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<tr>
<th><strong>Docket Number:</strong></th>
<th>16-TRAN-01</th>
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<tbody>
<tr>
<td><strong>Project Title:</strong></td>
<td>SB 350 Transportation Electrification (Publicly Owned Utilities)</td>
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<td>Presentation - Key Considerations for Incorporating Transport Electrification into IRP by Nancy Ryan</td>
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<td>Patty Paul</td>
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Key Considerations for Incorporating Transport Electrification into IRP

California Energy Commission

October 5, 2016

Nancy Ryan, Partner
About E3

- San Francisco-based consultancy with 40 professionals focusing on electricity sector economics, regulation, planning and technical analysis
- Leading consultant to California agencies governing renewables, energy efficiency, demand response, and distributed generation programs
- Consultant to many of the world’s largest utilities and leading renewable developers
- Our experience has placed us at the nexus of planning, policy and markets
Multiple scenarios are on a consistent trajectory to meet CA’s 2050 GHG goal:

- **Timing scenarios** vary the pace of decarbonization: 2030 GHG emissions range from 26-38% below 1990 level.
- **Technology scenarios** (not shown) assess impacts and interactions for specific technologies.
Decarbonizing CA’s economy depends on four energy transitions:

1. **Efficiency and Conservation**
   - Energy use per capita (MMBtu/person)

2. **Fuel Switching**
   - Share of electricity & H₂ in total final energy (%)

3. **Decarbonize electricity**
   - Emissions intensity (tCO₂e/MWh)

4. **Decarbonize fuels (liquid & gas)**
   - Emissions intensity (tCO₂/EJ)

Energy use per capita and emissions intensity are shown over time with various scenarios and reference lines.
Fuel switching drives rapid growth in electric generation after 2030

+ Energy efficiency offsets impact of electrification through 2030
+ Beyond 2030 new loads offer potential for flexibility to help integrate solar and wind generation

### Electricity demand by sector

- Residential
- Commercial
- Industrial, Oil & Gas
- Agriculture & other
- Transportation
- Hydrogen production, CNG/LNG compression

![Electricity demand by sector (Straight line scenario)](chart)
California policy is driving significant renewable adoption

+ Gov. Brown’s GHG goals: 40% reduction in economy-wide emissions, relative to 1990 levels, to be accomplished with:

  • 50% renewable electricity
  • Doubling of energy efficiency savings in existing buildings
  • Up to 50% reduction in petroleum use in cars and trucks

+ Net energy metering decision will drive significantly more adoption of rooftop PV
SB350 renewable energy target probably too low to meet 2030 GHG goal

Renewables account for 50-60% of annual energy use by 2030

Integration solutions are needed in all high renewables cases:

- Regional coordination, renewable diversity, flexible loads, more flexible thermal fleet, curtailment energy storage, flexible fuel production for ZEVs

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### Annual Energy

<table>
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<tr>
<th>Year</th>
<th>Renewable</th>
<th>Nuclear</th>
<th>Hydro</th>
<th>Imports</th>
<th>CA CCGT/CT</th>
<th>CHP</th>
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<tbody>
<tr>
<td>2015</td>
<td>20%</td>
<td></td>
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<tr>
<td>2030-SL</td>
<td>50%</td>
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<tr>
<td>2030-ED</td>
<td>60%</td>
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</table>

### 2030 Renewable Generation by Type (%)

- Wind
- Solar thermal
- Geothermal
- Small hydro
- Rooftop PV
- Grid solar
- Bio
- Nuclear
- Hydro
- Imports
- CA CCGT/CT
- CHP
In 2015, California is achieving $\approx 25\%$ RPS

- Some resources out of state
- California resources will need to double by 2030 to reach a 50% RPS

Source: CPUC RPS Calculator (v.6.1)
In-state resource potential is largely solar

+ “Bucket 1” resources must be 75% of RPS portfolio by 2020

  - Must interconnect to or be dynamically scheduled to a California BA
  - Applies to LSEs, CCAs

+ Developable in-state potential:

  - Geothermal: 1800 MW
  - Wind: < 3000 MW
  - Solar: 100,000+ MW

“Bucket 1” resources must be 75% of RPS portfolio by 2020

- Must interconnect to or be dynamically scheduled to a California BA
- Applies to LSEs, CCAs

Developable in-state potential:

- Geothermal: 1800 MW
- Wind: < 3000 MW
- Solar: 100,000+ MW
Current policy driving robust growth in distributed solar

+ Recent CPUC decision on NEM successor tariff ensures a significant rooftop solar market in California

