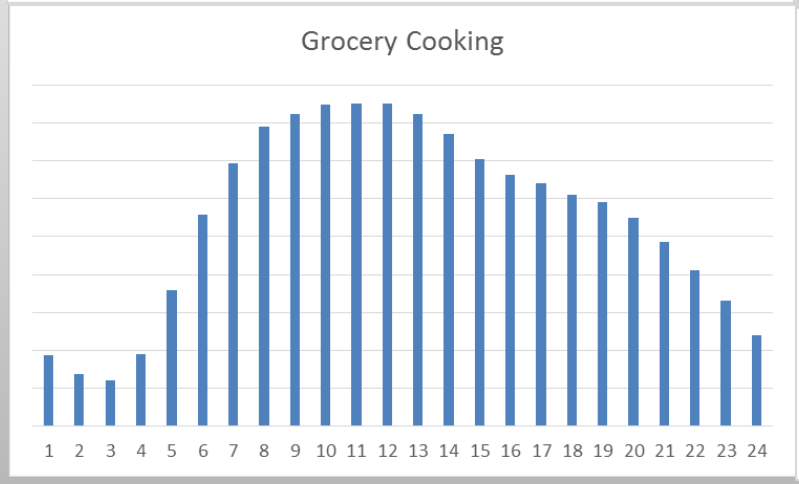
From Demand to Loads

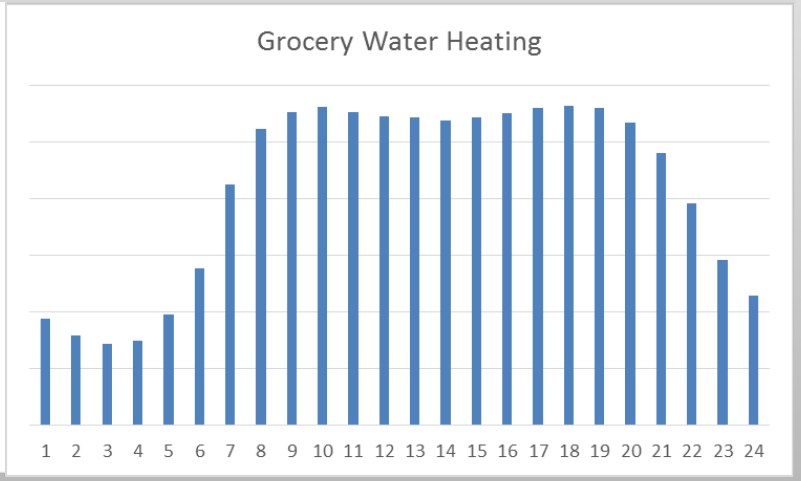
- Demand for energy is measured at the point-of-use, behind the meter.
- Load is measured at the point-of-generation (includes Transmission and Distribution losses)
- We use hourly enduse load shapes to convert annual and monthly demand into loads.

