Achieving Energy Efficiency through Smart Grid

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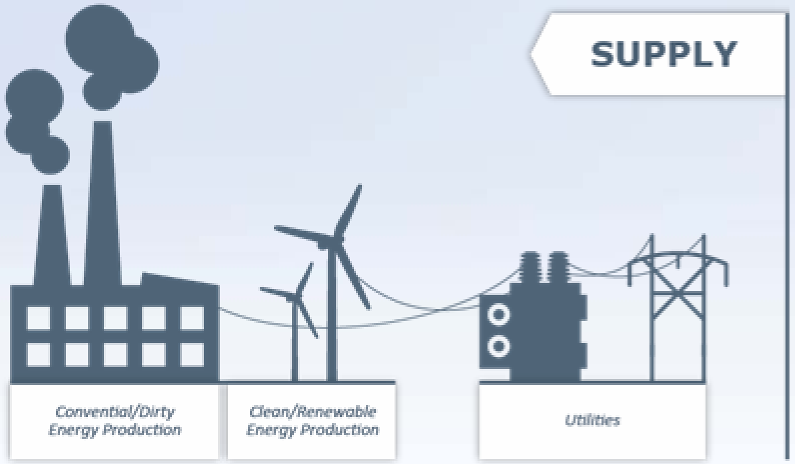
ENERGY SUPPLY AND DEMAND

SUPPLY SIDE POLICIES



ISSUES

- CO_2 emissions
- Fixed fuel source
- Dirty energy

INITIATIVES

- Large-scale Smart Grid planning
- Public-Private partnership
- Federal and state level financing and incentives
  - Transmission infrastructure
  - Clean energy systems
  - Smart metering infrastructure
- Applied research into smart grid technology and issues
- Utility partnerships

DEMAND SIDE OPPORTUNITIES

ECONOMICS

- Utilities require compelling business case for investment in advanced metering systems

BUYING HABITS

- Consumer privacy concerns
- Dynamic pricing

SOCIAL RESPONSIBILITY

- Efficiency
- Security
- Decentralized Power Generation

WHAT MAKES A BUILDING 'SMART GRID' READY?

A simple question with a *complex* answer:

Due to the constantly changing technology the choice, design and integration of building systems, and the infrastructure of the Grid it has become critical to ensure that a high performance building continues to meet the changing needs of occupiers, owners and the environment.

It depends on the Various Stakeholders and their desired outcomes:

- Owners
- Users
- Builders
- Designers
- Occupants
- Environmental Impacts

CREATING A SMART BUILDING ?

Making the building work for us

The Building needs to:
“ Sense ” the internal and external environments

“ React ” to ensure, in the most efficient way, provide a safe and comfortable stay, while minimizing the amount of energy and operational resources consumed

“ Interact ” with people by means of simple and easily accessible communications channels focused on there responsibilities

Enable energy efficiency opportunities *case study:*

Pacific NW Smart Grid Project

- Validate new smart grid technologies and business models
- Provide two-way communication between distributed generation, storage, and demand assets and the existing grid infrastructure
- Quantify smart grid costs and benefits
- Advance standards for "interoperability" (the smooth, seamless integration of all elements of the electric system) and cyber security approaches.

The proposed project, led by Battelle, will:

•Run 5 years and span 5 Pacific Northwest states: Idaho, Montana, Oregon, Washington and Wyoming

•Involve 12 utilities in the five-state region, the Bonneville Power Administration, and multiple technology partners

•Include direct participation from 2 universities—the University of Washington and Washington State University — with outreach to other academic centers

•Involve more than 60,000 metered customers and will engage, using smart grid technologies, system electricity assets exceeding 112 megawatts

•Cost approximately $178 million, half of which will be cost-shared by the project partners.

case study:

University of Washington – Smart Building

- Energy Management Information System
  - Smart Building Meters (240+ Electric)
  - Transactive Control
  - Auto Demand Response (33 buildings; lighting & DDC controls)
  - Electric Vehicle Charging Stations & PV System
- Classroom Building & Dormitory Building Demonstrations
  - Sub meter and monitor plug loads
  - Classroom / Dorm competitions
- Measurement & Verification

