Energy Smart Industrial

Integration of Strategic Energy Management (SEM) and Demand Response

Steve Brooks, Bonneville Power Administration

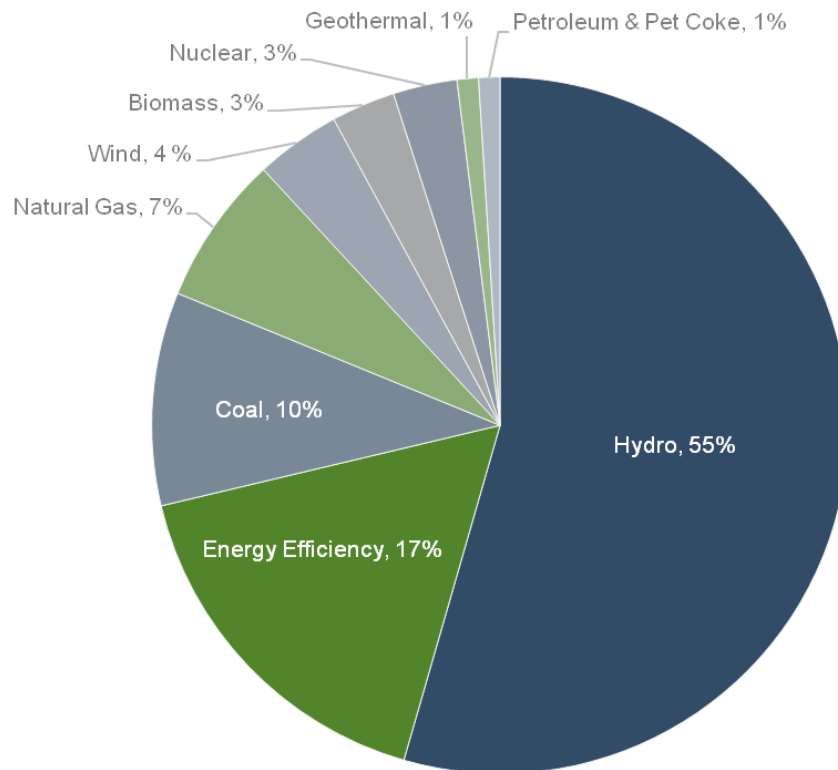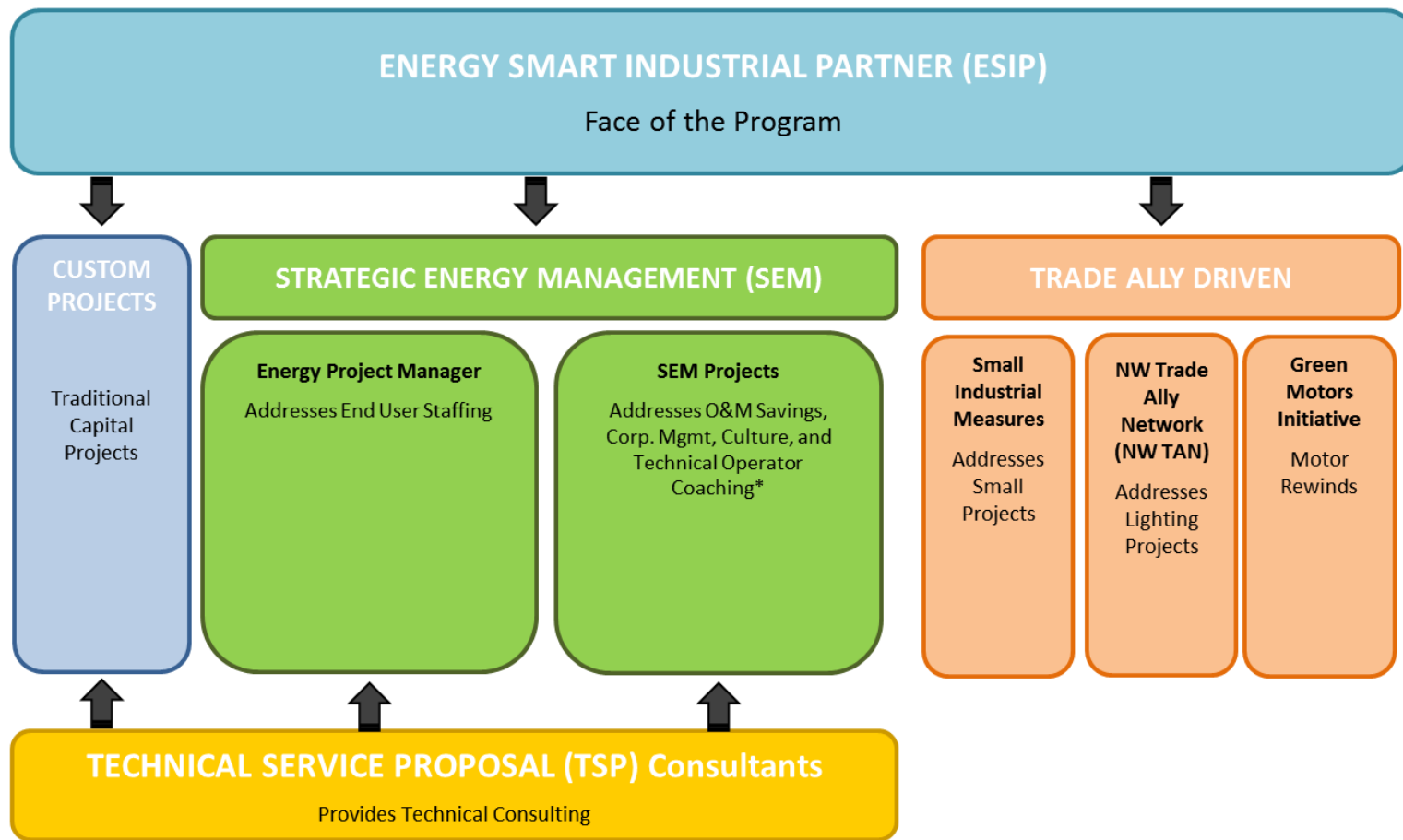*Steve Martin, Cascade Energy*

BONNEVILLE
POWER ADMINISTRATION

Canada

U.S.

Boundary

WA

OR

ID

MT

Columbia

Clark Fork

Snake

Snake

Snake

Willamette

Columbia

Seattle

Portland

Libby

Hungry Horse

Albeni Falls

Grand Coulee

Wells

Chief Joseph

Cabinet Gorge

Noxon Rapids

Kerr

Rocky Reach

Rock Island

Wanapum

Roza

Priest Rapids

Little Goose

Lower Monumental

Lower Granite

Dworshak

Chandler

Ice Harbor

Bonneville

The Dalles

McNary

Hells Canyon

Oxbow

Brownlee

Big Cliff

Detroit

Cascade

Deadwood

Foster

Green Peter

Black Canyon

Palisades

Dexter

Hills Creek

Boise Diversion

Lucky Peak

Anderson Ranch

Lookout Point

Lost Creek

Green Springs

Minidoka

EE as a Resource

Energy Efficiency is the Pacific Northwest's Second-Largest Resource

ESI Program Components

Energy Smart Industrial
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ENERGY SMART INDUSTRIAL PARTNER (ESIP)

Face of the Program

CUSTOM PROJECTS

Traditional Capital Projects

STRATEGIC ENERGY MANAGEMENT (SEM)

Energy Project Manager

Addresses End User Staffing

SEM Projects

Addresses O&M Savings, Corp. Mgmt, Culture, and Technical Operator Coaching*

TRADE ALLY DRIVEN

Small Industrial Measures

Addresses Small Projects

NW Trade Ally Network (NW TAN)

