

NOVEC Weather-Normalized Forecasting Model

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Contents

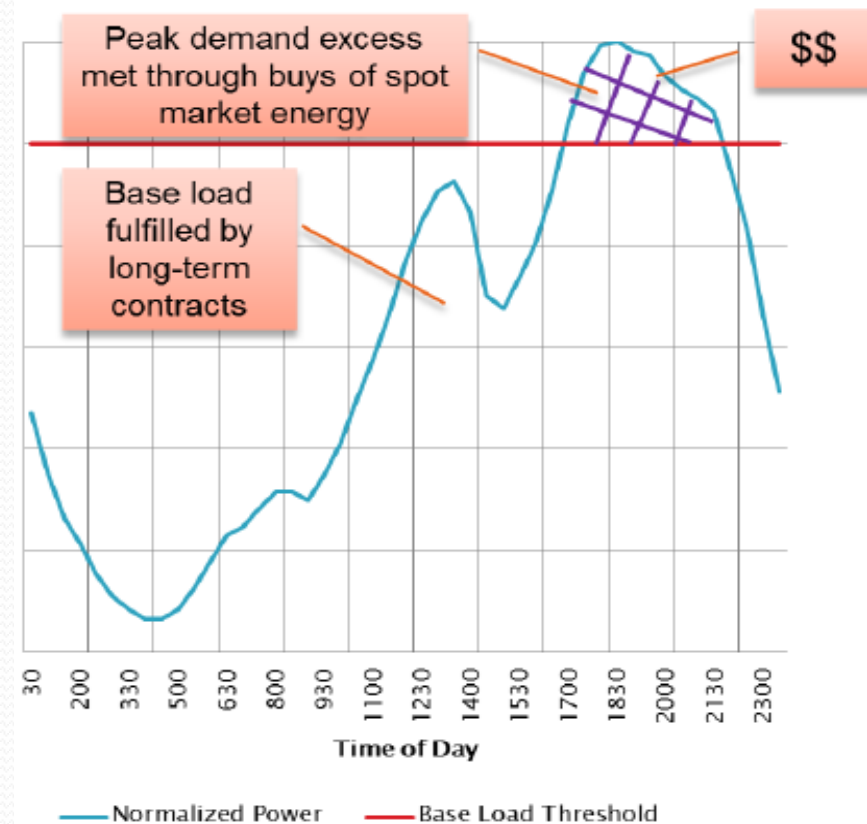
- Context
- Problem Statement
- Method of Analysis
- Forecasting Model
- Way Forward
- Earned Value

NOVEC Background (1 of 2)

- Northern Virginia Electric Cooperative (NOVEC) is a distributor of energy to 6 counties in Northern Virginia.
 - Nearly 150,000 customers.
 - Mandated to meet all energy requests in pre-specified zones of obligation.
 - Primary means to service communities is through bulk energy market purchases.

NOVEC Background (2 of 2)

- Energy Purchases:
 - 1) Bulk purchases via contracts 1 month to 3 years prior to delivery.
 - 2) Spot purchases as needed to meet peak demand up to one day prior to delivery.



Problem Statement

- Warming trends have caused NOVEC to question whether the current weather-normalization methodology is still the best available model.
- NOVEC needs a new weather-normalization method that accounts for changing weather trends or a recommendation that the existing model is sufficient.

To what extent is the climate and its impact on energy demands changing?

Purpose & Objectives

- Purpose:

- NOVEC needs to remove weather-effects from energy consumption to more accurately inform bulk purchases.
- Explore and recommend a methodology to normalize monthly energy purchases.

- Objectives:

- Characterize the relationship between economic variables, weather, customer-base, and energy consumption.
- Develop a normalization procedure to remove weather effects from energy demand.

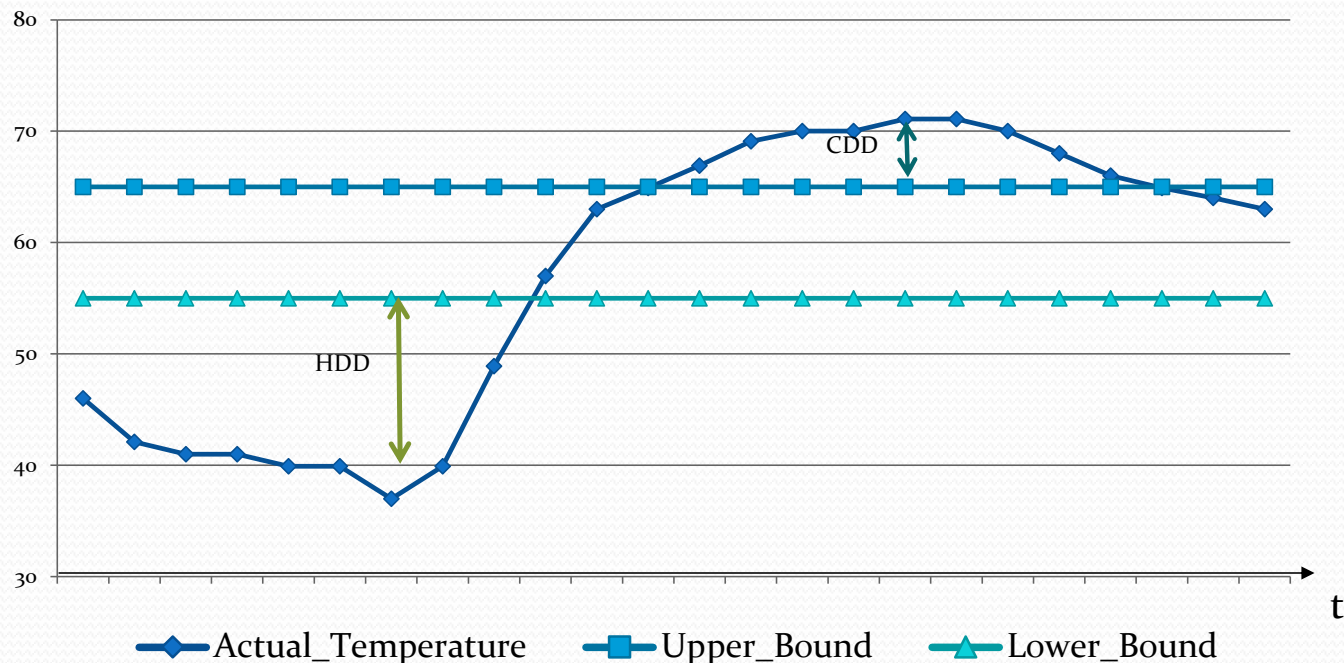
Recommendation for improvement to current weather-normalization methodology.