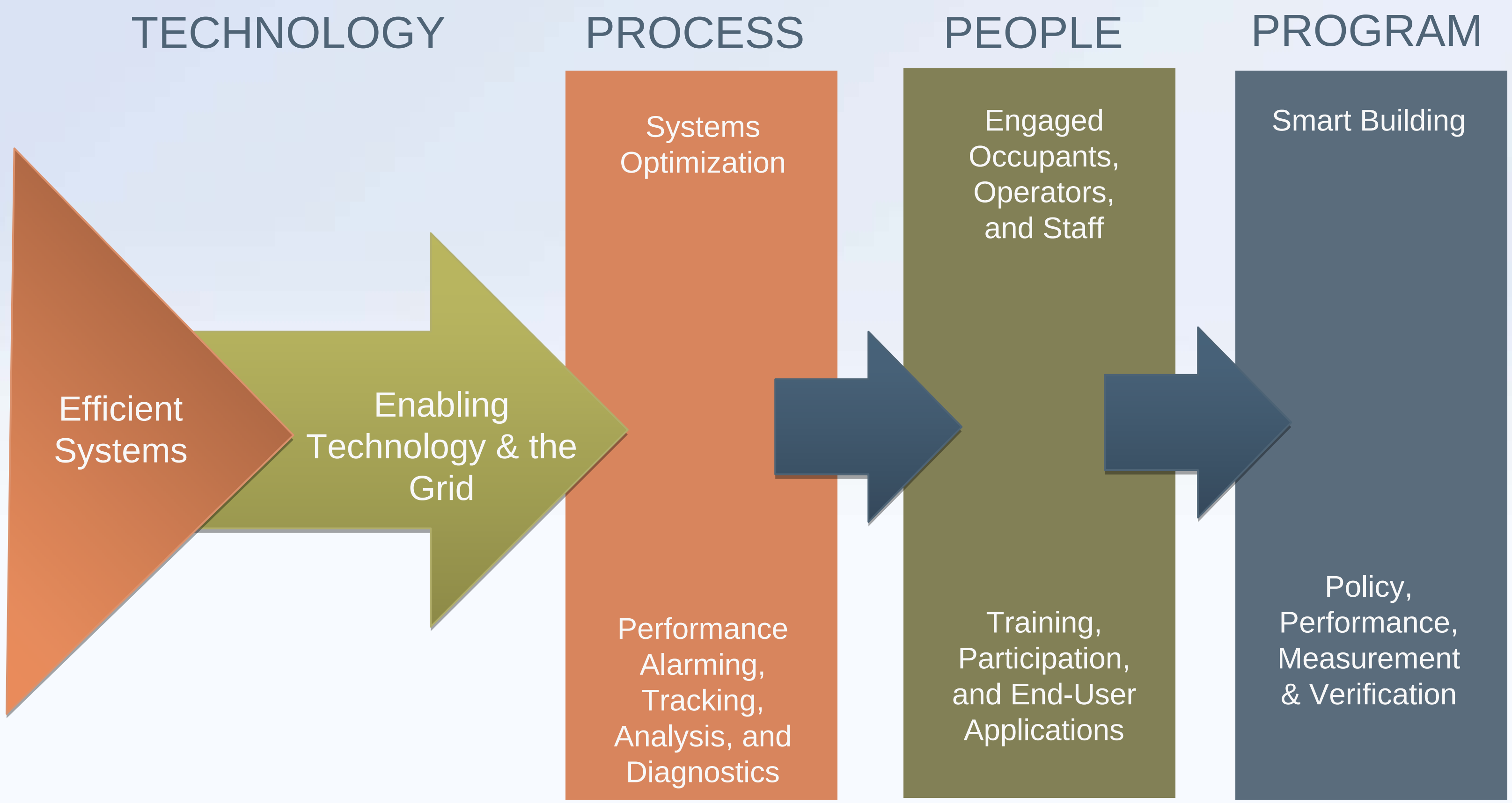
SMART BUILDINGS REQUIRE:

SMART OCCUPANTS

SMART OPERATORS

Use technology as an *accelerator*

ACHIEVING OUTCOMES



outcomes of a

SMART BUILDING

Reengineered behavior of its occupants and operators

Save energy, water and operational cost

Leveraged information to gain efficiencies

IBM Smarter Cities Challenge - Boulder

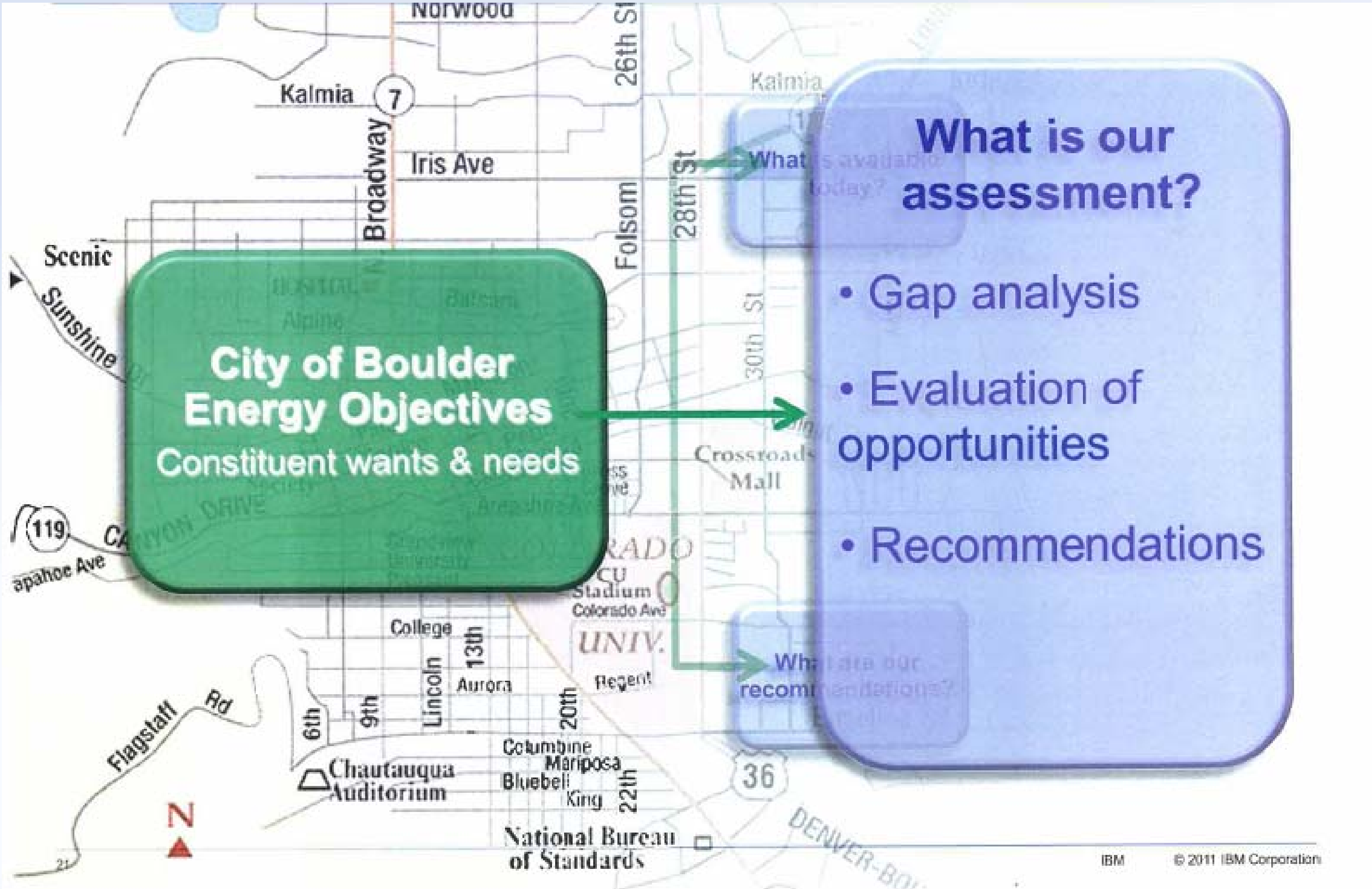
Project Objectives

Empower the City of Boulder (CoB) to achieve its energy objectives

- Assess capabilities of SmartGridCityTM (SGC) infrastructure and associated functionality and benefits
- Identify opportunities to leverage SGC to accelerate achievement of CoB energy objectives
- Recommend specific actions CoB can take independently and with its energy partners

Source: used in multiple slides for discussion
IBM Smarter Cities Challenge Boulder_SmartGridCity presentation delivered to City of Boulder

City of Boulder Project Review



Items reviewed

1. Identify key gaps in the current functionality
2. Assess impact of gaps on CoBs goals
3. Prioritize the gaps
4. Recommend key actions to address

The assessment discovered capability gaps associated with SGC

Utility responsibility

1. Aggregate customer demand
2. Near real time data access
3. Demand forecasting for grid operations
4. Localized demand forecasts
5. SMB C&I engagement
6. Dynamic pricing

Utility & Customer responsibility

7. Renewable integration
8. PHEV integration
9. Interoperability
10. Data access beyond the meter

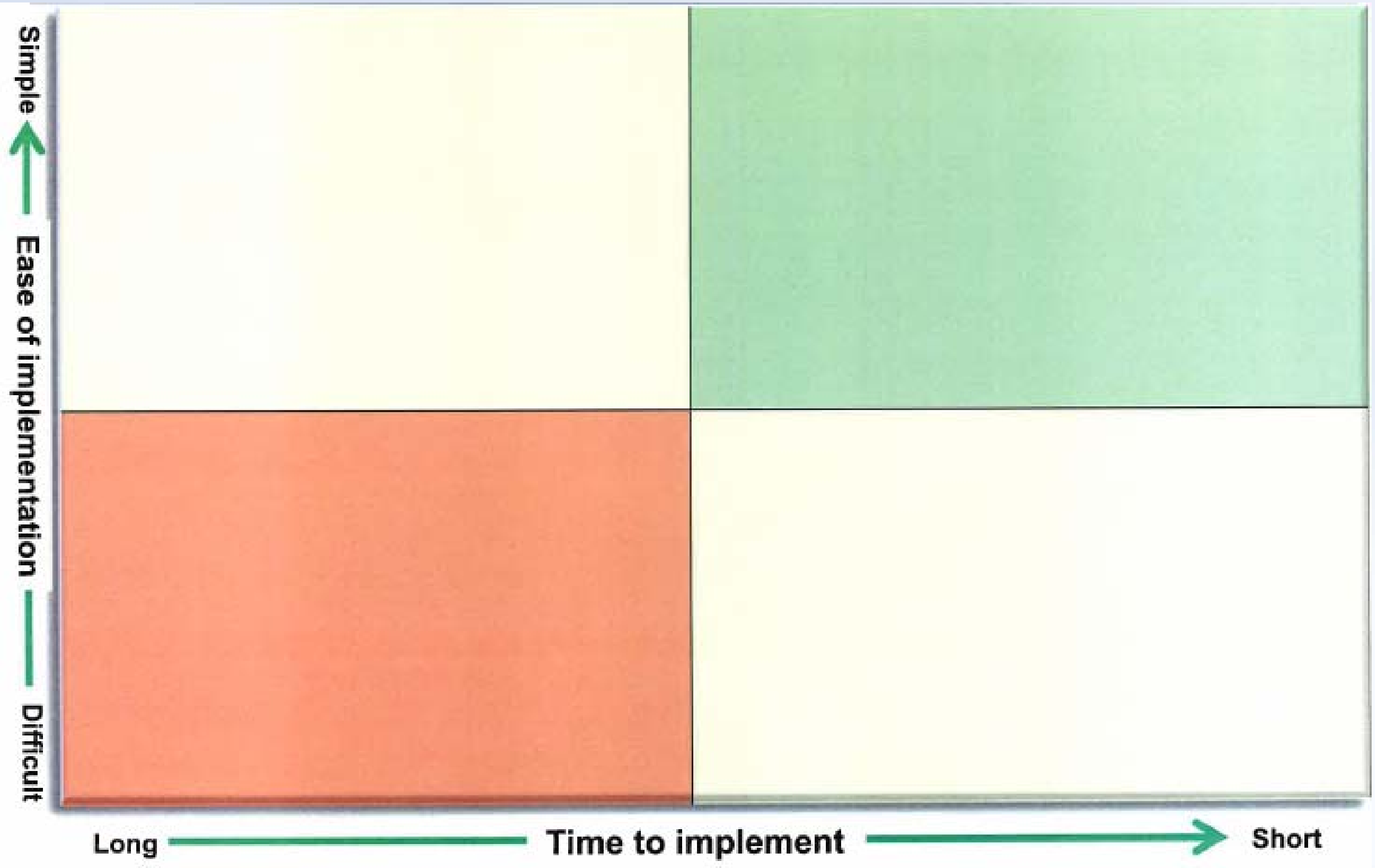
Correlate the gaps with CoBs Climate Action Plan and needs of the community

	Reliability	Rate	Renewable	Energy Efficiency
Aggregate customer demand			●	●
Real time data access		●		●
Demand forecasting @ aggregation point	●		●	
Predictive capabilities for grid operations	●		●	
C&I incentives for SMB		●	●	●