Addresses Lighting Projects

Green Motors Initiative

Motor Rewinds

TECHNICAL SERVICE PROPOSAL (TSP) Consultants

Provides Technical Consulting

Energy Smart
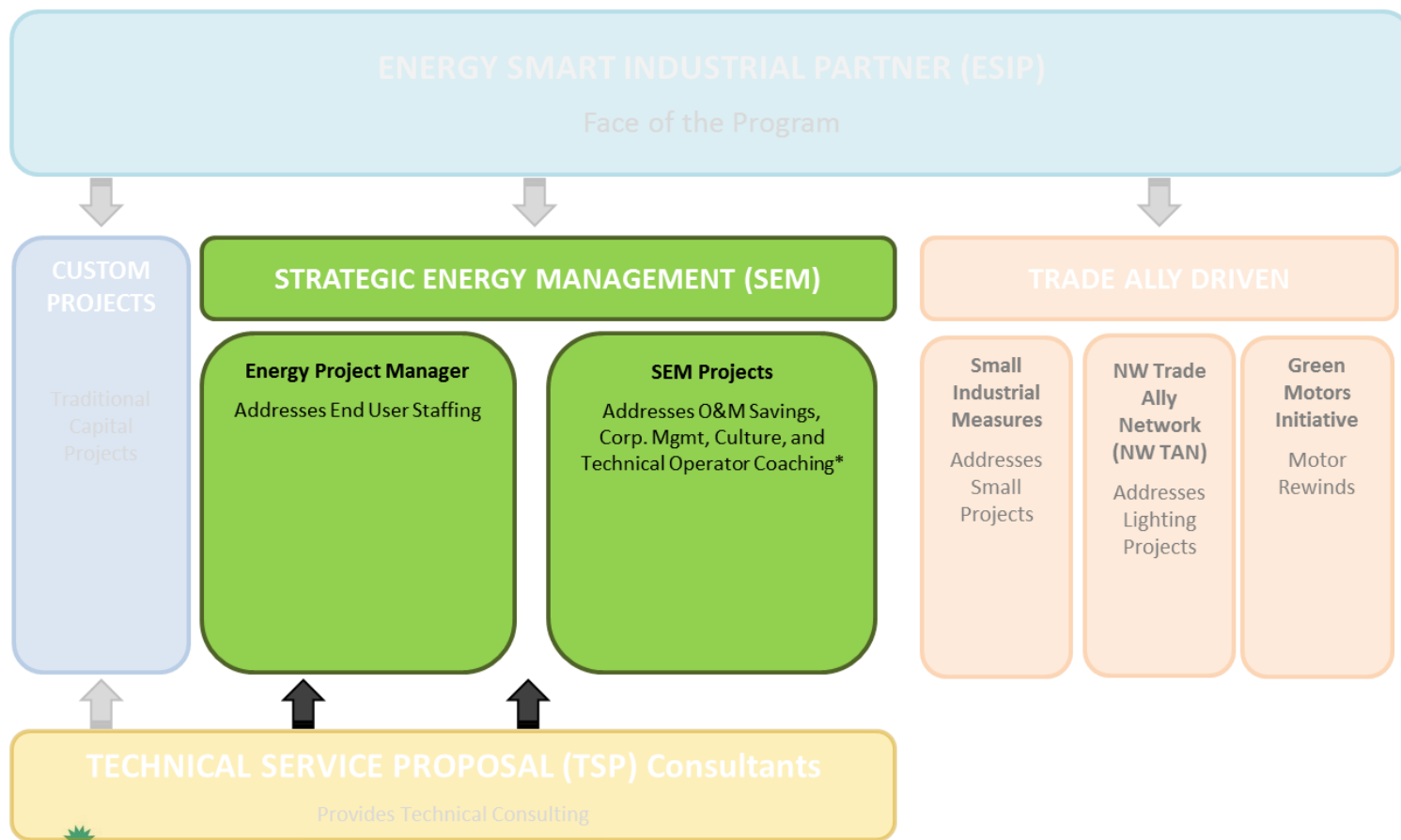**Industrial**
BPA ENERGY EFFICIENCY

About Cascade

- BPA's ESI program partner since 2009

- Eight 'boots on the ground' Energy Smart Industrial Partners with backgrounds in:

  - Food Processing

  - High Tech Manufacturing

  - Pulp and Paper
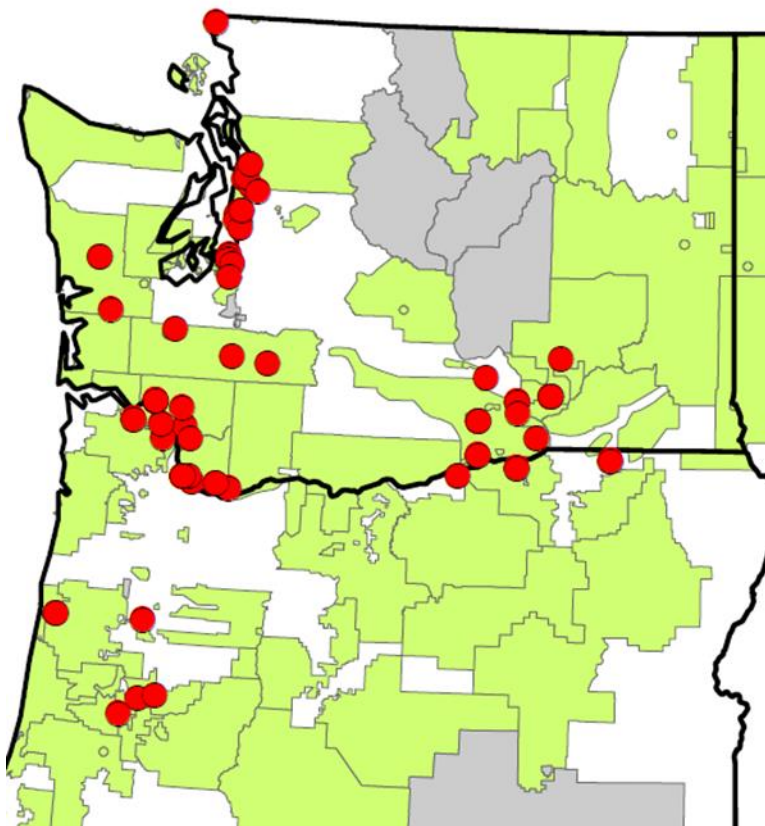
- Two water/wastewater sector specialists

ESI Results

BPA Industrial Energy Savings Goal vs. Achieved

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ESI Program Components

Energy Smart Industrial
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ENERGY SMART INDUSTRIAL PARTNER (ESIP)

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BPA-served Industrial SEM Participants

➢ ~100 Participants
➢ ~ 20% of BPA-served industrial load

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ESI Program SEM Design

BPA

Cascade

ESI Program SEM Design

~100 Sites

ESI Program SEM Design

~25 Local Utilities
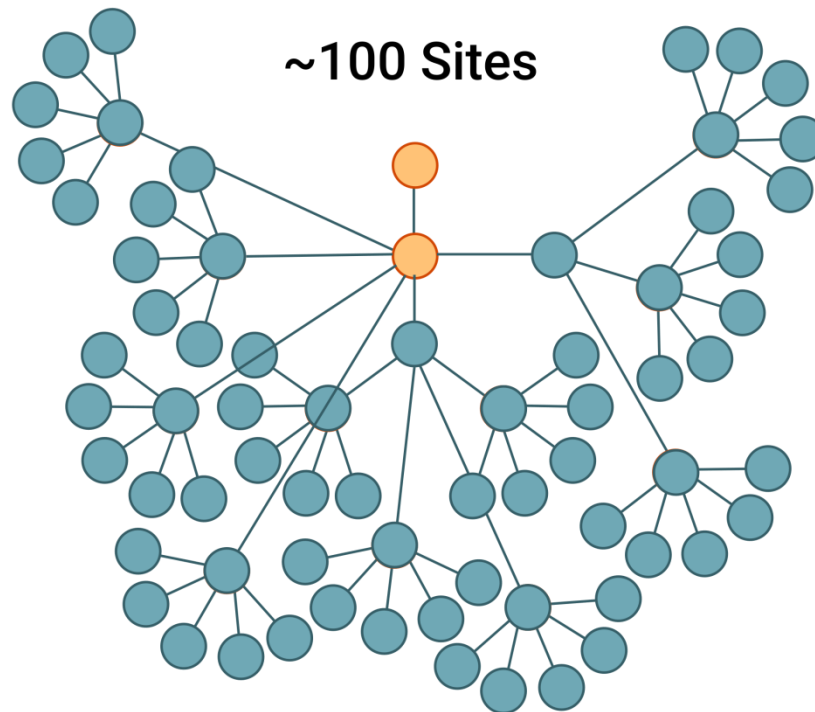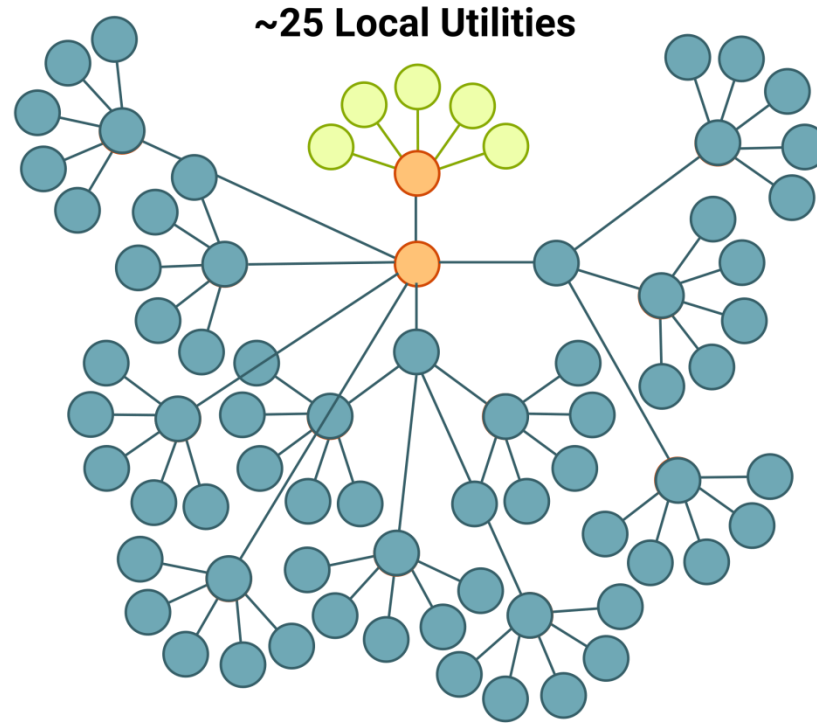
ESI Program SEM Design

