Integrating Renewables and Electric Vehicles
Where the Rubber Meets the Road
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San Diego Gas & Electric
A Sempra Energy Company
Outline of Presentation

• Introduction

• Business Landscape
  – Key Energy Business Drivers
  – Transformational Changes
  – Big Picture Perspectives

• Integrating Renewables & Electric Vehicles
  (Implementation: where the rubber meets the road)
  – New Supply Challenges (Renewables)
    ➢ Connectivity
    ➢ System Impacts
  – New Demand Challenges (Plug-in Electric Vehicles)
    ➢ Charging Infrastructure
    ➢ System Impacts
  – Bridging the Gaps
    ➢ Shaping Supplies & Demands
    ➢ Transmission Requirements

• Into the Future
About SDG&E

- SDG&E is a California regulated public utility with 3.4 million consumers through 1.4 million electric meters and 840,000 natural gas meters in San Diego and southern Orange counties.

- SDG&E is a subsidiary of Sempra Energy (NYSE: SRE), a Fortune 500 energy services holding company based in San Diego.

Major Capital Projects:

- SDG&E Smart Meter Program ($500 million) - Approval Process, Installation - Estimated Completion 2011
- Sunrise Powerlink ($1.9 billion) - Approval Process, Construction - Estimated Completion 2012
California’s RPS is one of the most Aggressive in the Country

State Renewable Portfolio Standards – Aug 2008

**Source:** Black and Veatch

**Required Renewables MW**
- 15,000+ MW
- 5,000 – 15,000 MW
- 1,000 – 5,000 MW
- 0 – 500 MW
- 0 MW
RPS & Pending GHG Regulation Impacts (Geographical)

California's Greenhouse Gas Emissions

- Transportation, 41%
- Industrial Facilities (Over 40% Petroleum Refineries), 23%
- In-State Electricity Generation, 10%
- Out-of-State Generation, 10%
- Other, 16%

Data Source: 2007 – EIA-860 – Annual Electric Generator Report
Market Changes Driven by RPS

RPS Impact on Energy Supply Chain

- Domestic Production
  - Gas Trans./ Storage
  - Natural Gas
- Import
  - Coal
  - Solar, Wind, Others
- Renewable
  - Nuclear Plants
  - Simple/Combined Cycle Plants
  - Peakers
  - Transmission Network
  - Investor Owned Utilities
  - Public Owned Utilities
  - Distributed Resources
  - Customers
  - Smart Meters
  - Customers

Domestic Production

Import

Renewable
Market Changes Driven by GHG Reduction Regulation

**GHG Regulation Impact on Energy Supply Chain**

- **Domestic Production**
  - Gas Trans./Storage
  - Natural Gas

- **Import**
  - Solar, Wind, Others

- **Coal**
  - Coal Plants

- **Renewable**
  - Simple/Combined Cycle Plants

- **Peakers**
  - Energy Storage

- **Transmission Network**

- **Investor Owned Utilities**

- **Customers**
  - Smart Meters
  - Customers with CO2 Emission
  - Distributed Resources
  - Plug-in Electric Vehicles

- **Customers**
  - Public Owned Utilities
  - Customers
Market Changes Driven by Other Factors

Changes Driven by Fuel Volatility

- Domestic Production
- Gas Trans./Storage
- Natural Gas
- Solar, Wind, Others
- Nuclear Plants
- Coal Plants
- Simple/Combined Cycle Plants
- Peakers
- Renewable
- Energy Storage
- Gas Trans./Storage
- Peakers
- Renewable
- Energy Storage

Changes Driven by Smart Grid and New Demand (PEV)

- Customers
- Smart Meters
- Distributed Resources
- Plug-in Electric Vehicles
- Public Owned Utilities
- Customers
- Customers with CO2 Emission

- Changes Driven by Market Changes Driven by Other Factors
Transformational Changes Across Energy Supply Chain

An Evolving Energy Supply Chain

- Environment
- Sustainability
- Efficiency
- Reliability
- Cost

AN ORGANIZED MARKET

Domestic Production

Import

Gas Trans./Storage

Natural Gas

Coal

Coal Plants

Simple/Combined Cycle Plants

Nuclear Plants

Transmission Network

Investor Owned Utilities

Customers with CO2 Emission

Customers

Smart Meters

Distributed Resources

Plug-in Electric Vehicles

Public Owned Utilities

Customers with

CO2 Emission

Solar, Wind, Others

Renewable

Peakers

Energy Storage

AN ORGANIZED MARKET

Will Smart Grid Drive End-to-End Supply Chain Integration?
Integrating Renewables - Challenges

Implementation: Where the Rubber Meets the Road

Connectivity

- Existing Transmission Interconnection (capacity limitations)
- Dedicated Point to Point Transmission (economics & environmental)