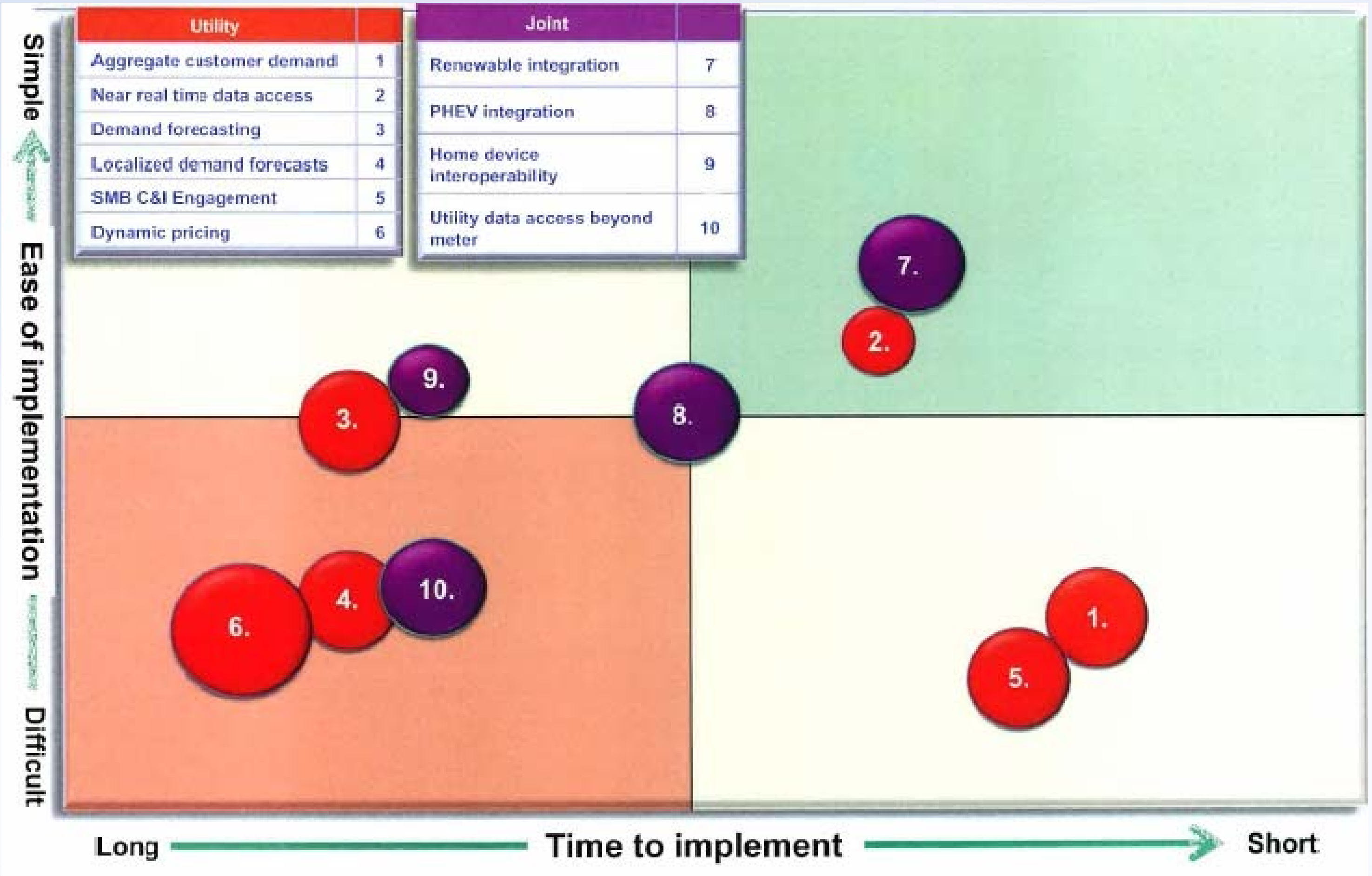
Correlate the gaps with CoBs Climate Action Plan and needs of the community

	Reliability	Rate	Renewable	Energy efficiency
Dynamic pricing capabilities		●		●
Renewable integration	●	●	●	●
PHEV integration	●	●	●	●
Interoperability in-home device exchange				●
Data access beyond the meter		●	●	●

Which gaps to address first?



Key opportunities: Renewable integration, near real time data access and PHEV integration



Representative set of recommendations to address key gaps

Gap: Increase level of renewable integration

- Assess local distributed generation & balanced portfolio of regional energy
- Leverage learning from storage demonstration project
- Leverage local partnerships to assess distribution grid capability
- Introduce incentives and supporting regulatory changes as needed