With relationship to their customers

Capacity is a growing consideration

Growing Cities

More Renewables

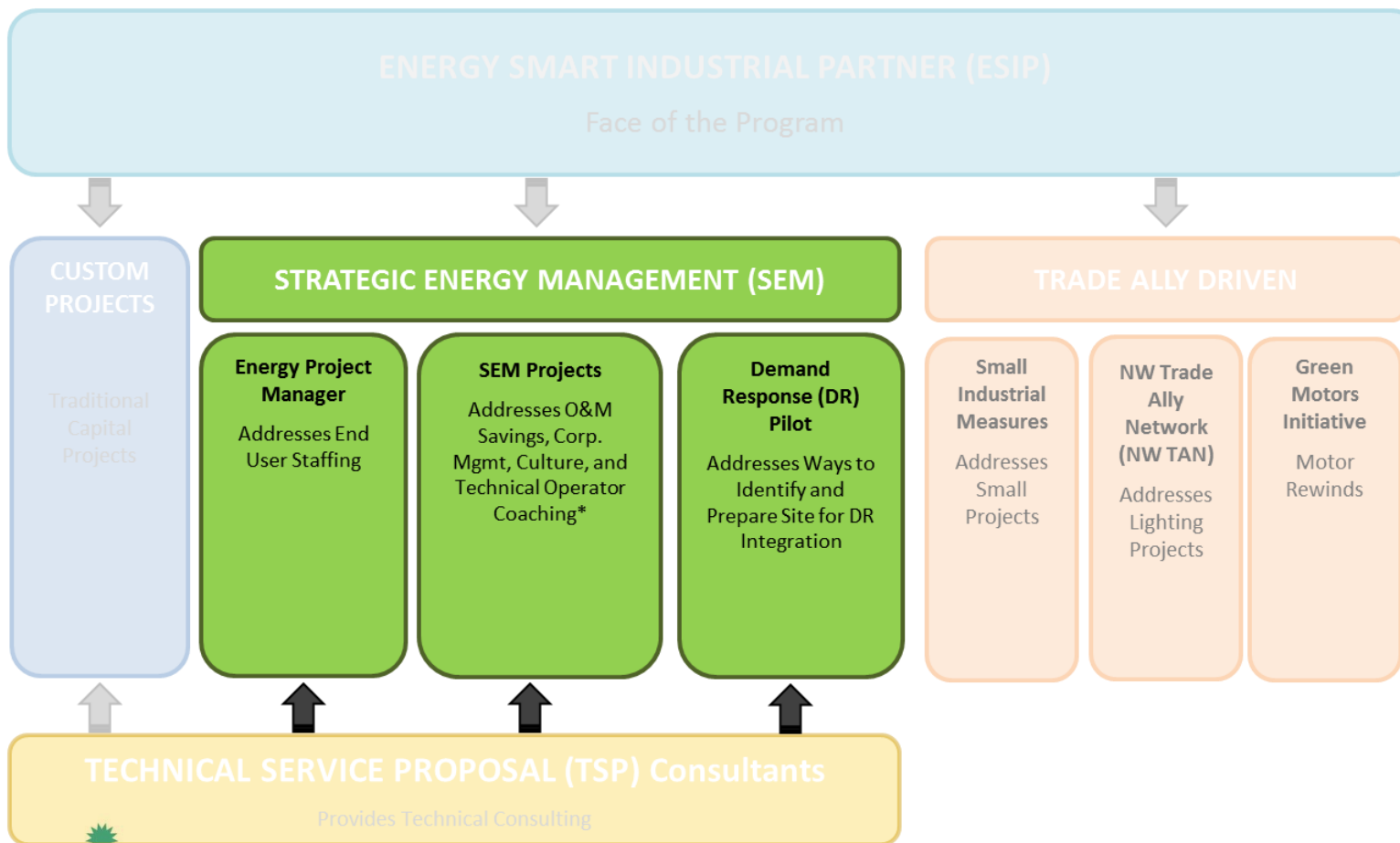Evolving Loads

I-5 Corridor Reinforcement Project Final Environmental Impact Statement

## Volume 1: Chapters 1-13

February 2016

ESI Program Components

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ENERGY SMART INDUSTRIAL PARTNER (ESIP)

Face of the Program

CUSTOM PROJECTS

Traditional Capital Projects

STRATEGIC ENERGY MANAGEMENT (SEM)

Energy Project Manager

Addresses End User Staffing

SEM Projects

Addresses O&M Savings, Corp. Mgmt, Culture, and Technical Operator Coaching*

Demand Response (DR) Pilot

Addresses Ways to Identify and Prepare Site for DR Integration

TRADE ALLY DRIVEN

Small Industrial Measures

Addresses Small Projects

NW Trade Ally Network (NW TAN)

Addresses Lighting Projects

Green Motors Initiative

Motor Rewinds

TECHNICAL SERVICE PROPOSAL (TSP) Consultants

Provides Technical Consulting

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BPA Pilots DR

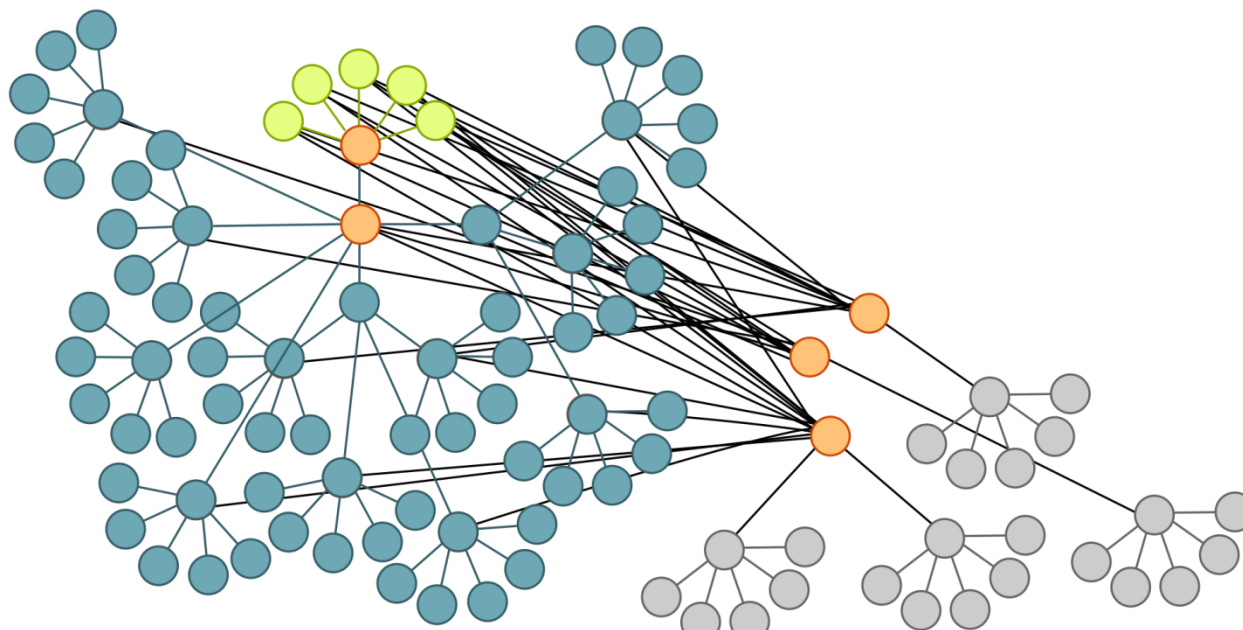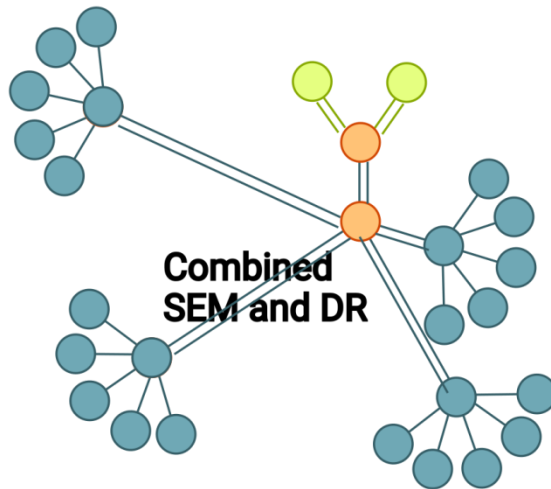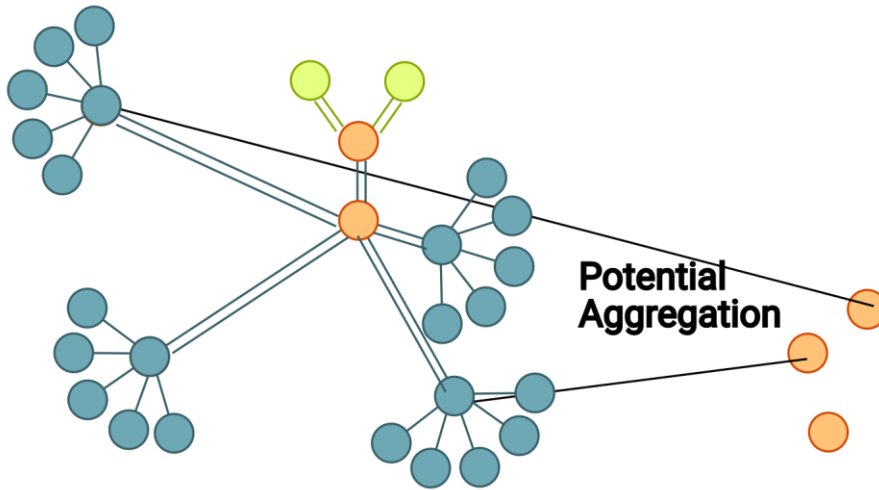| Demand Response Product	Purpose
Renewable Integration	Reduce reserved generation for highly variable renewable resources
Summer Peak	Reduce generation and transmission requirements during regional, three-day heat wave
Winter Peak	Reduce generation and transmission requirements during regional, three-day cold snap
Transmission Relief	Reduce peak transmission requirements on congested transmission lines