Examples of Commercial Sector Load Profiles

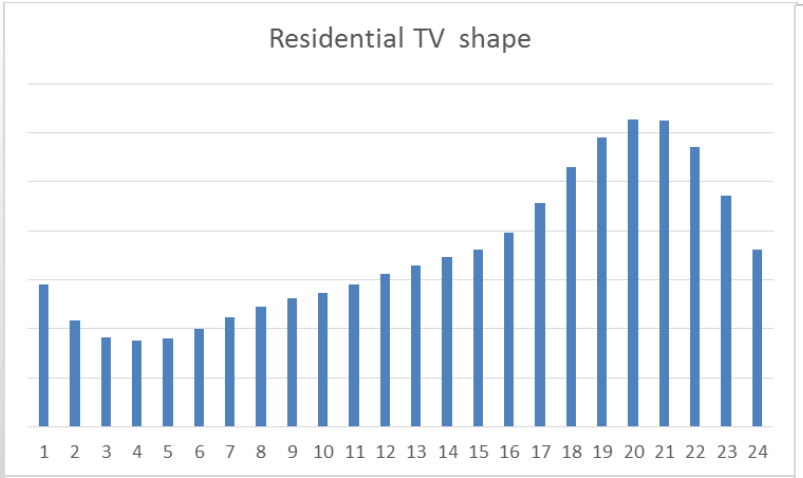


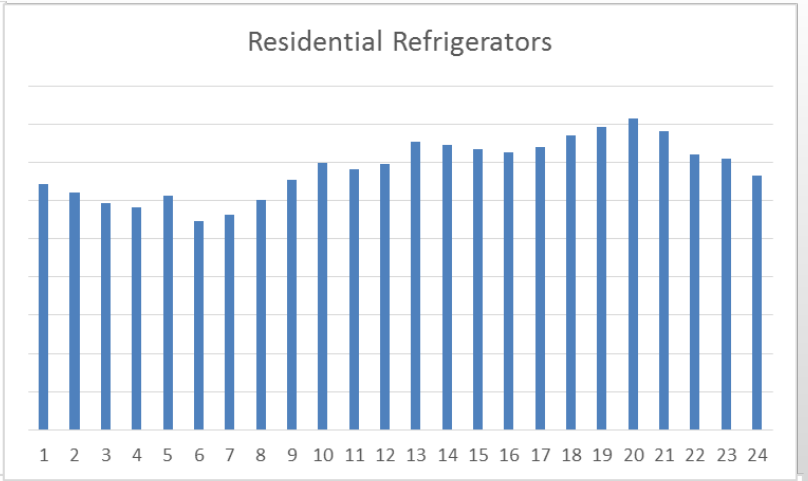


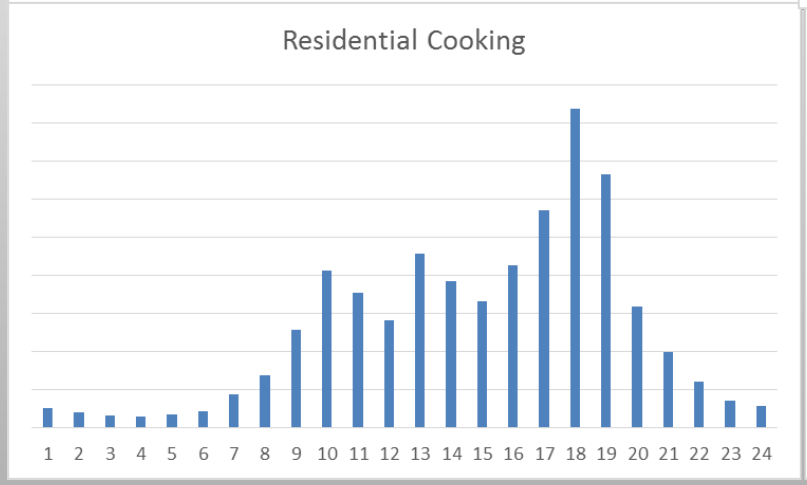


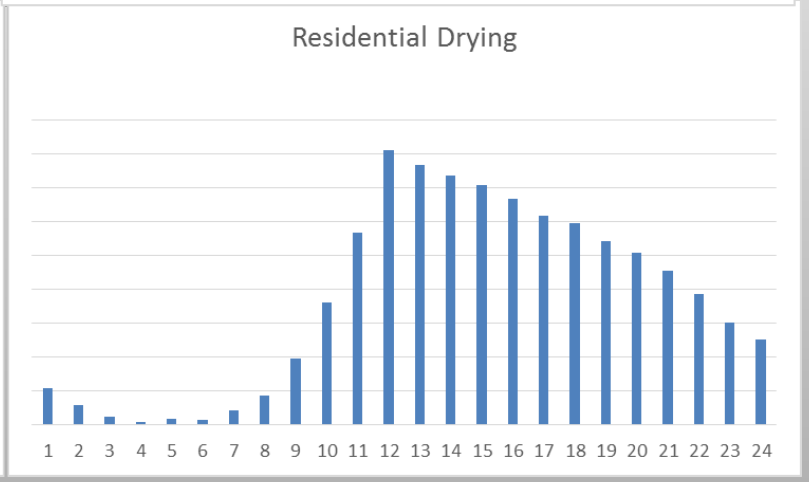


Examples of Residential Sector Load Profiles



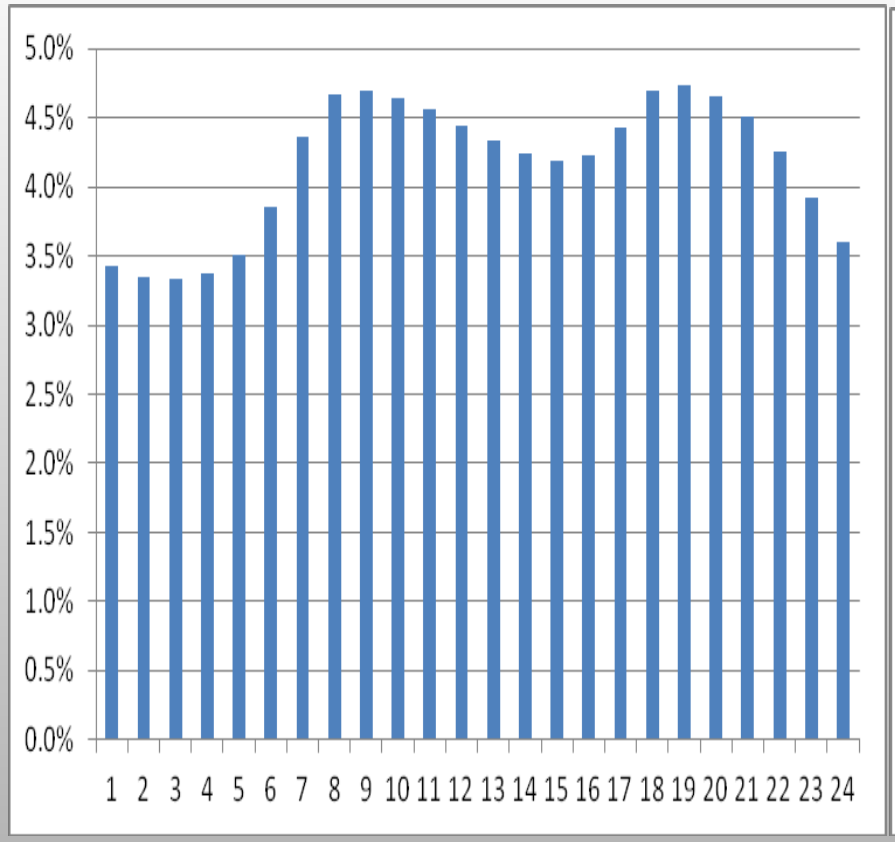




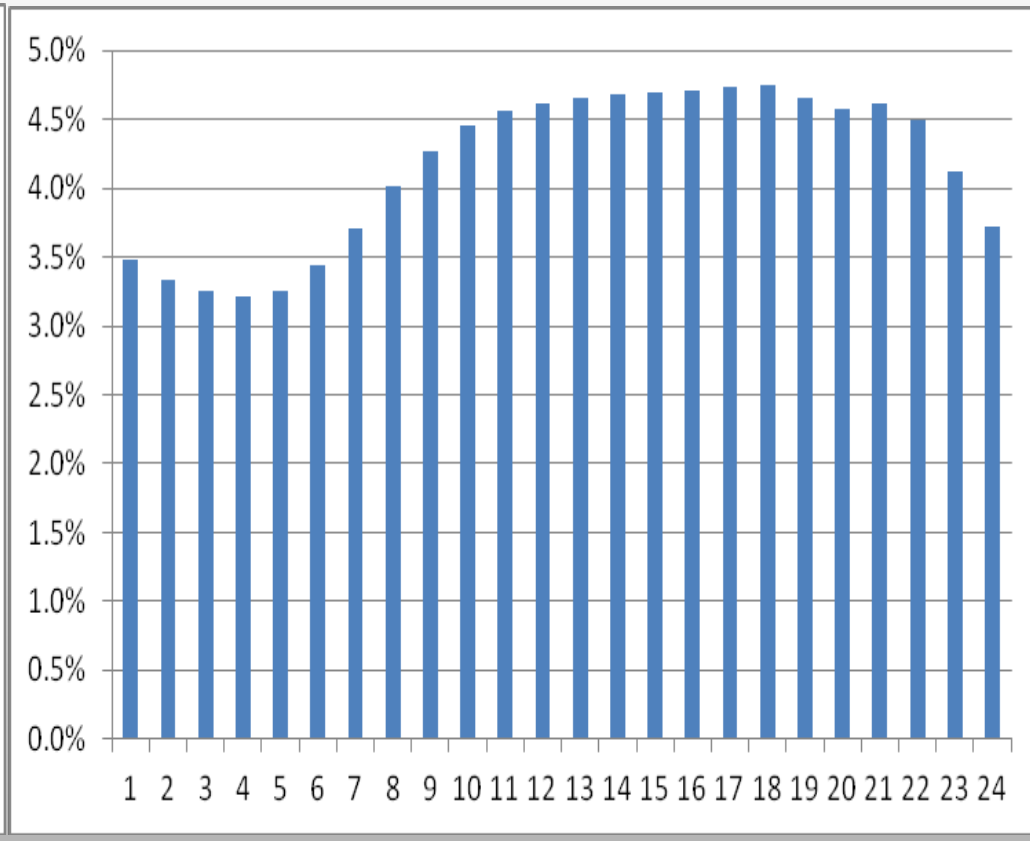