Gap: PHEV integration

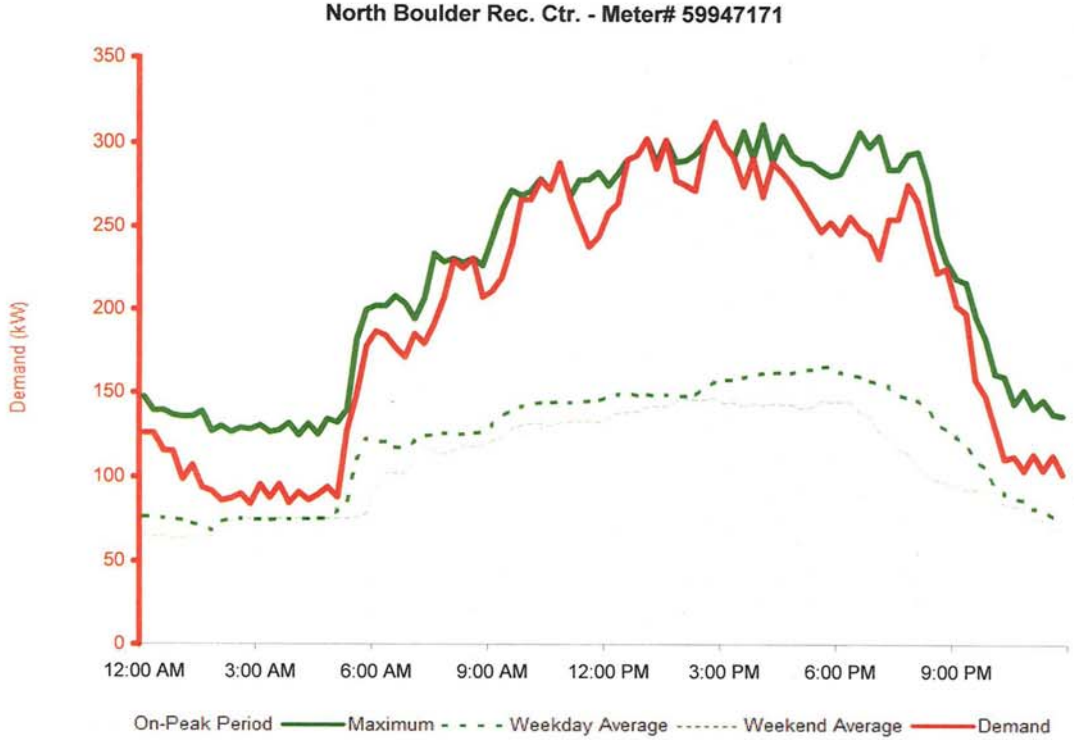
- Test smart charging and billing infrastructure
- Test rate plans and gather learning from other EV pilots
- Assess integration of PHEV's with renewable energy storage
- Pursue EV pilot funding

Energy Performance Contracts, Phase 1 and 2

- Lighting audit and retrofits
  - 10,239 fixtures to be retrofit = 1,382 KW of existing lighting power
- Water conservation audit - 57 buildings & irrigation
  - 1,591 fixture to adjust/modify/calibrate
- Building envelope: 57 buildings audited; “weatherization” at 43
- Solar PV at 9 locations – total output of 711 kW
- Solar thermal pool heating systems at 2 Recreation Centers
  - 19,300 annual therm output
- Mechanical Replacements (chillers, boilers, air handlers, etc.)
- Variable frequency drives
- Building controls, scheduling and optimization/re-commissioning

BEFORE ENERGY EFFICIENCIES

GX Meter Monthly
Intervals Page



▶ The red line in the chart above updates to display the demand profile for the selected day. The green lines are static and represent the maximum and average demands for each interval over the last 18 months.

Scroll Days in Chart

Wednesday - 07/14/10

▶ Use the scrollbar above to scroll left or right to select which day to display in the chart.

Max Demand	
313 kW	
Average:	200 kW

Consumption	
4,807 kWh	
On-Peak:	3,190 kWh (66%)
Off-Peak:	1,617 kWh (34%)

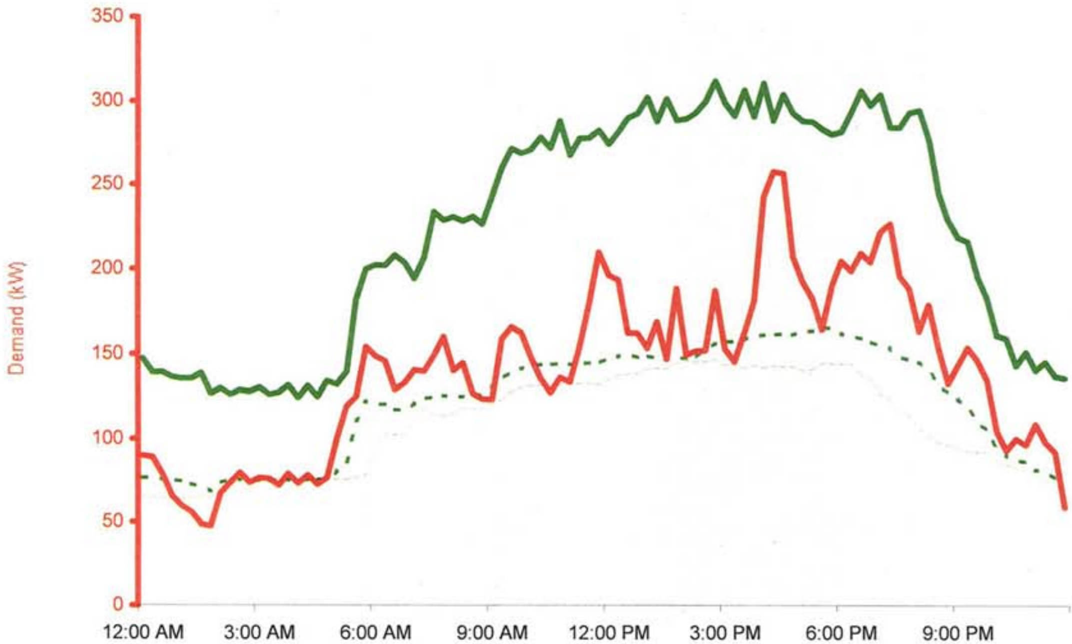
▶ The summary statistics above update to reflect the data for the day displayed in the chart.

Open Tabular Interval Data

AFTER

GX Meter Monthly
Intervals Page

North Boulder Rec. Ctr. - Meter# 59947171



On-Peak Period ——Maximum - - - Weekday Average ------- Weekend Average ——Demand

▶ The red line in the chart above updates to display the demand profile for the selected day. The green lines are static and represent the maximum and average demands for each interval over the last 18 months.

Scroll Days in Chart

Wednesday - 07/06/11

▶ Use the scrollbar above to scroll left or right to select which day to display in the chart.