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While…

DR Pilots Launch

DR Aggregators
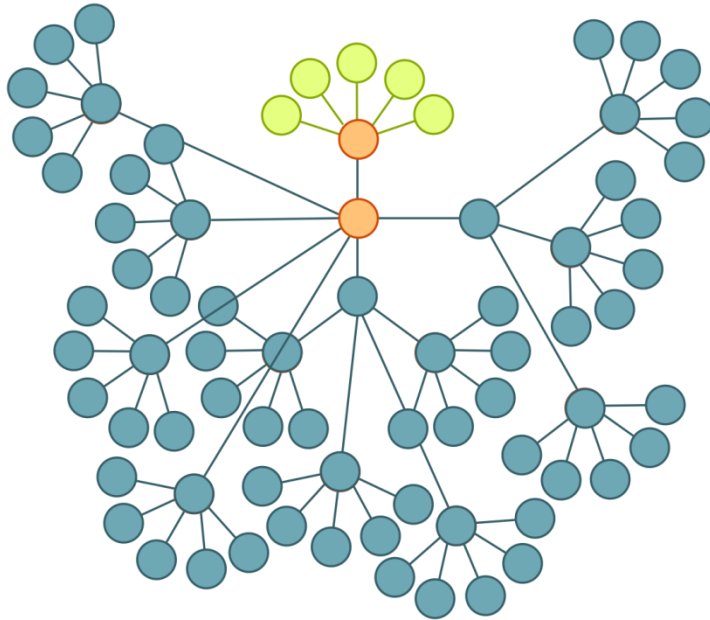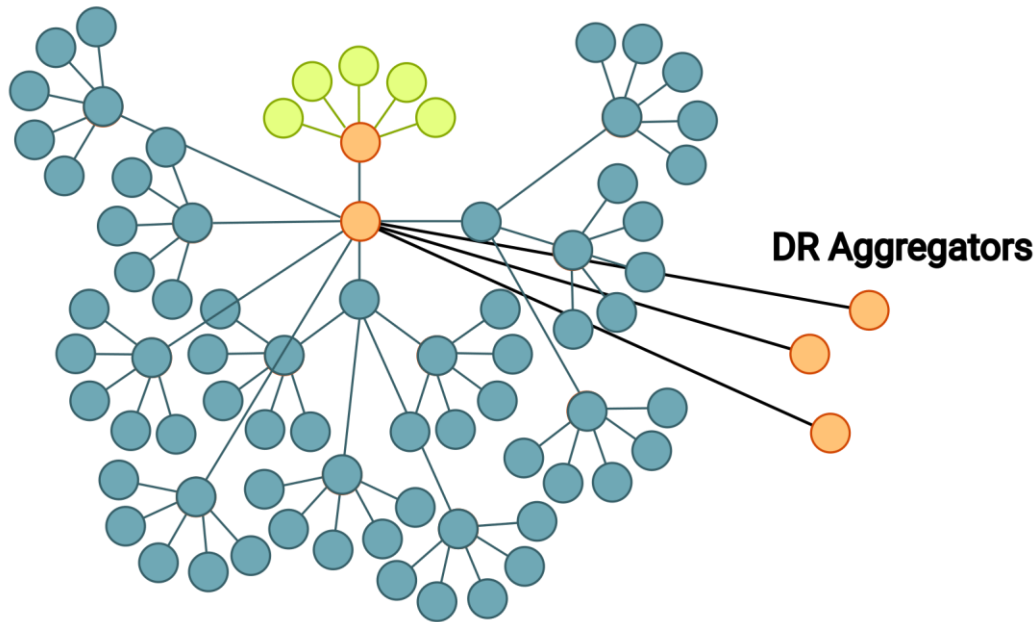
Attention is Scarce

Pilot Design

Combined
SEM and DR

Informed Match Making

Potential Aggregation

South Puget Sound SEM Cohort
Year 5 Celebration

Verified Energy Savings

	Year 1	Year 2	Year 3	Year 4	Year 5
■ Custom Project Savings	344,016				
■ O&M/Behavior-Based Savings	4,646,541				

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Verified Energy Savings

	Year 1	Year 2	Year 3	Year 4	Year 5
■ Custom Project Savings	344,016	4,279,752	9,188,286	12,068,642	13,196,806
■ O&M/Behavior-Based Savings	4,646,541	7,345,658	11,638,767	15,793,426	22,539,330

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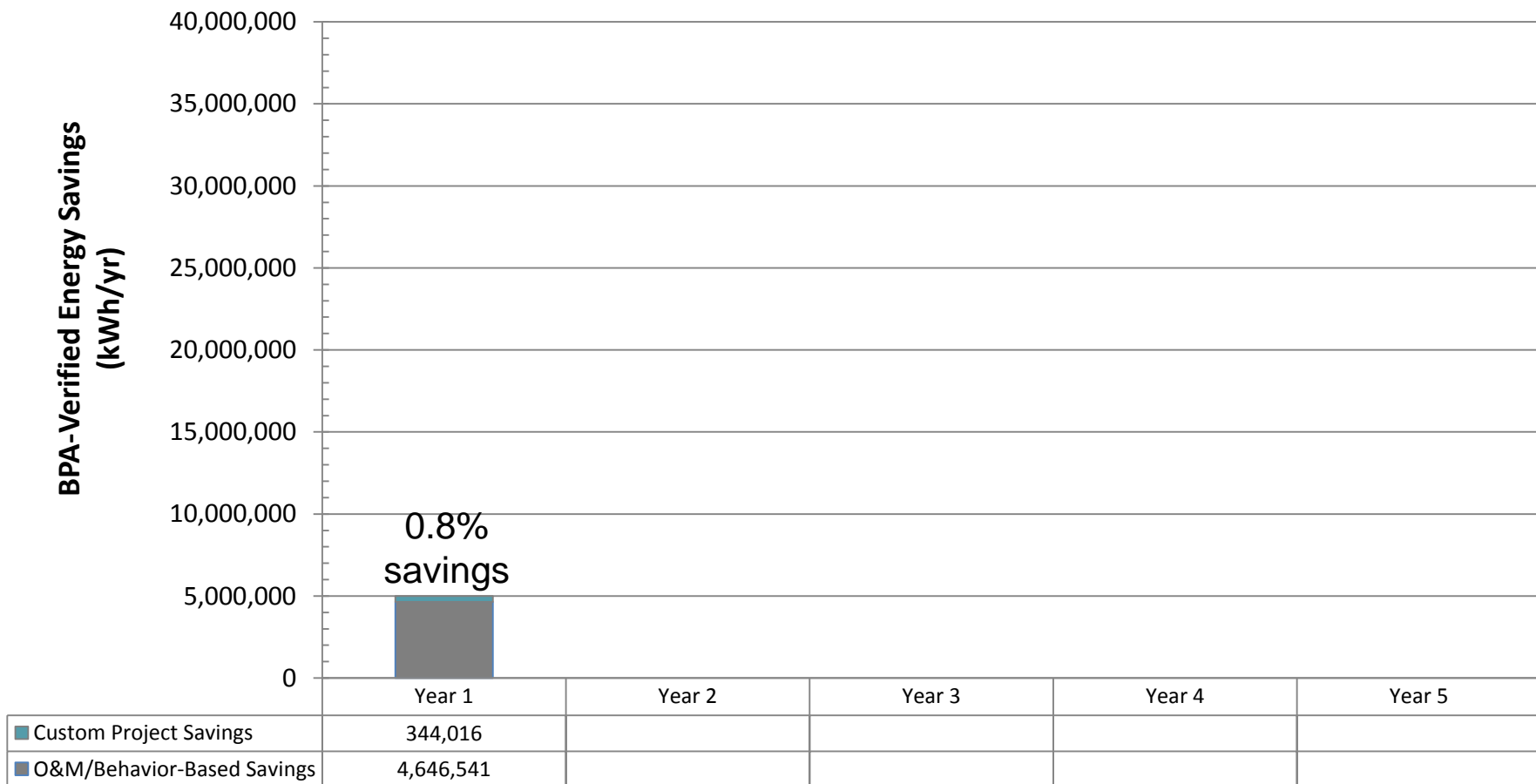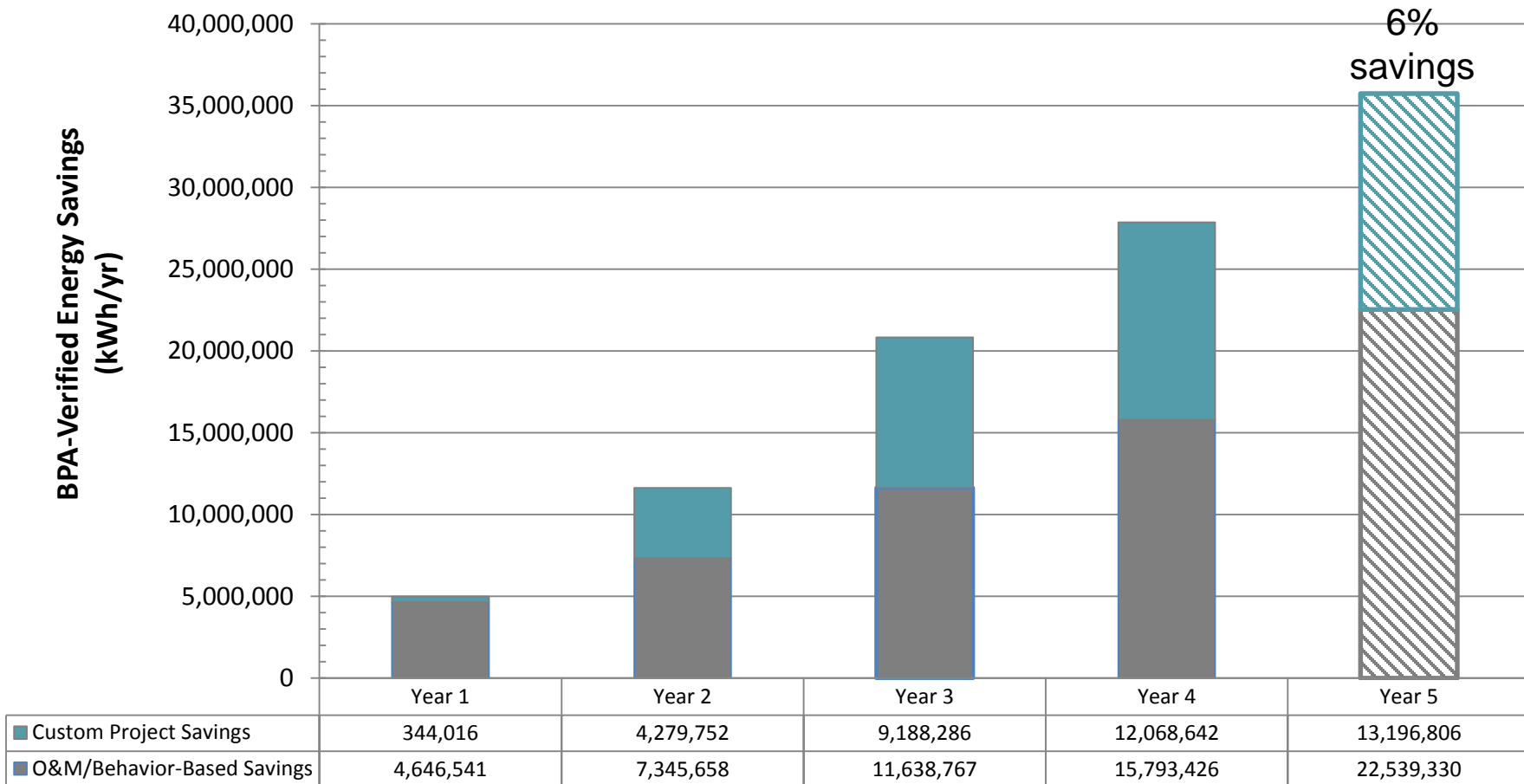
Three SEM **+ Demand Response** Success Factors