Scope

- Data:
 - NOVEC monthly energy purchases data since 1983.
 - Dulles weather data since 1963.
 - Historic economic factors data since 1980s.
 - 30 years of forecasted economic factors.
- Model:
 - Parameters: historic energy purchases, weather data, economics, and customer-base.
 - Predictions for energy consumption over a 30-year horizon.
 - Regression: characterize dynamics between parameters.
 - Weather-normalization: remove seasonal weather impacts on NOVEC's load.
 - Forecast: facilitate testing of varied normalization methodologies.
 - Ensure synergy with NOVEC's existing suite of models (regression, weather-normalization, forecast).

Key Definitions

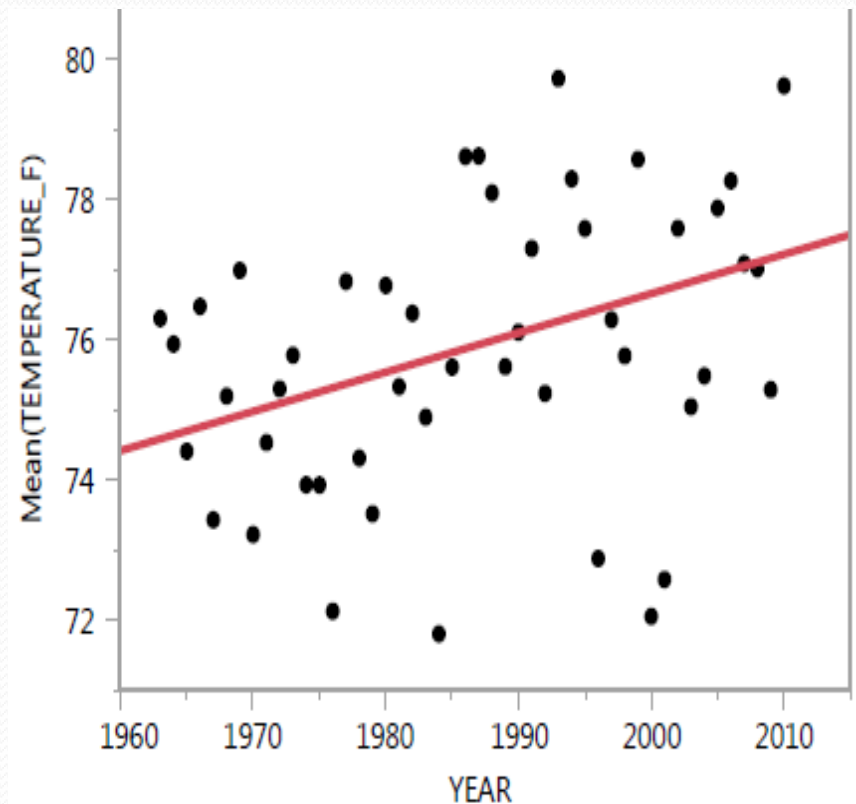
- CDD: Cooling Degree-Day = $\text{MAX}(\text{ActualDegree} - \text{UpperBound}, 0) * \text{Duration}$.
- HDD: Heating Degree-Day = $\text{MAX}(\text{LowerBound} - \text{ActualDegree}, 0) * \text{Duration}$.
- Neutral zone: Upper and lower bounds for temperatures that do not impact load.