Max Demand	
259 kW	
Average:	140 kW

Consumption	
3,361 kWh	
On-Peak:	2,122 kWh (63%)
Off-Peak:	1,239 kWh (37%)

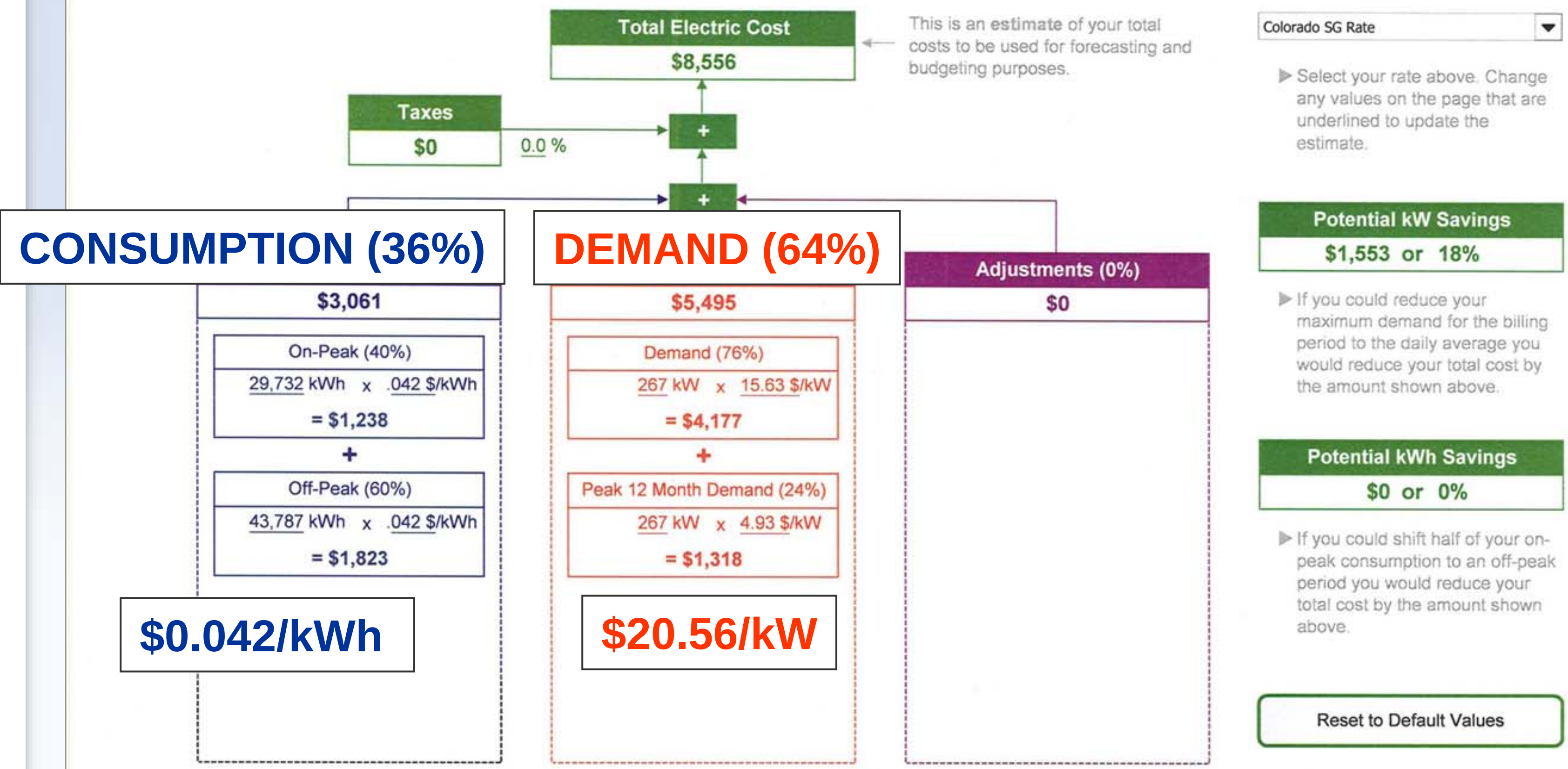
▶ The summary statistics above update to reflect the data for the day displayed in the chart.

Open Tabular Interval Data

EPC, Phase 3

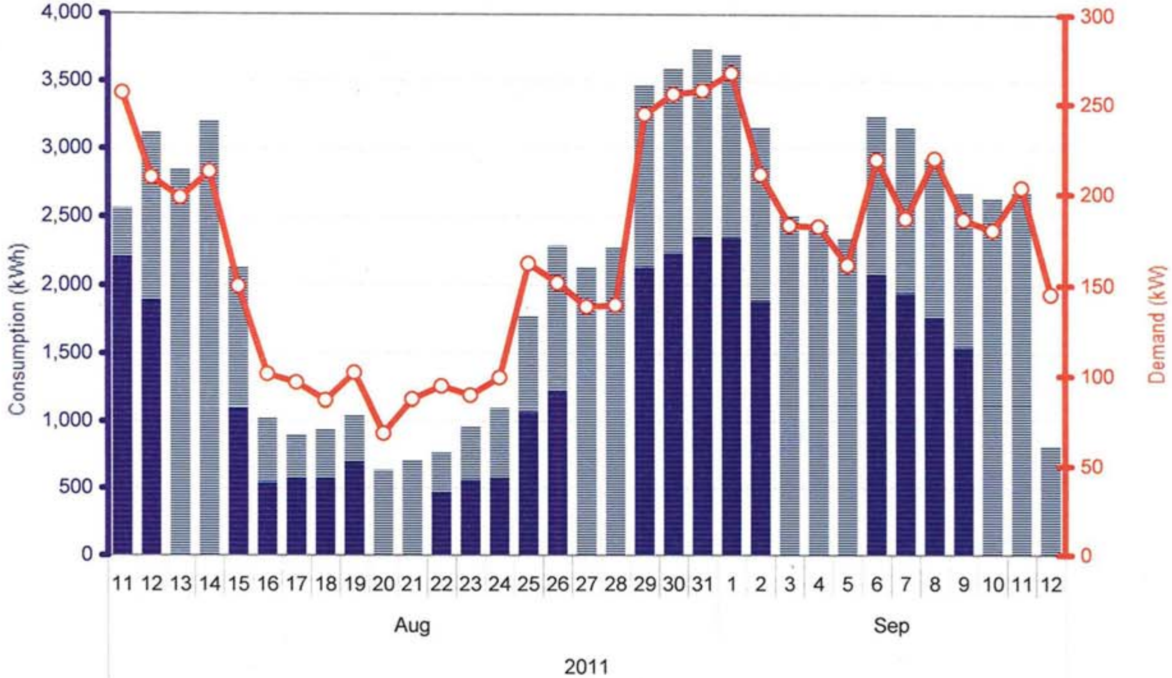
- $3.1M in additional lighting and HVAC retrofits in city buildings
- 336KW and $1.8M in solar PV
- $205,000 in utility savings
- Smart Buildings and Employee Education
- Another 2,000 mtons of CO_2 reductions
- Buildings 47% more efficient
- Overall goal was to accomplish >20% reduction in carbon emissions through the EPC
  - ~17% reduction accomplished with Phases 1 & 2
  - Possibly another 6% - **Total 23%**