Typical System Load Profiles

Typical Winter Day Load Profile



Typical summer Day Load Profile



3 different load forecasts

1. Price-effect (it captures consumers response to retail prices)

2. Frozen Efficiency (base year efficiency is held constant, this forecast is used for conservation assessment work)

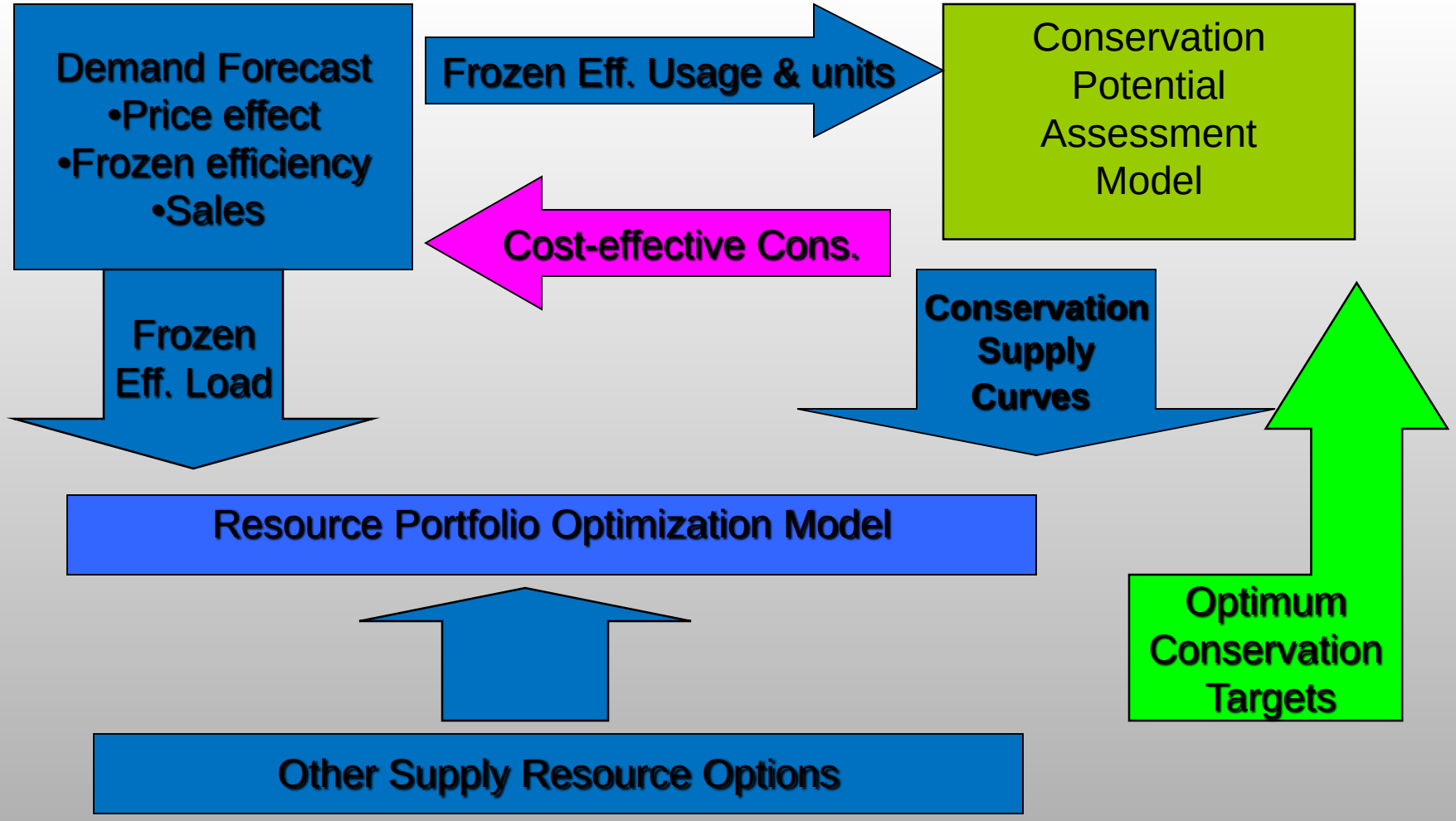
3. Sales (Frozen Efficiency forecast of loads net of optimized target conservation levels)

Comparison of the Three Energy Forecasts from the 7th Plan analysis (aMW)

Forecast	Scenario	2016	2021	2035	AAGR 2016-2035
Price-effect	Low	20,783	21,115	22,916	0.5%
Price-effect	High	21,427	22,395	26,073	1.0%
Frozen Efficiency	Low	20,781	21,117	22,976	0.5%
Frozen Efficiency	High	21,436	22,466	26,620	1.1%
Sales (FE-EE)	Low	20,611	19,720	18,632	-0.5%
Sales (FE-EE)	High	21,257	21,006	21,909	0.2%

By 2021, delta between Frozen Efficiency and Price-effect forecasts is between 2-71 aMW depending on the scenario.
By 2035 the delta increases to 60-550 aMW
However, by 2021 the forecasts will be updated.