Leadership

Management made **quick, informed decisions** to enroll in DR pilot.

Personnel

Energy Champions **Empowered** to implement.
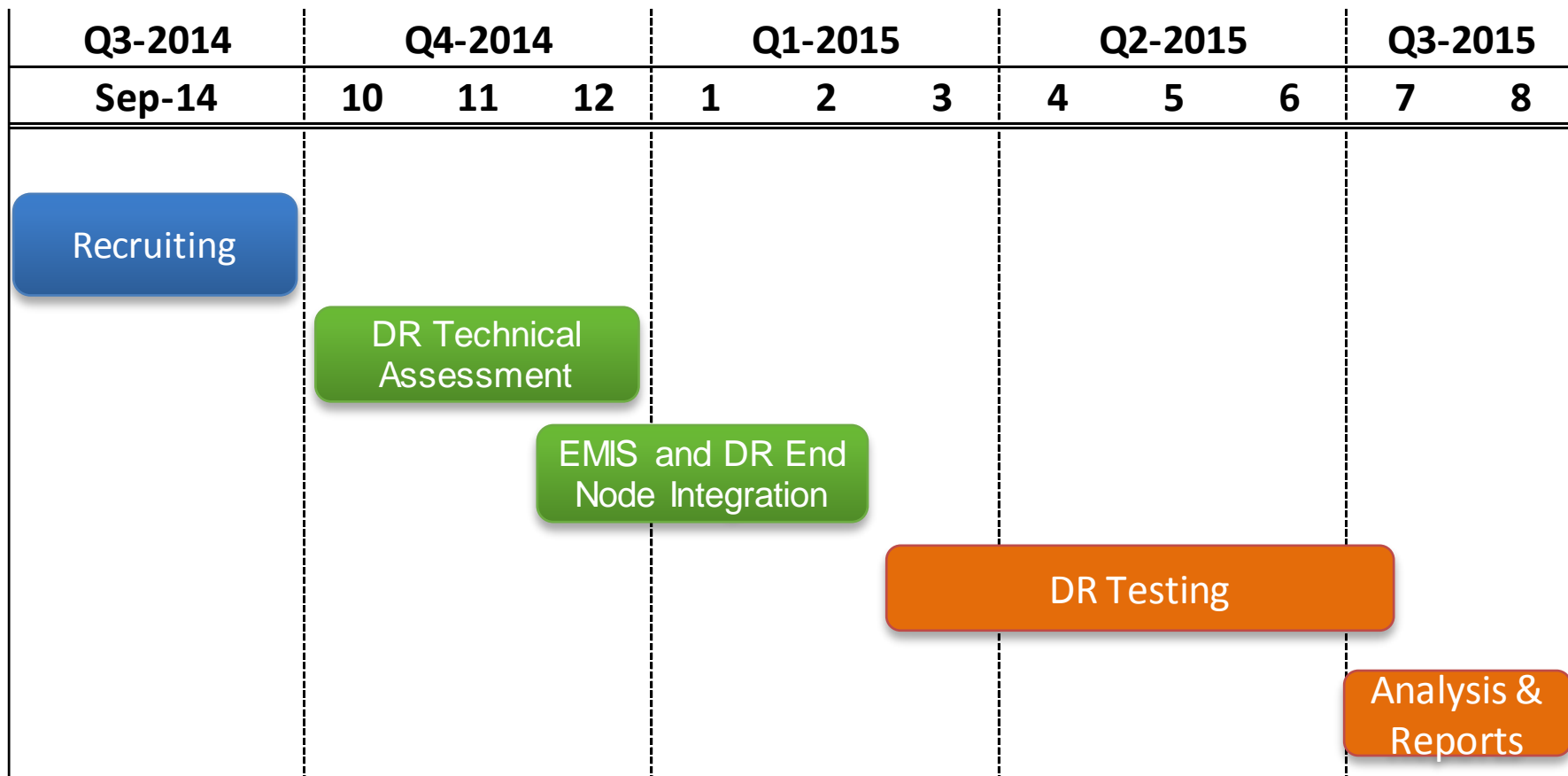**Trust** program and recommendations.

Technical

Energy drivers known and metered. Installed **control systems** enable control of energy use.

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1st Lesson Learned

SEM and DR share common organizational and technical success factors. Program designs should be integrated.

Energy Smart
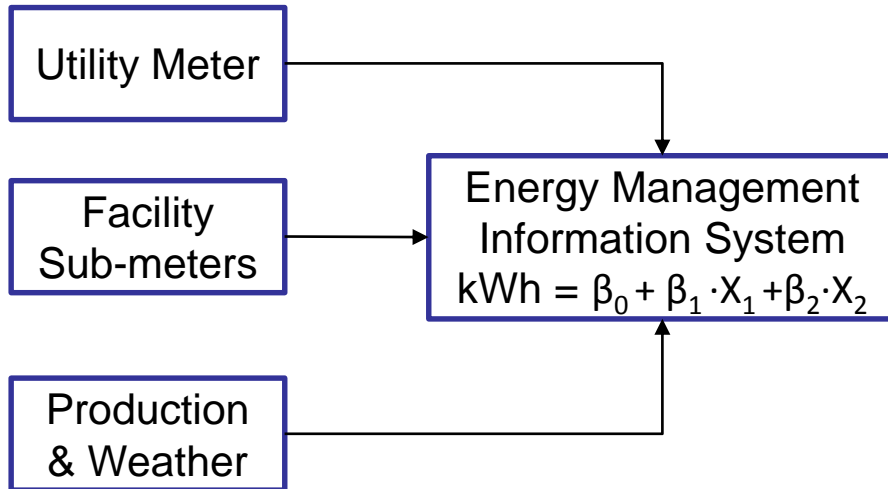**Industrial**
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EE-DR Pilot Timeline