* Analysis will explore varied upper/lower bounds for temperature

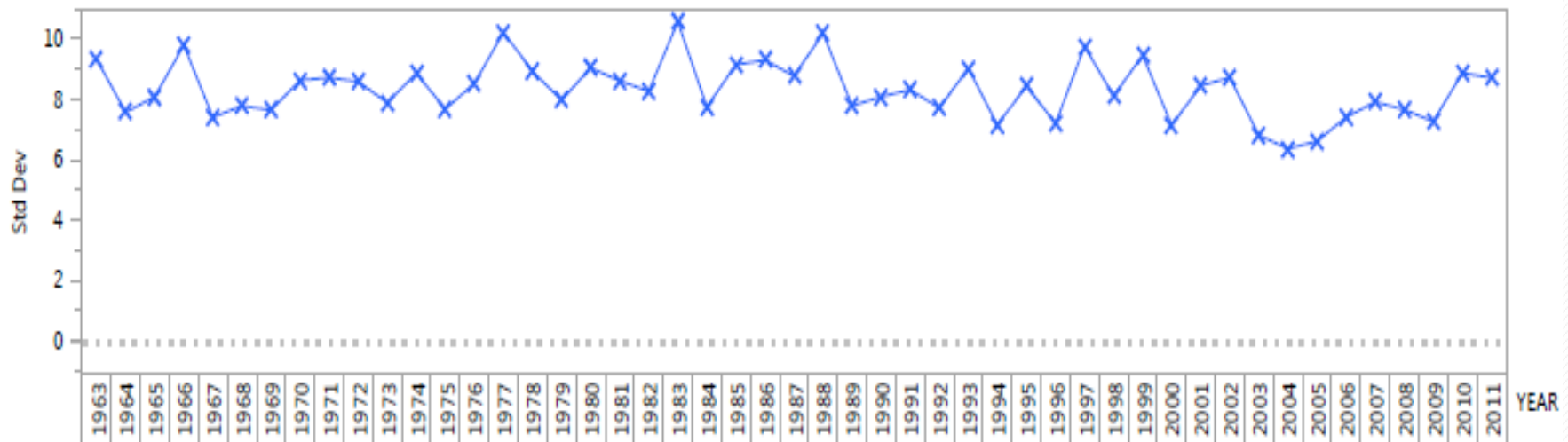
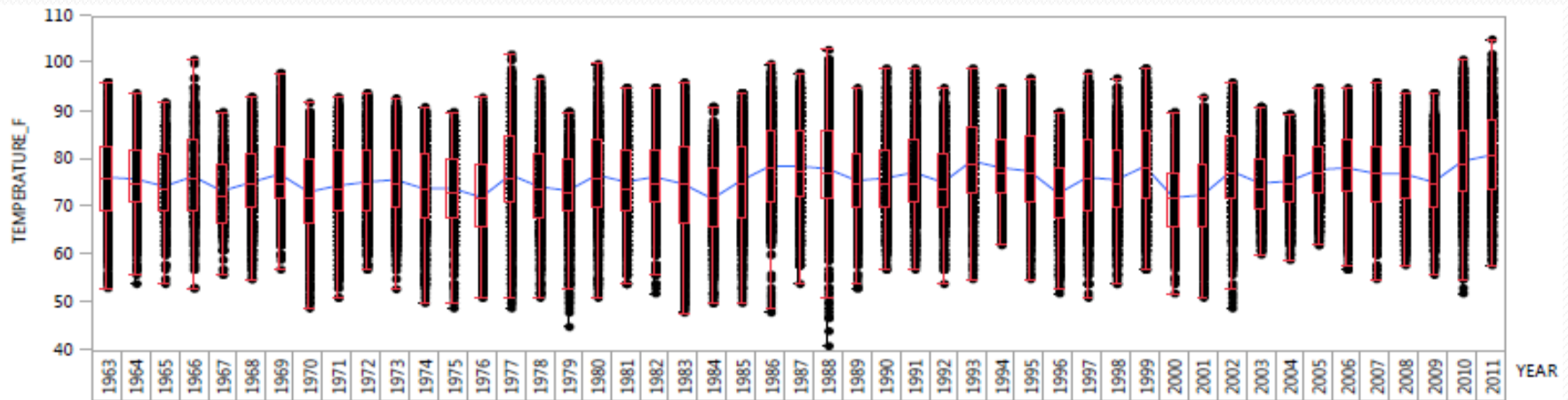
Weather Data Visualization (1 of 2)

- Historic weather data was analyzed by average temperature per month to view trends.
- Average temperature trending upwards from 1960 to the present for each month (graph is for July).



Weather Data Visualization (2 of 2)