System Impacts

- Intermittencies Issues
  - Intra-day variations
  - Intra-hour variations
- Other Technical Issues
  - Var Management
  - Low Voltage Ride-through
## Renewable Resource Availability in the West

### Total Renewable Resource Availability by Region (MW)

<table>
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<th>Region</th>
<th>Biogas</th>
<th>Biomass</th>
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<th>Small Hydro</th>
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<th>Wind</th>
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<td><strong>WECC Total</strong></td>
<td>592</td>
<td>2,361</td>
<td>6,004</td>
<td>2,356</td>
<td>729,538</td>
<td>277,005</td>
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- Biomass & hydro limited
- Good wind resources plentiful in Rockies
- Lots of solar thermal theoretically available, but at a higher cost
Integrating Renewables in the West

Local Integration
- Local Transmission
- System Limitations
- Tradable REC

Remote Integration
- Long Transmission
- Environmental Concerns
- Long Permitting Process
- Congested Import Points
- Economic Risks

NOTE: For clarity, not all WECC Rated Paths are shown.

B/C Ratio > 1
System Impacts - Solar Resources

Operations Concerns:

- Forecasting & Scheduling
  - Intra-day Variations
  - Intra-hour Variations
- Var Control
- Low Voltage Ride-through
System Impacts - Wind Resources

- Output Profile Varies Geographically
- Low Capacity Value
- Maintaining System Balance is a Concern
- Accurate Forecasting and Modeling is Critical for Successful Integration
- Operations Planning
  - A/S & Regulation
  - Operating Reserves
  - Ramping
  - Quick-start
  - Over Gen.
System Impacts – Integrating Distributed Renewables

Generator/PV Metering – Customer load less than Generation

Operations Concerns:
- Troubleshooting
- Safety

SDG&E Received Power

Point of Service Meter (Bi-directional)

Customer Load (Meter 2 - Meter 1)

Generator Output Meter

Customer Generator/PV
System Impact Modeling

**Annual Hourly Dispatch Sorted by Load**

- The need to dump power as must-take and renewable power exceed loads during some hours
- Operations Management by CAISO will be a critical factor
Where the Rubber Meets the Road

• Infrastructure
  – Need for charging infrastructure – 110/120V vs. 220V/240V
  – Hierarchy Approach for Infrastructure (Home, Multi-unit, Workplace, Public)
  – Penetration Estimates for PEVs

• Energy Requirements for PEVs
  – Renewables and RPS requirements
  – Potential storage capacity projections provided by PEV battery
  – PEV as a renewable energy sink – wind power example
  – Solar power and PEV peak charging

• Second life for PEV batteries - stationary storage facility (renewables)
  – Very flexible renewable sink - solar, wind, etc.
Plug-in Electric Vehicles (PEVs) include:

Battery Electric Vehicles (BEVs) or also called Electric Vehicles (EVs)
  - ONLY run on electricity supplied by an on board battery charged from the grid
  - i.e. Nissan EV

Plug-in Hybrid Electric Vehicles (PHEV)
  - Plug-in-Hybrid denotes the vehicle connects to the grid for electric energy
  - Parallel PHEV (i.e. PHEV Prius)

Extended Range Electric Vehicles (EREV)
  - IC engine directly powers an "on-board generator" for electric drive
  - Series PHEV (i.e. Chevy Volt)

Vehicle Charging
  - SAE standards work, single approved design
  - Level 1 = 110/120V AC
  - Level 2 = 220/240V AC
  - Level 3 = 440V AC and higher
  - Direct Charging – High Voltage using DC
PEV makes, models & timing

- BYD in Europe
- Fisker Karma
- Subaru Stella
- Chrysler
- Smart for Two
- ZENN City
- BYD EV (China)
- Tesla Roadster

### 2009
- Tesla Roadster

### 2010
- Nissan EV (mule)

### 2011
- Toyota PHEV

### 2012
- BYD

**Production – Plans and Capacity**
- Fisker Karma – 15,000 per year
- Subaru Stella – 170 through March 2010
- Tesla Roadster – 500 owned by end of May 2009
- Saturn VUE – Production cancelled
- Toyota Prius – 500 for lease by end of 2009
- EPRI Trouble Truck – 50 vehicles for eval
- Nissan Smyrna, Tenn. – 150,000 capacity (2012)
- BMW Mini E – 500 for field trial
- Mitsubishi iMiEV – 2000 through current yr (Japan). 5000 next year (Japan).
- Aptera – 4,000 deposits beginning production in late 2009
Significant acceleration in PEV penetration post 2020

1.3 million in 2020

~0.5 million in 2015

San Diego PHEV Penetration Estimates

A Potential of 100,000 PHEV by 2020 in San Diego
THE NISSAN EV

SDG&E Announced Partnership with Nissan on Charging Infrastructure

Features

- Compact Car Size
- Space For 5 People
- 100-Mile Range
- Advanced Safety Features
- Unique Design
- Premium Amenities
- J1772 Connector (SAE Std)
- Charge time 8 Hr@ 220V 16 Hr@110V