Q3-2014	Q4-2014			Q1-2015			Q2-2015			Q3-2015	
Sep-14	10	11	12	1	2	3	4	5	6	7	8

Recruiting

DR Technical Assessment

EMIS and DR End Node Integration

DR Testing

Analysis & Reports

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Description of Participants

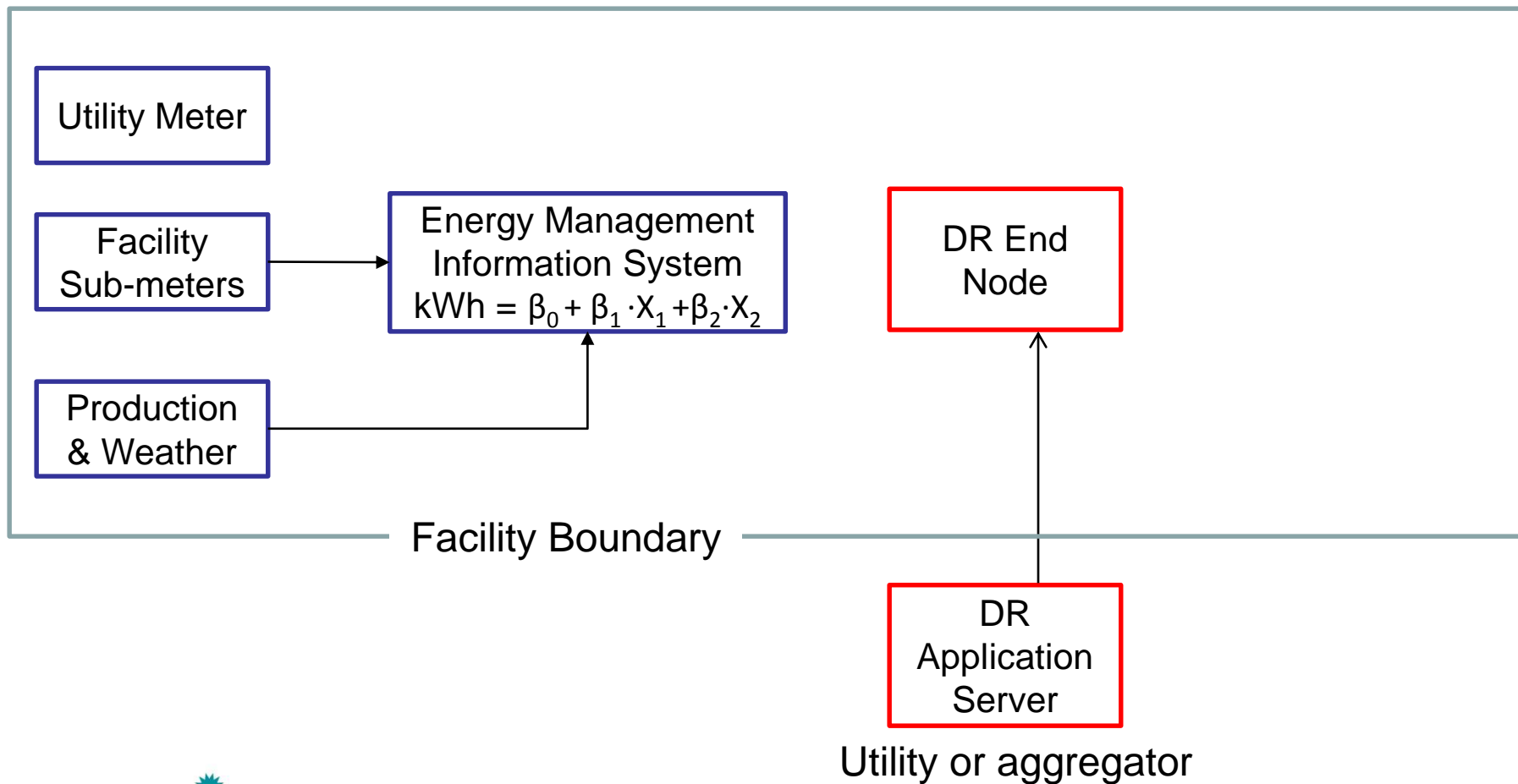| SITE CHARACTERISTICS	MUNICIPAL WATER	COLD STORAGE	FOOD PROCESSING – CHILLED	FOOD PROCESSING - FROZEN
EE Engagement	SEM Year 2	SEM Year 1 Large Capital Project	SEM Year 2	SEM Year 2
DR Opportunities	Pumping Systems	Refrigeration & Battery Chargers	Production Scheduling Change	Refrigeration
Connected Load (average)	2,000 kW	300 kW	1,500 kW	4,000 kW

Integrated EMIS and Open ADR End Node

Utility Meter

Facility
Sub-meters

Production
& Weather

Energy Management
Information System
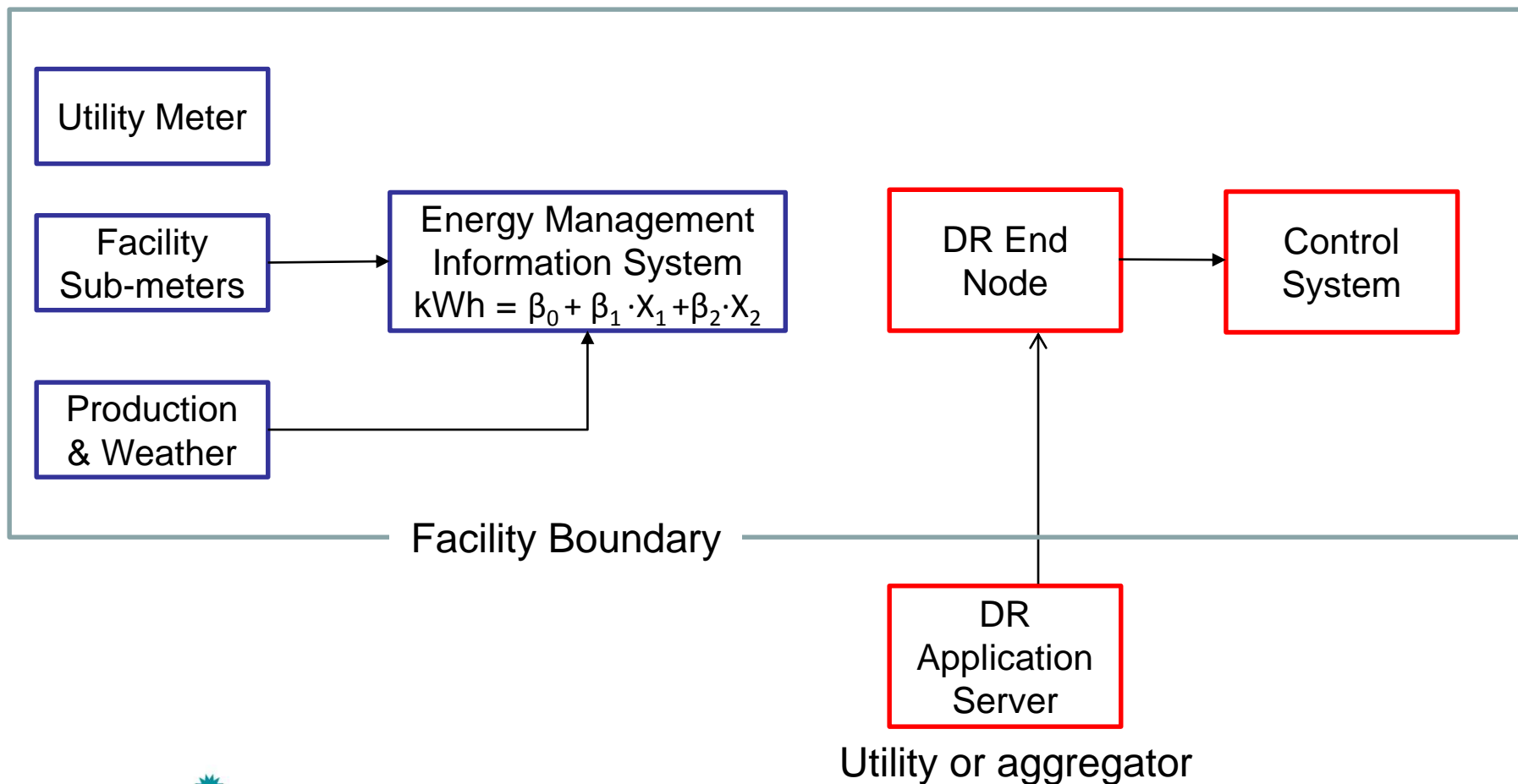$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

Core EMIS Requirements*

- The ability to quantify savings using a predictive model.
- The ability to incorporate production data into savings calculation.
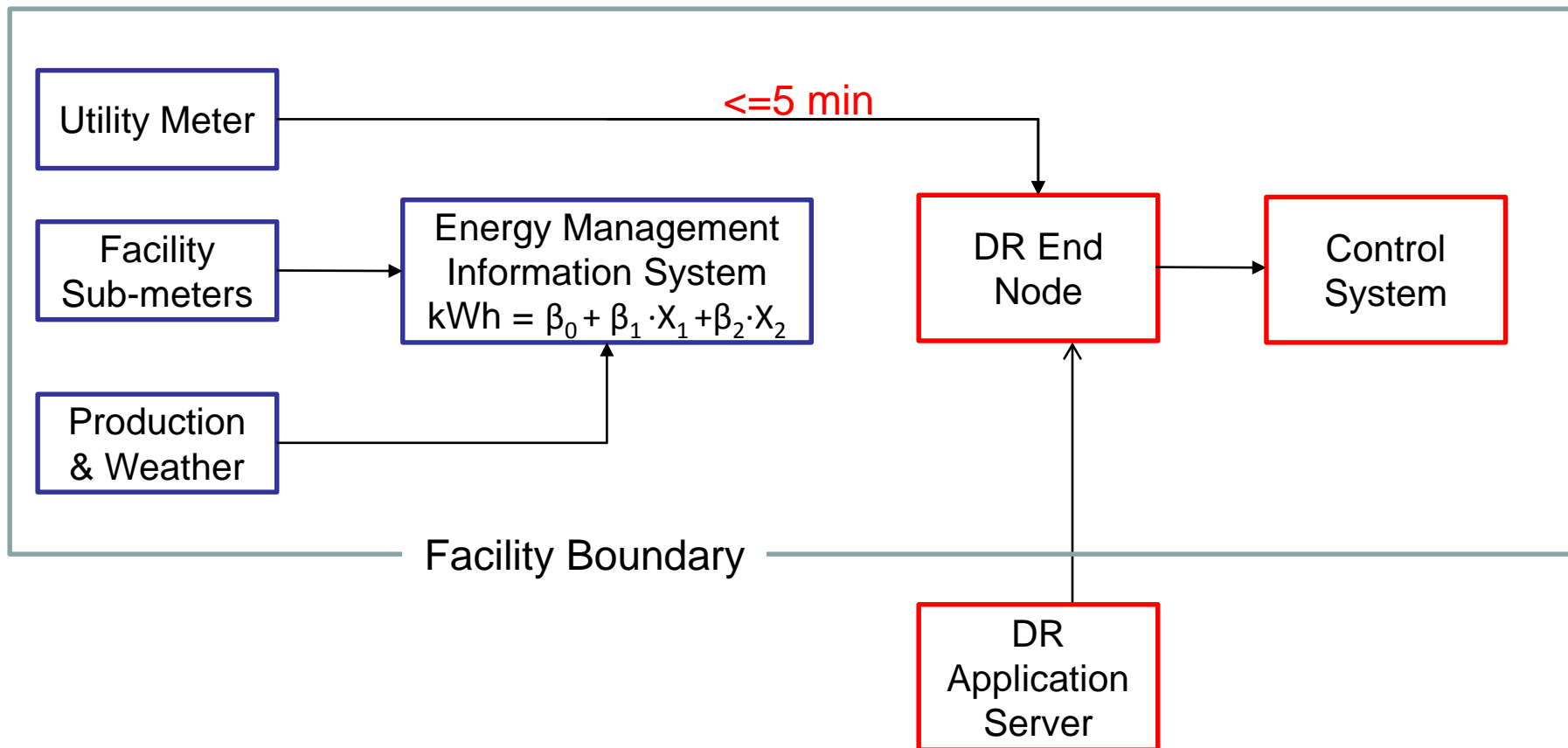- The ability to track energy data at a daily (or more granular)