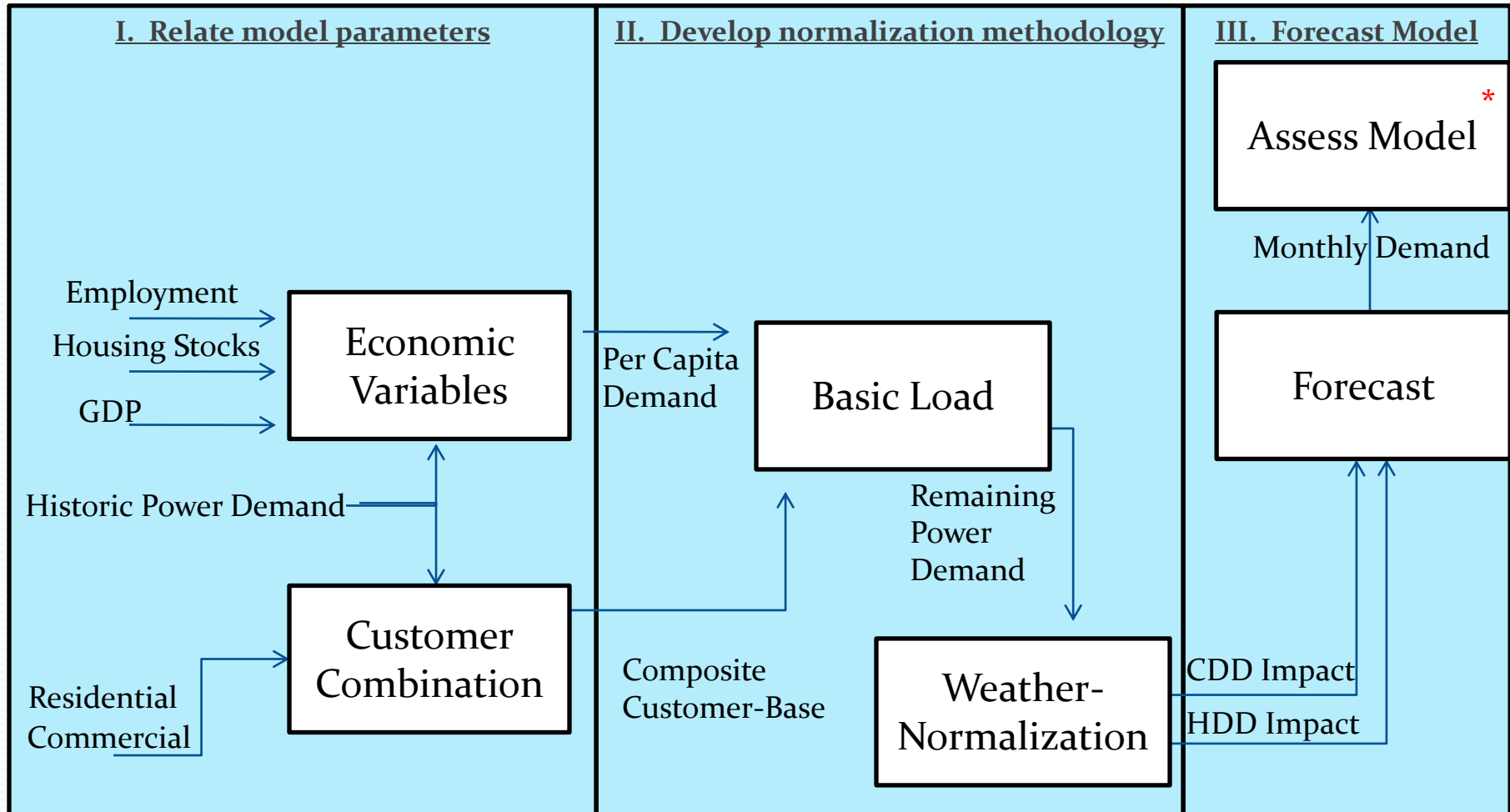
- Variance was also evaluated and no change is seen.



Essential Elements of Analysis & Measures of Effectiveness

- EEA 1: What is the rate of climate change?
 - MoE 1.1: Seasonal trends and variability.
 - MoE 1.2: Rate of climate change.
- EEA2: What econ-model best predicts NOVEC's customer-base?
 - MOE 2.1: Best subset of econometrics to gauge service demand.
 - MOE 2.2: Goodness of fit test for selected model.
- EEA3: What impact does weather have on energy demand?
 - MOE 3.1: Relationship between weather and load beyond base demand.
 - MOE 3.2: Changes in climate compared to per capita consumption.
 - MOE3.3: Goodness of fit test for selected model.

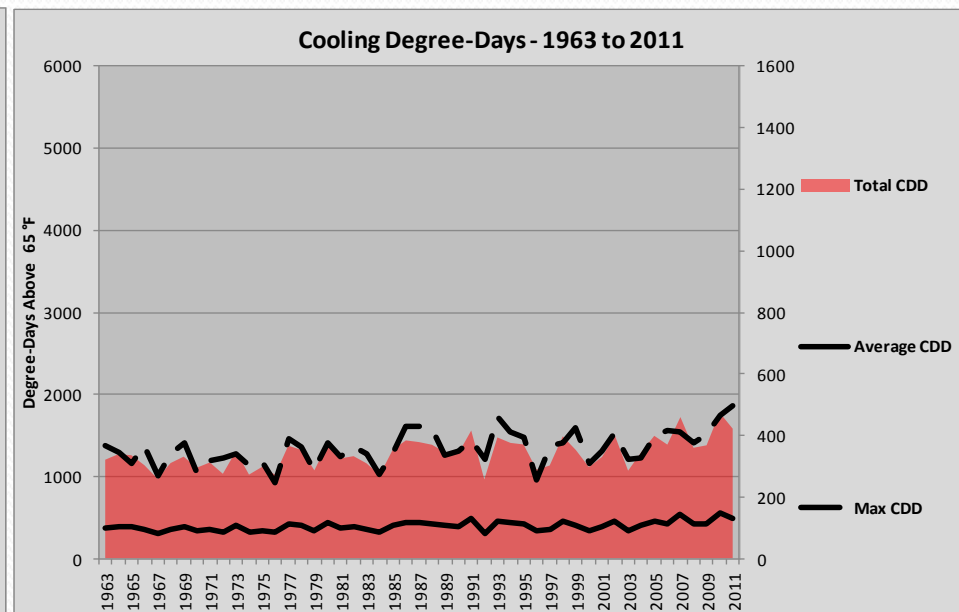
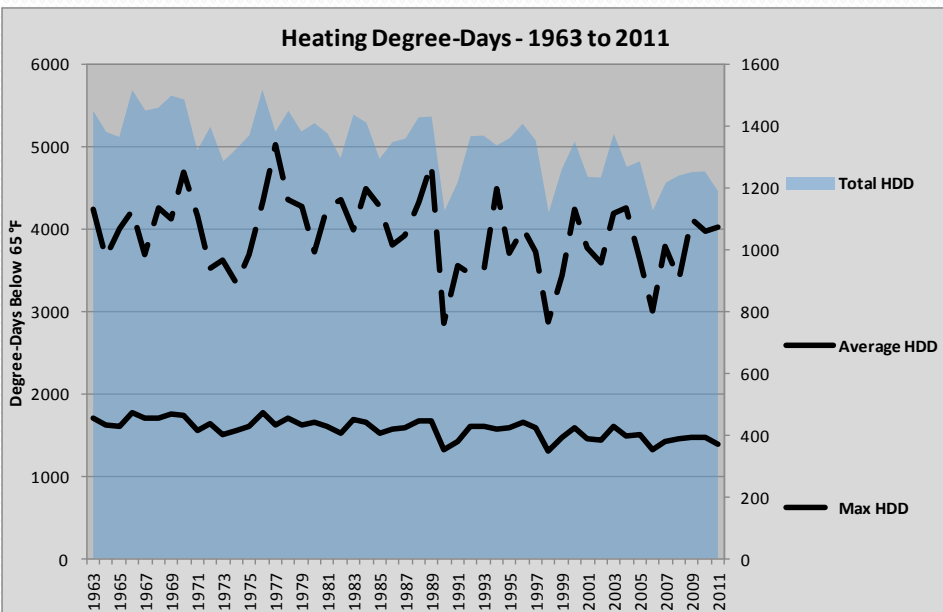
Methodology