GX Meter Monthly
Cost Estimator Page



SMART METER:
-- BANDWIDTH LIMITATIONS
-- DATA IS DAY-AFTER

GX Meter Monthly
Billing Period Page



▶ The chart above shows on-peak and off-peak periods for consumption. On-peak periods are 9 am to 9 pm on weekdays. Off-peak periods are 9 pm to 9 am on weekdays plus weekends and holidays.

Colorado SG Rate

Estimated Cost
$8,556

▶ Estimated total cost for the reported period based on your rate selection above.

Max Demand
267 kW

Average:	168 kW
Peak Interval:	09/01/11 - 05:30 PM

▶ Demand is the maximum power in kilowatts (kW) for each day for the reported period.

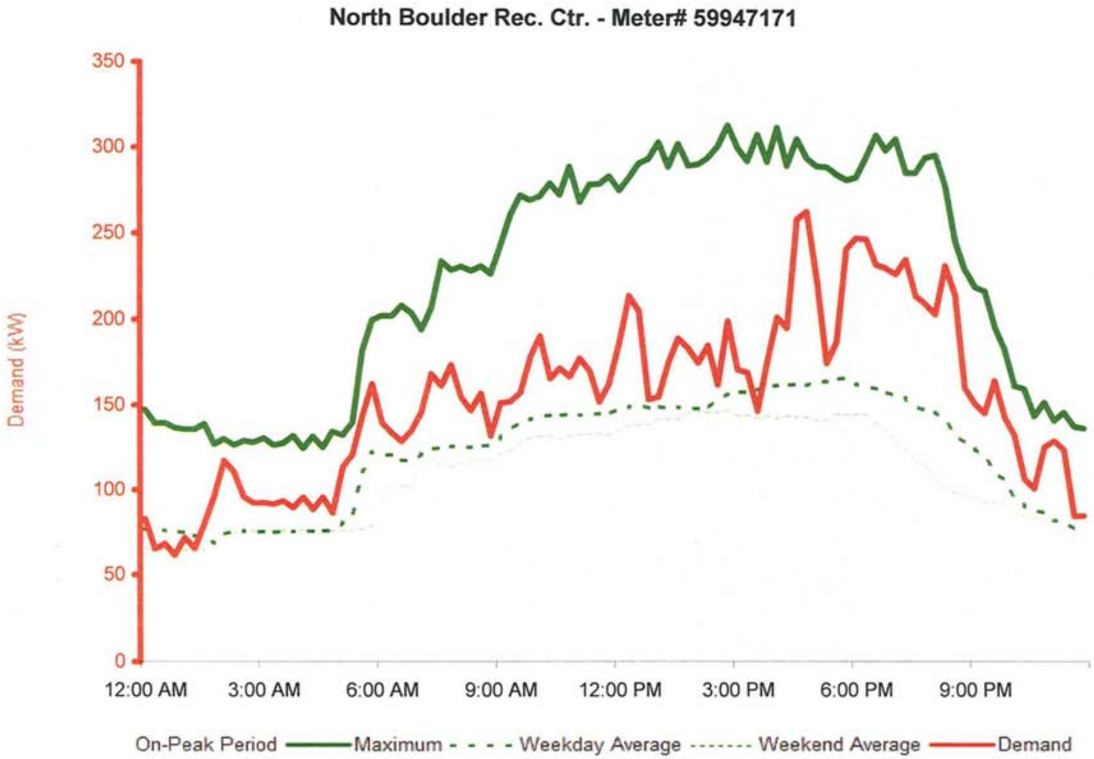
Consumption
73,519 kWh

On-Peak:	29,732 kWh (40%)
Off-Peak:	43,787 kWh (60%)

▶ Consumption is the total energy in kilowatt hours (kWh) for the reported period.

SMART METER:
-- NOT NET METER CAPABLE

GX Meter Monthly
Intervals Page



▶ The red line in the chart above updates to display the demand profile for the selected day. The green lines are static and represent the maximum and average demands for each interval over the last 18 months.

Scroll Days in Chart

Monday - 07/25/11

▶ Use the scrollbar above to scroll left or right to select which day to display in the chart.

Max Demand	
263 kW	
Average:	154 kW

Consumption	
3,698 kWh	
On-Peak:	2,311 kWh (62%)
Off-Peak:	1,387 kWh (38%)

▶ The summary statistics above update to reflect the data for the day displayed in the chart.