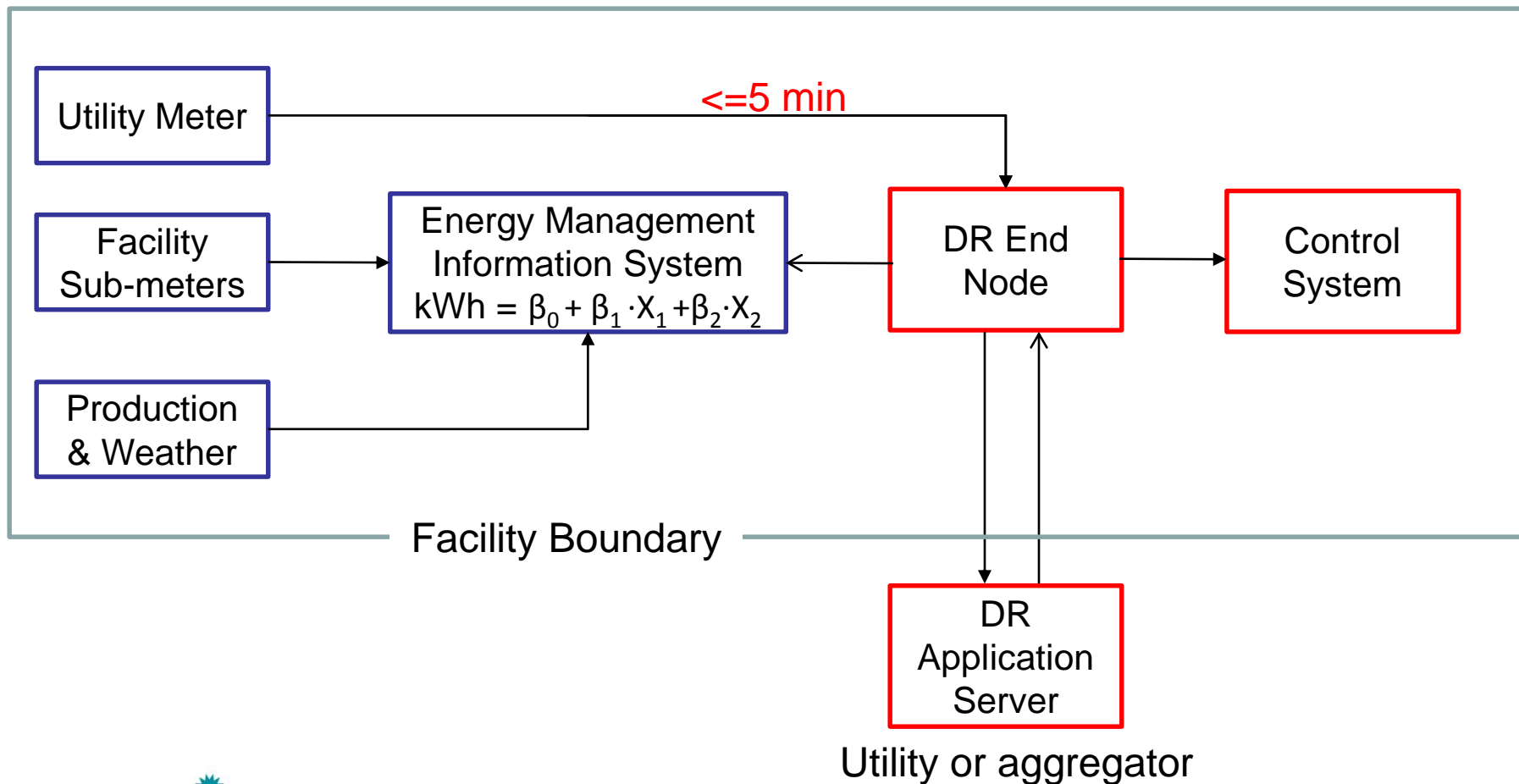*Inventory of Industrial Energy Management Information Systems (EMIS) for M&V Applications, Northwest Energy Efficiency Alliance, June 2014.

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Integrated EMIS and Open ADR End Node

Utility Meter

Facility Sub-meters

Energy Management Information System
$$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$$

Production & Weather

DR End Node

Facility Boundary

DR Application Server

Utility or aggregator

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Integrated EMIS and Open ADR End Node

Utility Meter

Facility Sub-meters

Energy Management Information System
$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

Production & Weather

Facility Boundary

DR End Node

Control System

DR Application Server

Utility or aggregator

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Integrated EMIS and Open ADR End Node

Utility Meter

<=5 min

Facility Sub-meters

Energy Management Information System
$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

DR End Node

Control System

Production & Weather

Facility Boundary

DR Application Server

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Integrated EMIS and Open ADR End Node

Utility Meter

<=5 min

Facility Sub-meters

Energy Management Information System
$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

DR End Node

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Production & Weather

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Integrated EMIS and Open ADR End Node

Utility Meter

<=5 min

Facility Sub-meters

Energy Management Information System
$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

DR End Node

Control System

Production & Weather

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DR Application Server

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Integrated EMIS and Open ADR End Node

Utility Meter

Facility Sub-meters

Energy Management Information System
$kWh = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2$

Production & Weather

<=5 min

DR End Node

Control System

Facility Boundary

DR Application Server

Utility or aggregator

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2nd Lesson Learned

Data requirements are similar. Integrated EMIS systems should include production data and energy models.

Water System – SEM Energy Map
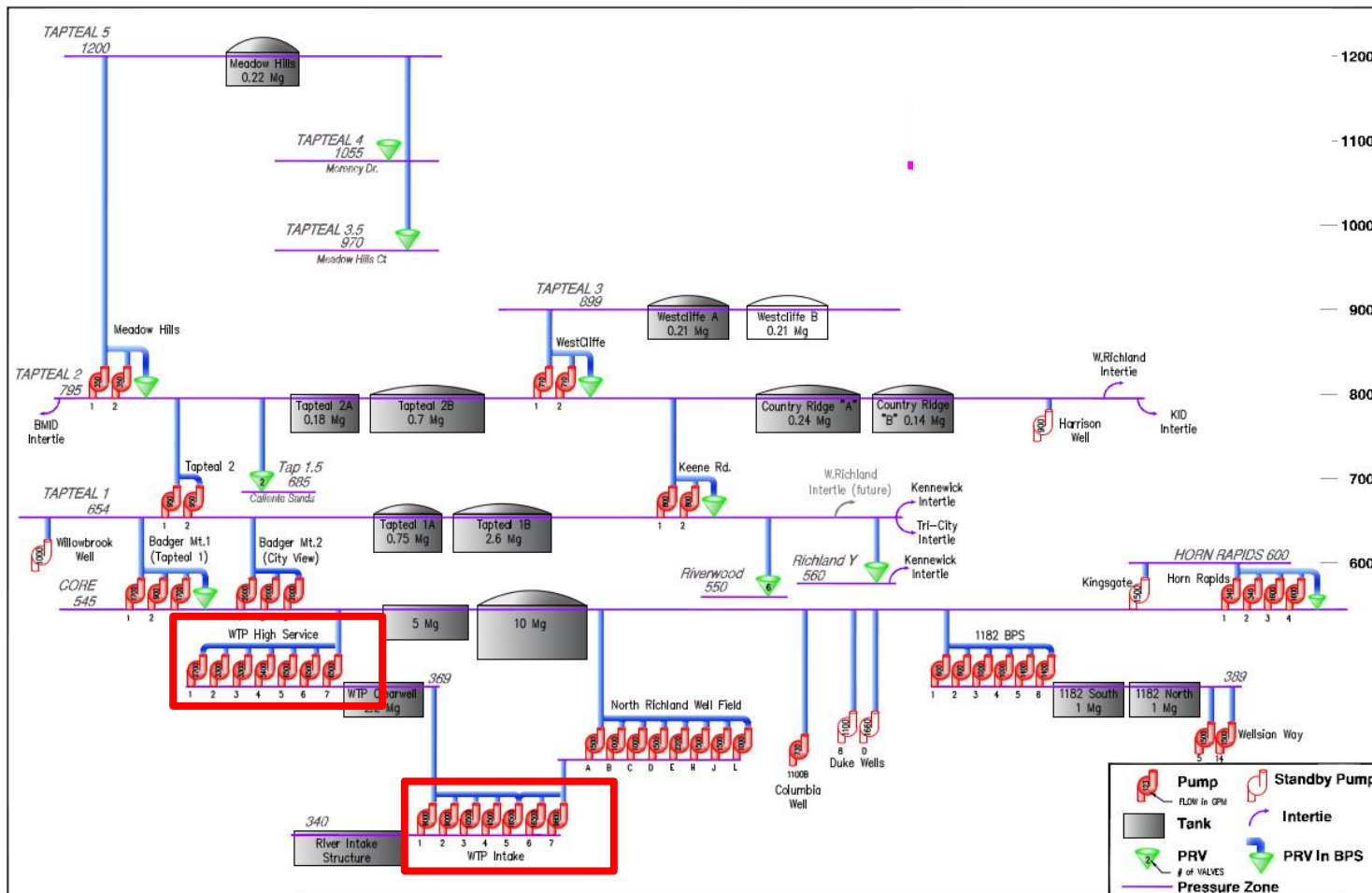
Municipal Water System

Energy Storage

Dispatchable Load

Municipal Water System

Opportunity – Large reservoirs can supply water demand while pumping is curtailed.
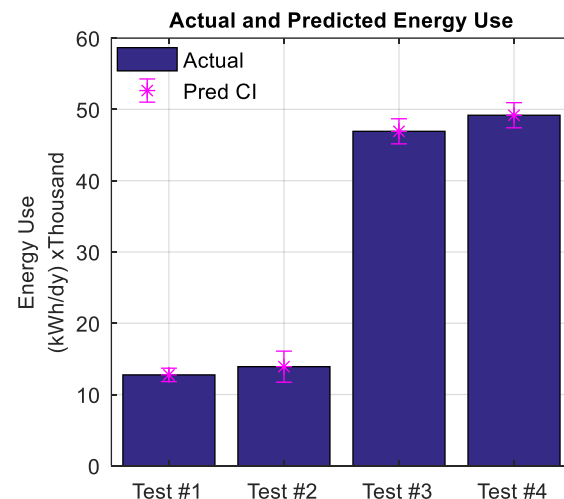**Testing –** Test events conducted during low and peak water demand.
Interaction - DR event did not affect energy efficiency before or after the event.