* Model forecast will be verified against 2012-2013 power demand and compared to existing model's accuracy.

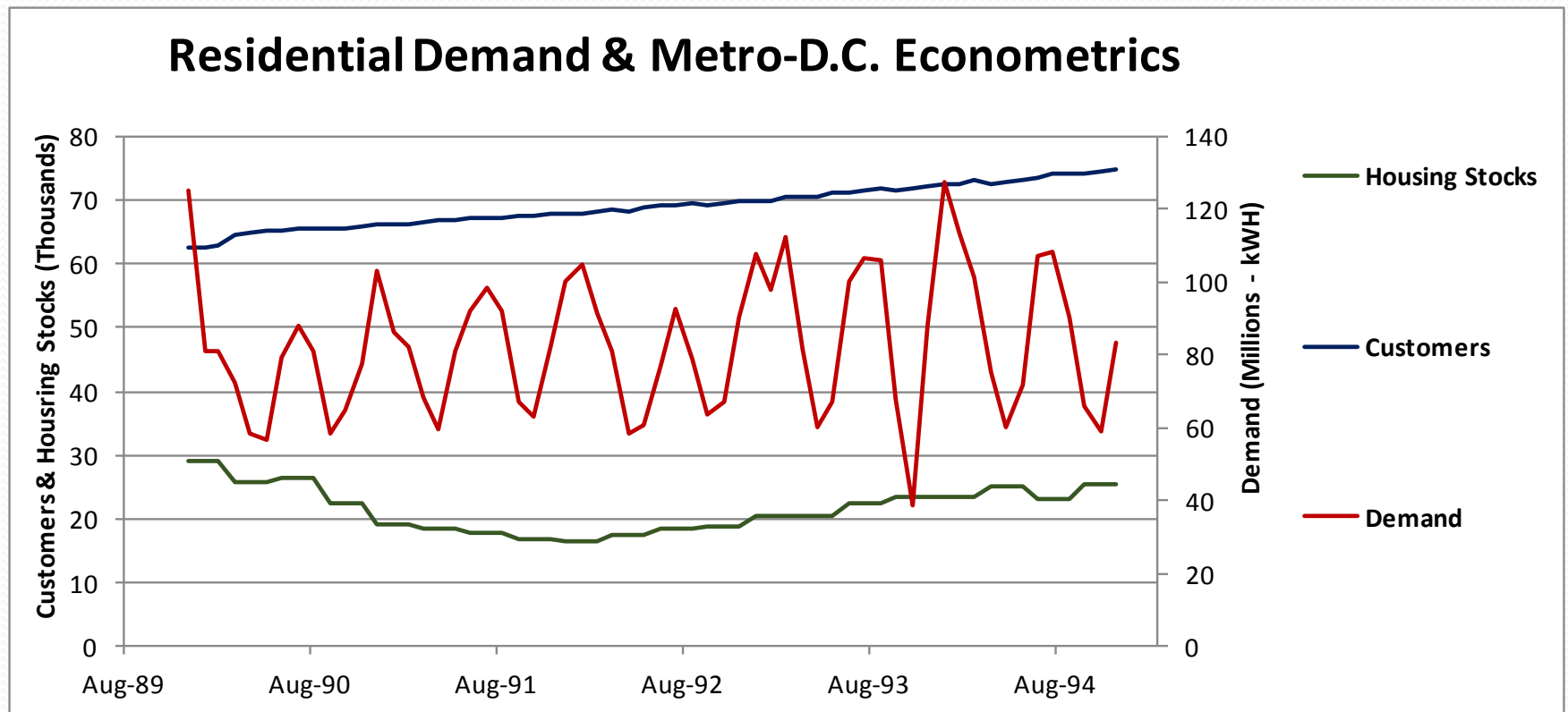
EEA1: Rate of Climate Change

- Historic weather data was analyzed to determine trends:
 - Seasonal fluctuations.
 - Overall rate of change.
 - Characterize uncertainty/variability.