Open Tabular Interval Data

North Boulder Rec Center

eGauge

Stats | Kiosk | Status | Settings | LAN Access | Tools | Help

7/24/2011 4:03PM – 7/25/2011 4:03PM

Summary for time-period shown in graph

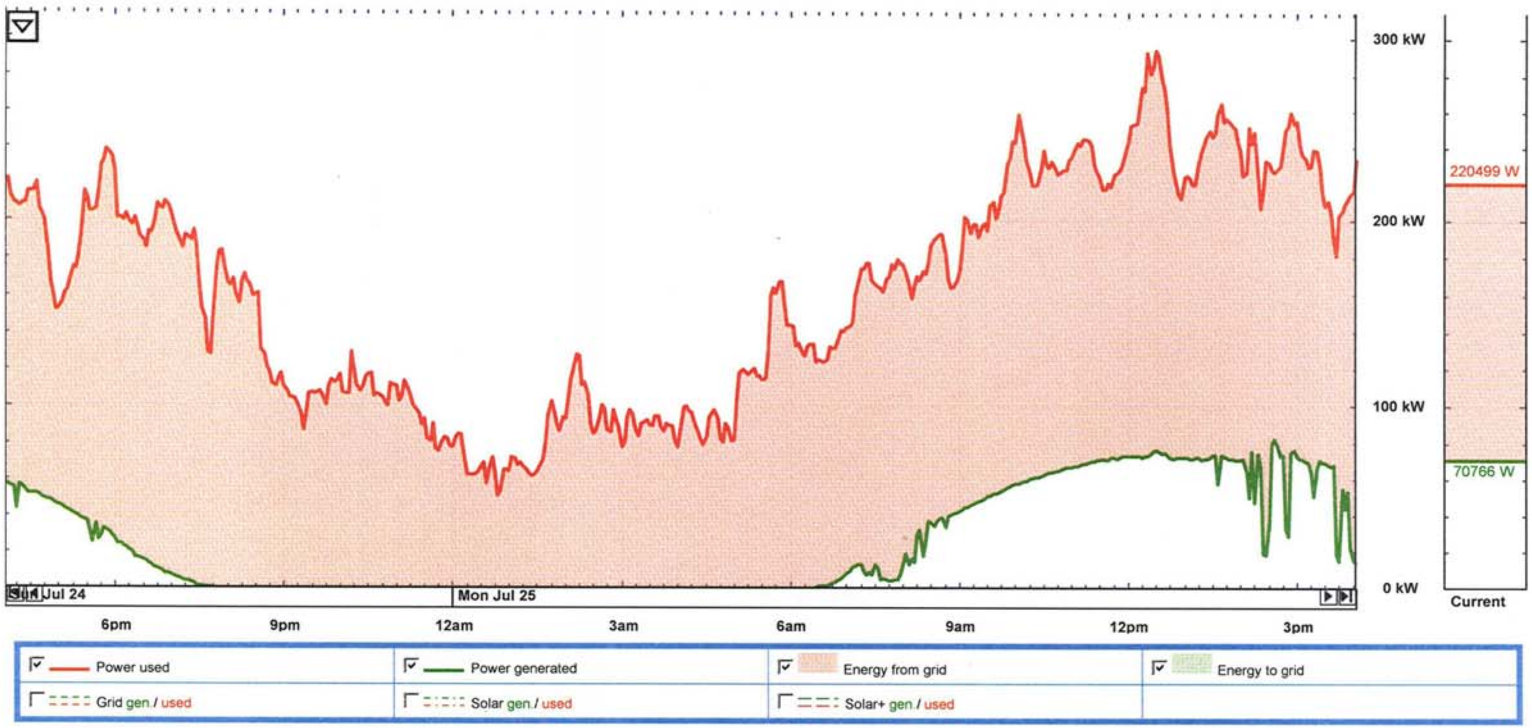
Energy Used	3.89 MWh	(approx. $505.57 used)
Energy Generated	590 kWh	(approx. $76.76 saved)
Net	3.30 MWh bought	(approx. $428.82 bought)

Summary over last 30 days

Energy Used	93.4 MWh	(approx. $12,144.02 used)
Energy Generated	12.2 MWh	(approx. $1,585.31 saved)
Net	81.2 MWh bought	(approx. $10,558.72 bought)

All | 1y | 6m | 3m | 1m | 3w | 1w | 3d | 1d | 12h | 6h | 3h | 1h | 60s

Auto | 500kW | 100kW | 50kW | 10kW | 5kW | 1kW | 500W | 100W | 50W



Solar PV Systems

BOULDER EV PROJECT

(DRAFT- 24 Aug 2011)

Zam Energy

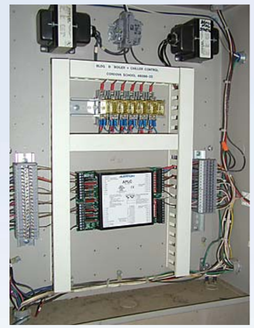
McKinstry / Namaste

PV Inverter

Grid

Xcel Energy

Power Tagging

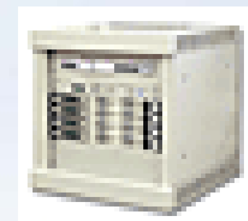


Building Automation System (BAS)

McKinstry

EVSE and Battery Storage System

Eaton – Level 1& 2; V2G



EETrex

Charging Sequence:

1. EV plugs into EVSE
2. BAS determines if pre-set building peak load will be exceeded
3. If not, BAS allows direct charging from solar PV to EV
4. If no solar PV and peak load not exceeding, then EV charges from 240V building circuit
5. If no solar PV & peak load exceeded, then use battery storage systems or do not allow charging
6. Other technology – power tagging, V2G inverger, solar trees

PHEV with V2G

EETrex

EV / PHEV

City of Boulder / Ego CarShare / CU Boulder