Municipal Water: Test #3

Municipal Water: Test #4

Actual and Predicted Energy Use
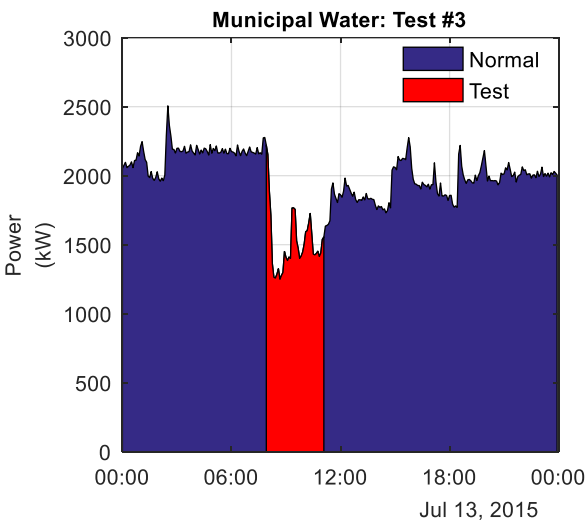
Test #3 Curtailment
377 kW
3 hours
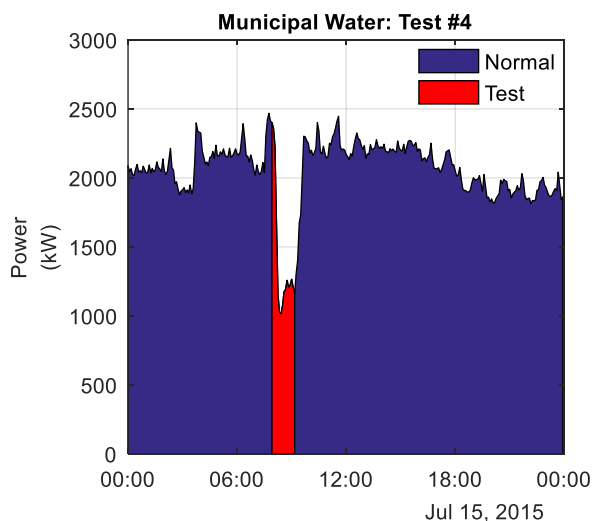
Test #4 Curtailment
714 kW
1.5 hours

No impact on energy
consumption on day
of curtailment

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3rd Lesson Learned

System knowledge gained from SEM enhances ability to troubleshoot and optimize DR performance

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DR Product Criteria

Notification Window

Time between notification and event.

- Shorter windows reduce participation:
  - require automation
  - limit system preparation.

Duration

Length of time energy use is curtailed.

- Longer events reduce participation
  - Require more process storage

Availability

When the asset must be available.

- Industrial schedule must match criteria:
  - Time of Day
  - Days of Week
  - Months of Year

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Cold Storage Facility
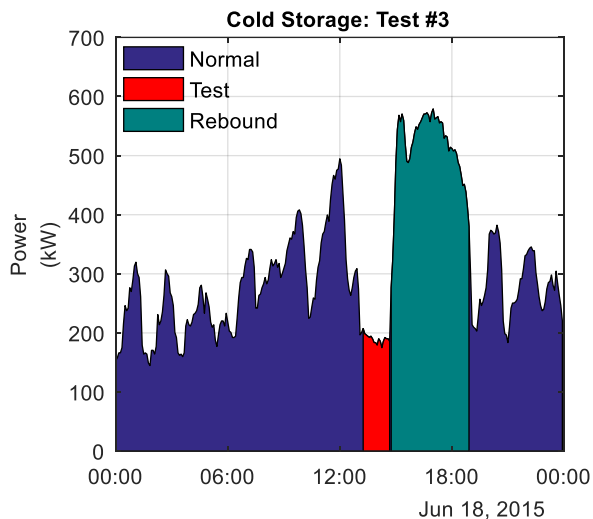

Energy Storage

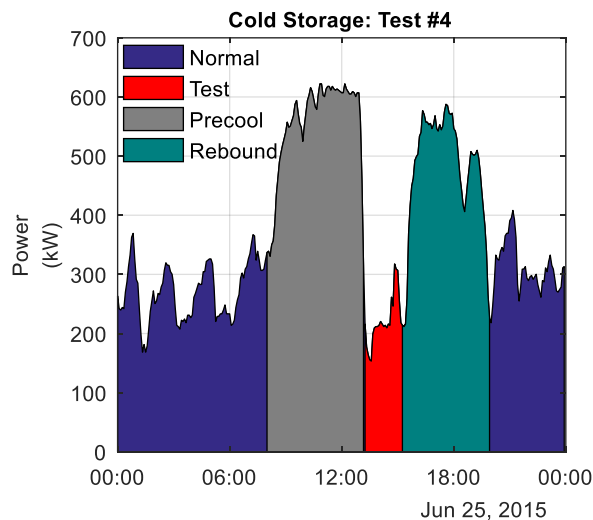

Dispatchable Load

Cold Storage Facility

Opportunity – Sophisticated refrigeration controls (EE project) enabled fine-tuned system control

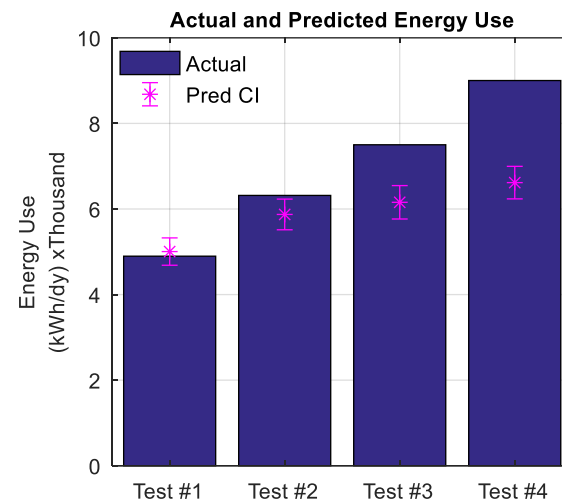**Testing –** Test events conducted during spring and summer.

Interaction – "Pre-cool" needed for sustained curtailment. Increased energy consumption during prep and recovery.

Test #3 Curtailment
122 kW
3 hours

Test #4 Curtailment
130 kW
1.5 hours

Approximately +10% energy consumption

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4th Lesson Learned

Interactive effects are system and DR Product specific.

Results from other programs or sites can not be used to predict interactive effects.

Supporting Material

Common Program Elements

Program Element	SEM	DR
Energy Information	15 minute interval	<=5 minute interval
Measurement and Verification	Regression-based models (daily or weekly)	Regression-based models or 'similar day' methods (using production data)
Key Site Contact	Energy Champion	DR Champion
Implementation Strategies	O&M improvements Control systems SOP modification	Control Systems SOP modification

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Summary of Demand Response Tests

Test #	Municipal Water		Cold Storage		Food Chilled		Food Frozen	
	Season	Duration	Season	Duration	Season	Duration	Season	Duration
1	Winter	Long	Spring	Short	Spring	Short	Spring	Spring
2	Winter	Long	Spring	Short	Spring	Long	Spring	Spring
3	Summer	Long	Summer	Short	Summer	Long	-	-
4	Summer	Short	Summer	Long	-	-	-	-

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Summary of Demand Response Tests

End-user	Test #	Season	Time Required to Curtail	Duration of Curtailment	Measured Curtailment	Impact on Energy Intensity
Municipal Water	1	Winter	15 Min	3 hr	334 kW	None
	2	Winter	10 Min	3 hr	476 kW	None
	3	Summer	15 Min	3 hr	377 kW	None
	4	Summer	15 Min	1 hr	714 kW	None
Cold Storage	1	Spring	15 Min	1 hr 15 min	0 kW	None
	2	Spring	15 Min	1 hr 5 min	11 kW	Increase
	3	Summer	15 Min	1 hr 30 min	122 kW	Increase
	4	Summer	10 Min	2 hr 15 min	130 kW	Increase
Food Chilled	1	Spring	2 hr	15 min	None	None
	2	Spring	2 hr	3 hr	None	None
	3	Summer	2 hr	3 hr	None	None
Food Frozen	1	Spring	20 Min	55 min	238 kW	None
	2	Spring	20 Min	1 hr 55 min	235 kW	None

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DR M&V Methodologies

Method	Baseline	Event
Observed Measured[1]	Minimum power measured within 2 hours of deployment	Minimum power during sustained response
Similar Days[2]	Average power for the hour of 10 similar days prior to the test	Average power for each hour during sustained response
Regression[3]	Power estimated from regression model using temperature and/or production during test	Average power during sustained response

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Conceptual Design
Integrated data management architecture