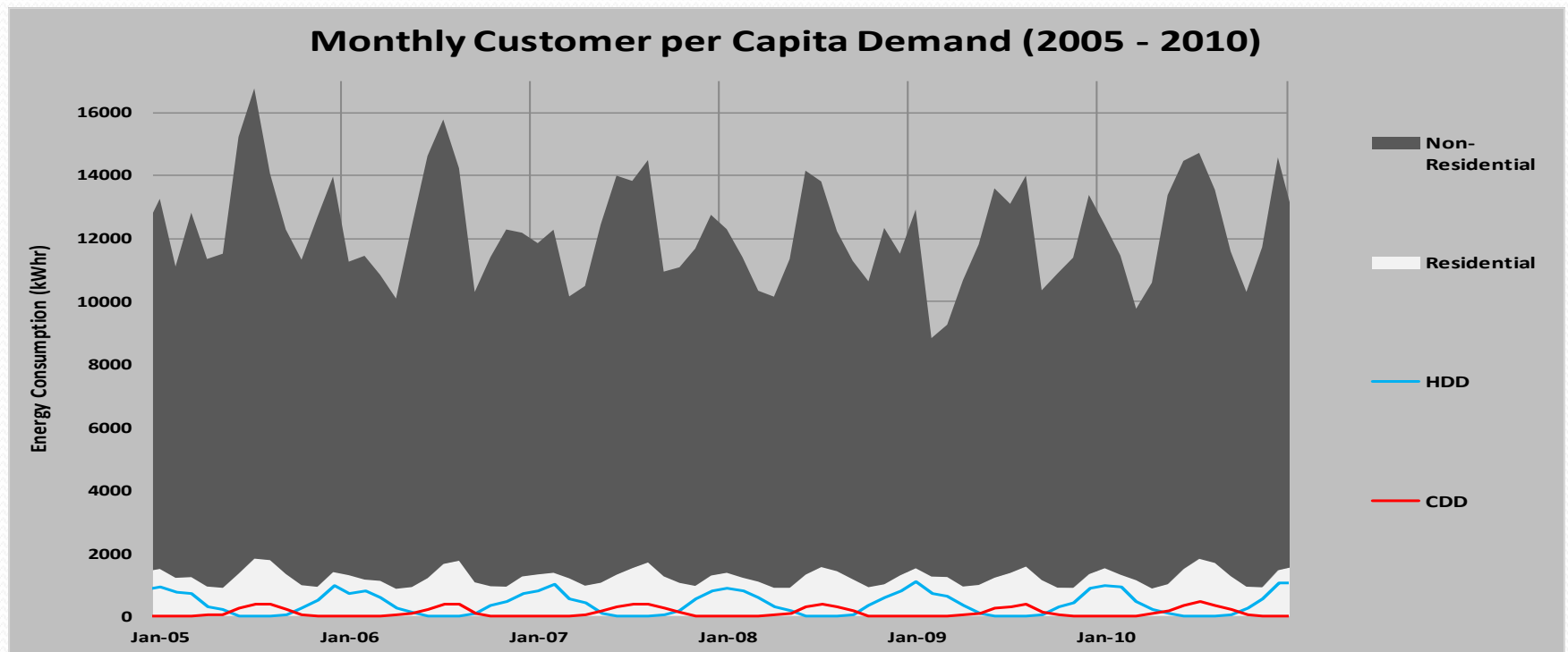
EEA2: Economics Model

- Model to associate economic factors to customer-base in under development.



EEA3: Impact of Weather

- Changes to per capita energy demand by customer type: residential and non-residential.



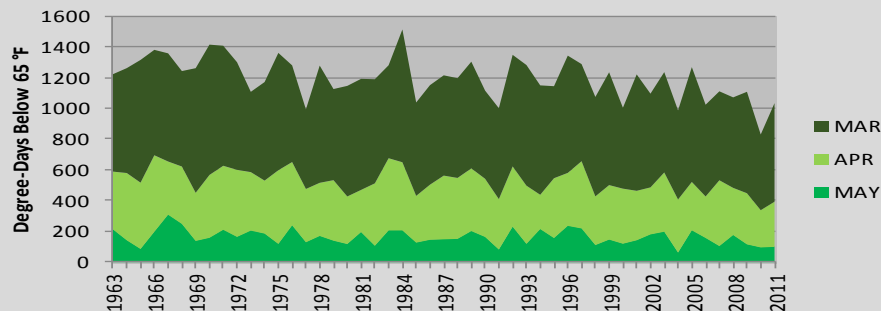
Model Development

- Pre-processing: Excel Workbook with VBA Macros.
 - Automated computations of HDD and CDD.
 - Allows user-defined “neutral” boundaries for calculating.
 - Ingests data as currently maintained by sponsor.
 - Automated linear transformations for regression models.
 - GUI design facilitates some simple regression models germane to VBA; limited capability.
 - Launch and export conditioned data to R; expanded capability.
- Statistical Modeling in R: Executable file for regression analysis and improved visualization.

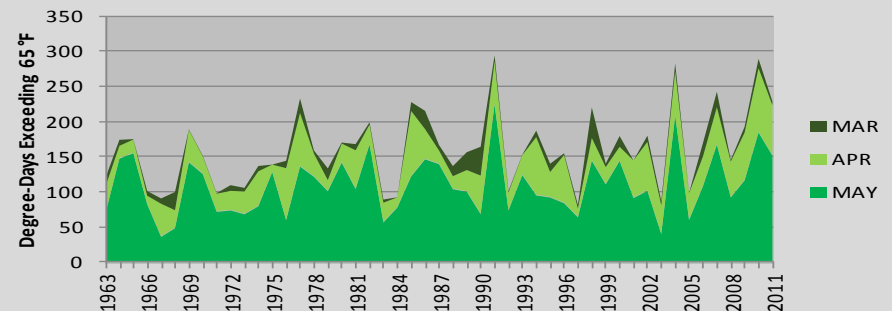
Preliminary Results

- Variability in yearly weather patterns doesn't appear to change.
- Climate change is more apparent in winter and summer than fall and spring.