+ Future adoption is highly uncertain, but most projections suggest 10-20 GW of customer PV by 2025

Predicted Growth of Customer-Adopted Solar PV
40 GW of solar expected in California by 2030

Unless procurement practices are changed, total solar installations in IOU service areas could reach 35–39 GW by 2030

- 15-20 GW utility scale
- 15-20 GW customer-owned
- Additional 2-5 GW from muni service areas (SMUD, LADWP)

Non-solar renewables will add another 15-20 GW

Source: CPUC’s NEM 2.0 Public Tool
Solar generation is already suppressing market prices

- Rapid increase in solar buildout has clearly begun to suppress daytime market prices—but negative pricing has not yet been observed in the day-ahead market.

CAISO Hourly Solar Generation by Year (March – May only)

NP15 Day-Ahead Hourly Market Price (March – May only)

High hydro conditions lead to low spring prices in LIH periods.

Limited impact of solar PV on market pricing apparent at low penetrations.

High solar penetration suppresses prices in the middle of the day; prices close to $0/MWh, but not negative (yet).
Negative prices have been observed in the real-time market in 2015

- Negative prices seen more frequently in spring
- Negative price magnitudes and frequency are higher in SP-15
- Day ahead markets have still not experienced negative prices
- We anticipate the real time and day ahead markets will both have considerable number of hours with negative prices with increasing solar
Integration solutions are needed in all high renewables scenarios

+ Increased regional coordination
  • Make best use of latent flexibility in current system

+ Renewable resource diversity
  • Reduces overgeneration and need for flexible resources

+ Flexible loads
  • Shifting loads from one time period to another, sometimes on short notice

+ Flexible generation
  • Need generation that is fast ramping, starts quickly, and has min. gen. flexibility

+ Energy storage
  • Deep-draw (diurnal) storage is important
In High BEV scenario long-duration energy storage provides bulk of renewable balancing services for the grid.

In Straight Line scenario flexible grid electrolysis for hydrogen FCVs balances renewables on the grid.

ZEV pathways require different electricity infrastructure.

**Zero Emissions Vehicles**
- Mix of fuels cell (FCVs) and battery electric vehicles (BEVs)
- Focus on BEVs if FCVs don’t materialize

**New Infrastructure**
- Electric vehicle charging load: 7,000 MW
- Flexible grid electrolysis: 9,000 MW
- H₂ fueling stations
- No new energy storage

**OR**
- Electric vehicle charging load: 20,000 MW
- New 4-8 hr energy storage: 5,000 MW
- No grid electrolysis
- No H₂ fueling stations

Electric vehicle charging load: 7,000 MW
Flexible grid electrolysis: 9,000 MW
H₂ fueling stations
No new energy storage

Energy + Environmental Economics
Thank You!

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Nancy Ryan, Partner (nancy@ethree.com)
# E3’s “Pocket Guide” to Renewable Integration Solutions

<table>
<thead>
<tr>
<th>Integration solution</th>
<th>Findings</th>
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<tr>
<td>Regional coordination</td>
<td>More efficient dispatch and reduced curtailment</td>
</tr>
<tr>
<td>Time of use rates</td>
<td>Shifts energy consumption toward daylight hours</td>
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<tr>
<td>Subhourly renewable dispatch</td>
<td>Allows system to operate with fewer thermal resources during overgeneration events</td>
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<tr>
<td>Renewable portfolio diversity</td>
<td>Avoids curtailment by spreading renewable production over more hours of the year</td>
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<tr>
<td>Flexible loads</td>
<td>Shifts energy consumption toward hours with overgeneration, but cost and potential are unknown</td>
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<tr>
<td>Advanced DR</td>
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<tr>
<td>Additional storage</td>
<td>Reduces curtailment but requires significant investment</td>
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<tr>
<td>Gas retrofits</td>
<td>Makes existing resources more flexible at a low cost</td>
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<tr>
<td>New flexible gas resources</td>
<td>Provides limited dispatch flexibility at a high cost</td>
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<tr>
<td>Energy efficiency</td>
<td>Provides significant cost and GHG savings but may not reduce curtailment</td>
</tr>
<tr>
<td>Conventional demand response</td>
<td>Provides cost savings but does not significantly reduce curtailment</td>
</tr>
<tr>
<td>Low cost solutions with potentially large benefits</td>
<td></td>
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<tr>
<td>Net benefits even w/o renewables</td>
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<tr>
<td>Costs and benefits should be evaluated on specific project or program basis</td>
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<tr>
<td>Valuable, though not as much for integration</td>
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