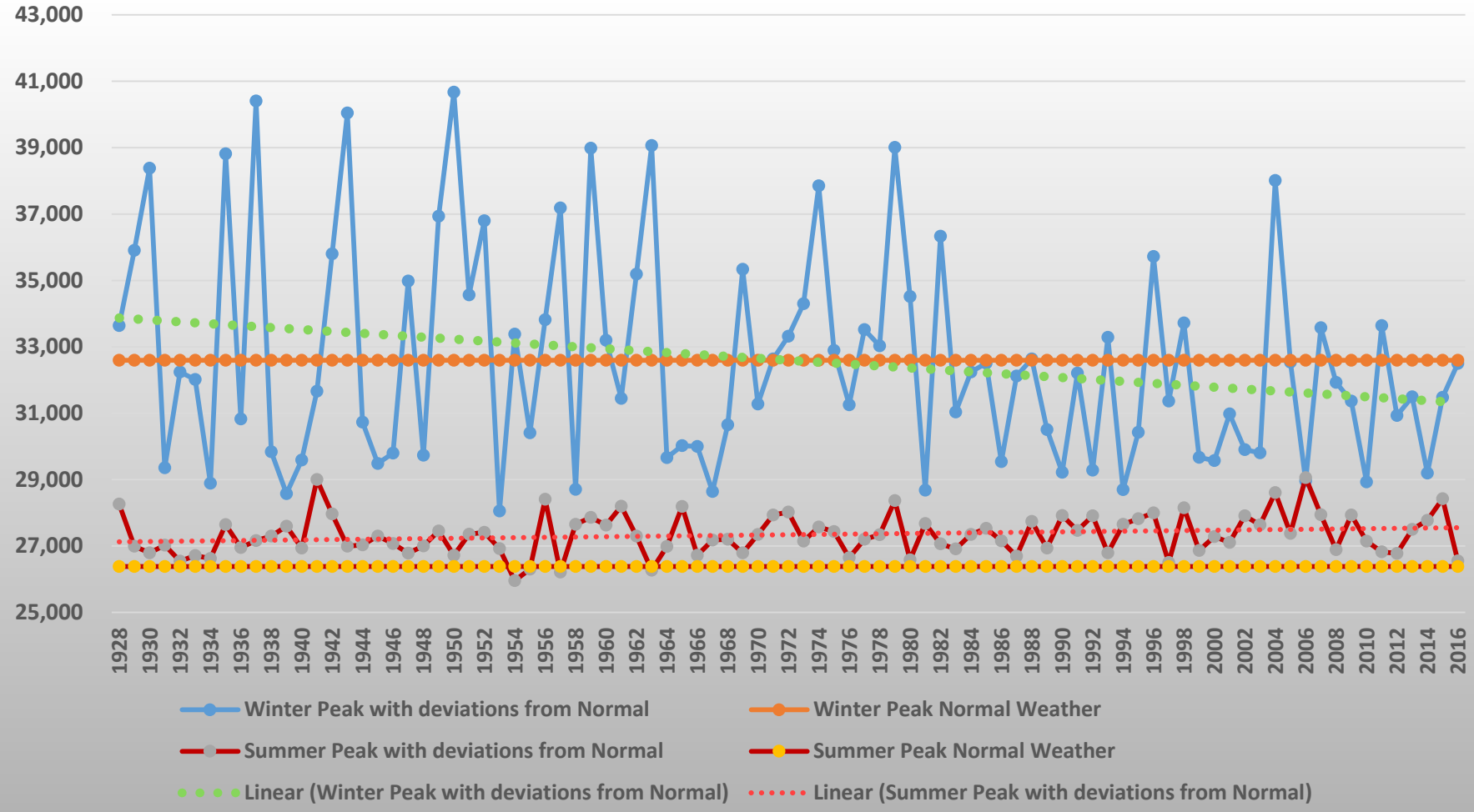
Demand forecast and Conservation Interface



Incorporating impact of temperature variations

- Currently LTM model is producing loads under normal weather.
- LTM is being modified to accommodate deviations from normal temperature, to simulate impact of extreme weather events of the past or forecasted climate change trends.

Example of Load impact of Variation from Normal Temperatures



Summary

- By the Act, Council is required to produce a long-term load forecast
- Council creates enduse level load Forecast.
- Long-term model produces three weather normalized forecast for loads in the region.
- Frozen-efficiency Forecast and the Conservation supply curves consistent with the forecast is provided to Regional Portfolio Model (RPM)
- In the Portfolio model, frozen efficiency load forecasts are subjected to 800 different futures. Optimum level of conservation acquisition as well as other resource options are determined.
- The target conservation levels are fed back to the demand forecast model to produce Sales forecast reflecting impact of conservation targets.
- Long-term model can be used for a variety of policy analysis including cap-and-trade, or deep decarbonization studies.
- Council annually produces short-term hourly forecast of loads for Resource Adequacy purposes. Different temperature profiles can be incorporated in the short-term model.
- Long-term model is being enhanced to produce load forecasts under a variety of temperature profiles.