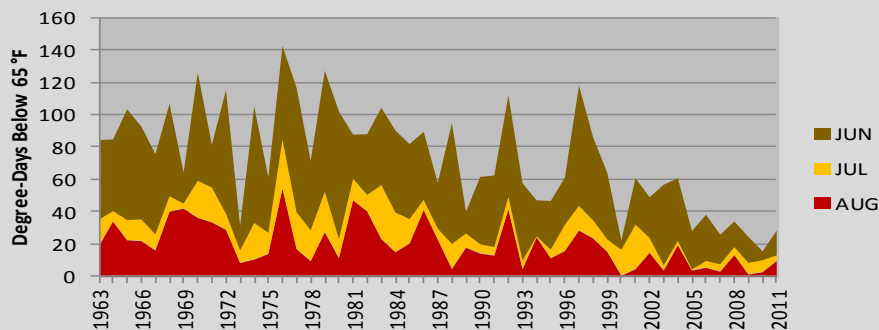
Spring Heating Degree Days



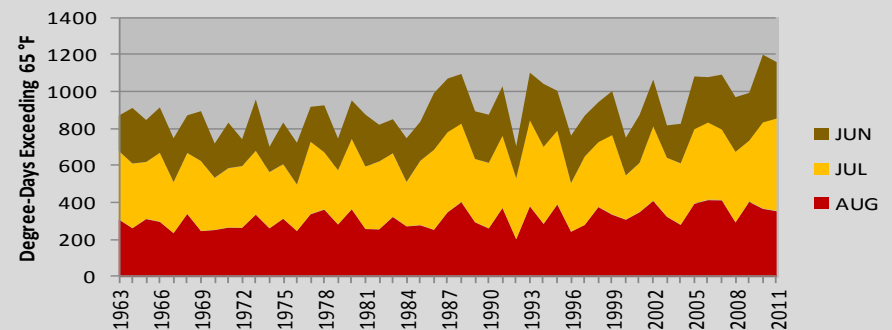
Spring Cooling Degree Days



Summer Heating Degree Days



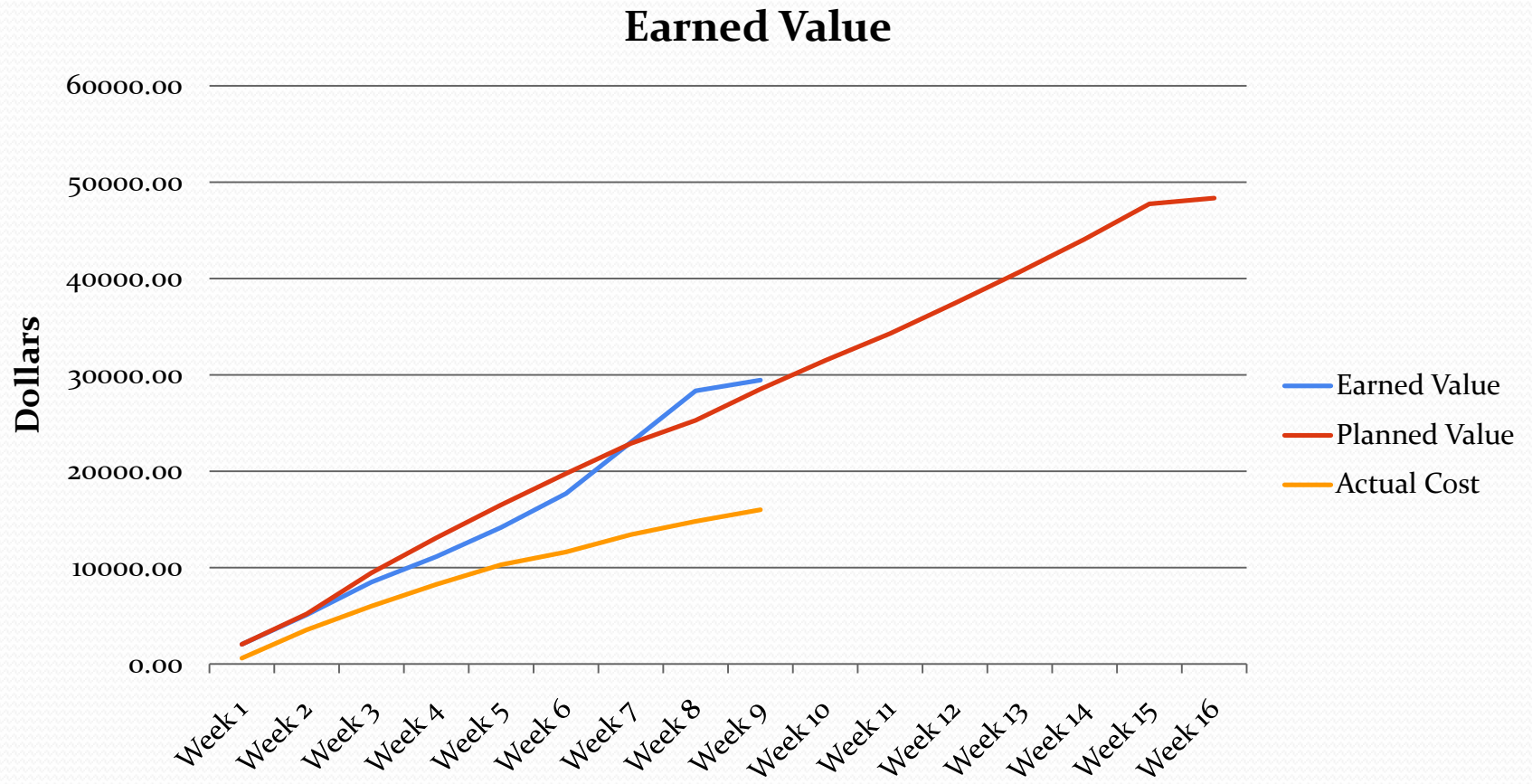
Summer Cooling Degree Days



Way Forward & Risks

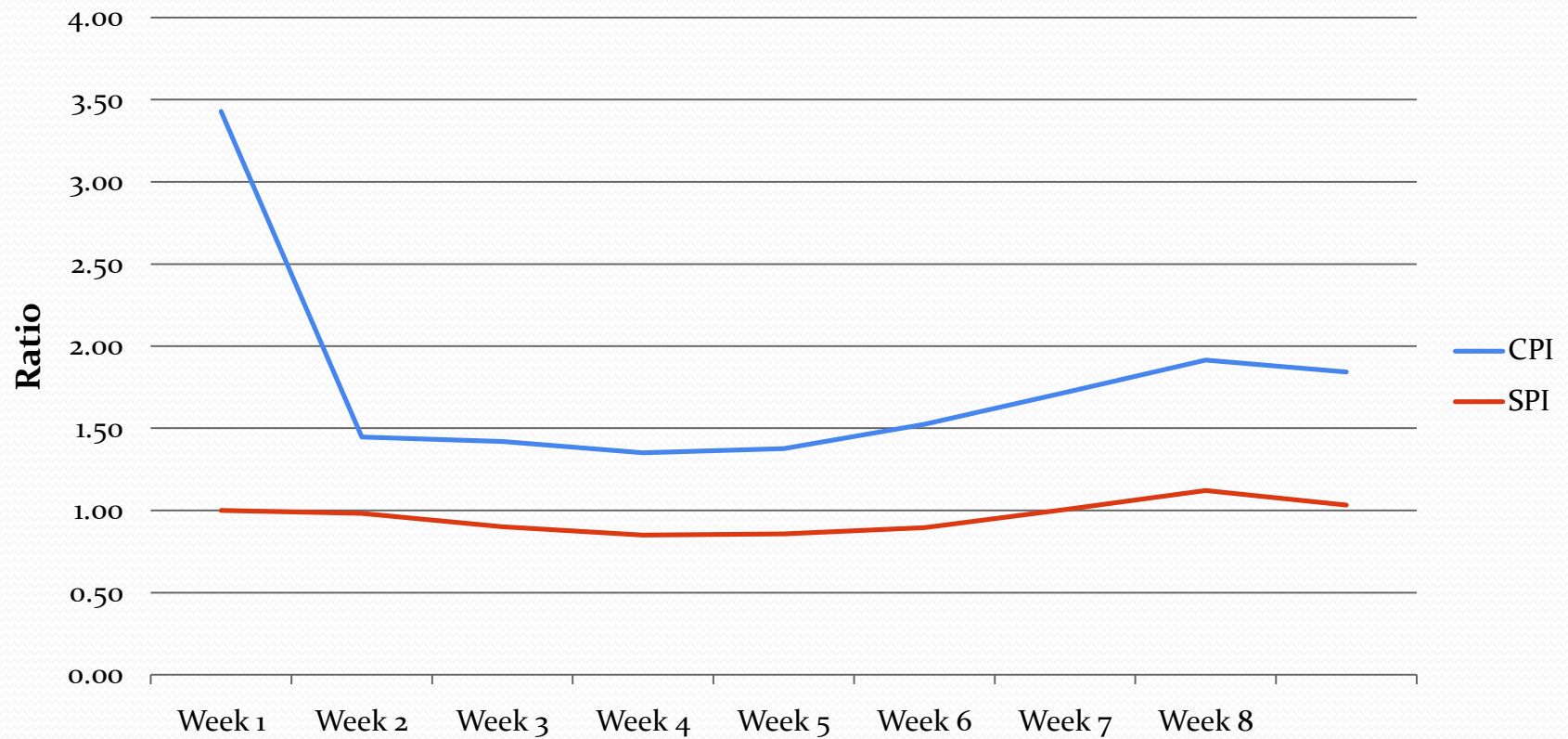
- Data visualization and preliminary analysis completed.
- Website design completed. Still need to finalize content.
- Model design/creation under construction. Major focus over next couple of weeks.
 - Excel calling R needs to be completed.
 - Customer transformation
 - Final model fitting
 - Forecast

Earned Value



CPI & SPI

CPI and SPI



References

- www.novec.com
- NOVEC 25th Anniversary History Film <http://www.youtube.com/watch?v=2qfeOKnPPGg>
- “Improving Load Management Control for NOVEC”; Kozera, Lohr, McInerney, and Pane.
<http://seor.gmu.edu/projects/SEOR-Spring12/NOVECLoadManagement/team.html>