~2,000 Nissan EVs released in San Diego Q4 2010

Nissan $1.6 Billion DOE Loan to Retool US Facility (TN)
- 100,000 EVs produced in US 2011
- 150,000 EVs & 200,000 Batteries/yr by 2012
Benefits to the Consumer of PEV

- **Zero-emission vehicle**
  - No tailpipe emissions – *no tailpipe!*

- **Low carbon footprint**

- **Lower cost of ownership**
  - EV DOE MPG rating - **367 mpg equivalent** *

  **Cost per mile @ 15k miles/yr:**

  - Conventional Car – (30mpg & $3/gal)
    - ~$0.10 per mile / $1,950 per year
  - EV @ $0.14 kWh (SDG&E Off-Peak EV TOU Rate)
    - ~0.04 per mile / $600 per year

  Cost advantage exists even if gasoline drops below $1.10/gal

- **Lower maintenance costs**
Impacts Assessment - Vehicle Charging Hierarchy

Where does your car park **MOST** of the time?

- **Home Base (generally off-peak hours)**
  - 50 – 65 % of parking time spend at vehicle’s home base
    - Single Family Residence – Est. 20% of consumers have their own garage
    - Multi-unit Dwellings in Urban/Suburban Areas (variety of scenarios)
    - General – Overnight Lot, Street Parking, Parking Structures

- **Workplace (generally on-peak hours)**
  - ~30 % of the vehicles time
    - Parking Lot, Street and Parking Structures (Day)

- **Public (both on-peak and off-peak hours)**
  - Est. 4% - 10% weekdays, higher on weekends
    - Commercial Establishments, Street and Structure Parking
50% of US Autos travel less than 26 miles/day (EPRI)

- Suggests home based charging will supply near-term charging needs of the PEV market

- Select public charging sites will add to consumer PEV confidence & reduce “range anxiety”

- PHEVs owners will not suffer “range anxiety” with dual fuel capability
- BEV owners will have an estimated 100 mile range

Volt 40 miles   Nissan EV 100 miles
Utility Charging Challenges – Priority Order

1. **Outreach to Multi-unit Dwellings**
   a) Prop. Managers/Owners and HOA
   b) Covenants and Policies

2. **Residential**
   a) Single Family Dwellings, Multi-unit dwellings
   b) Install Process, Rates, Permits

3. **Commercial**
   a) Workplace and Retail
   b) Commercial arrangements

4. **General Public Access**
   a) Municipal and private with general public access
   b) Limited deployment, increasing over time
Policy makers can provide the right incentives to maximize the system-wide benefits of PEVs which include:

- PEV time-of-use (TOU) rates provide electric customers with incentives to utilize **off-peak** charging
- Cost-effective sub-metering for PEVs

Studies indicate consumer charging patterns naturally occur during **off-peak** hours.
Hybrid Car Metering – Measure Customer Charging Power

SDG&E Delivered Power → M1 → Point of Service Meter (Total Energy Consumption) → M2 → Customer Load(s) → Additional Electric Vehicle Meter → Customer Plug-in EV
EV TOU Rates and options for consumer

### Electric Costs for Home and PEV

#### Avg. Home 500 kWh
- Average home monthly use/cost (tiered)
- PEV use/cost separate TOU meter (non-tiered)
- Combined Cost Home (tiered)

#### PEV 750 kWh
- PEV (non-tiered)
- Combined 1250 kWh
- Combined Home & PEV on EV TOU 2 (all use is TOU)
- Combined Home & PEV on DR Rate, (all use tiered)

### Vehicle Class Information

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Range [kWh/mile]</th>
<th>Battery Energy [kWh]</th>
<th>Level II Charging @120/240V @30/15A (3.3kW) [Hours]</th>
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<tbody>
<tr>
<td>Compact sedan</td>
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<td>20 - 30</td>
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</table>
No Major System Concerns for Plug-in EV Integration

- No Concern for Total Electric Demand (300MW - 5% system load in year 2020)
Local Overload Concerns for Plug-in Electric Vehicles

Potential Local Transformer & Secondary Overload (monitored with Smart Meters)

Overload can occur on a hot summer night with A/C loads and electric vehicle charging happening at the same time.
Into the Future

Integration and Coordination Within a Smart Grid Master Plan

Energy Flow

Shaping Renewable Supplies
- Pump Storage / Battery (Intra-day variations)
- Peaker / Battery (Intra-hour variations)

Shaping New Demands
- Smart Chargers for PEV
- Smart Appliances

SDGE
A Sempra Energy utility

Condition Based Maintenance
Mobile Workforce
Self-Healing Grid

Battery Storage
Smart House With Solar
Home Energy Control Device
Plug-In Hybrid

Smart Office
Fuel Cell
Smart Meter

Solar
Wind
Nuclear
Fossil

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The End!