Energy+Environmental Economics

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Long term energy system modelling: comparing UK and California

wholeSEM Conference

University of Cambridge

Oliver Rix, Baringa

Dr. Ren Orans, Energy & Environmental Economics (E3)

Energy and Environmental Economics, Inc.

- E3 was founded in 1989 by Dr. Ren Orans.
- Advises utilities, regulators, government agencies, power producers, energy technology companies, and investors on a wide range of critical issues in the energy industry
- Work throughout U.S. as well as an international practice that includes work in Canada, China, and India
- Extensive experience with scenario planning and deep energy sector modeling

Baringa Partners

- **Baringa Partners LLP is a market-leading consulting company with a focus on energy, commodities, telecoms and financial services**
- **Founded in the UK in 2000 – Baringa Partners has a market turnover of approximately £100m, with more than 400 professionals, based in London and Dusseldorf**
- **Baringa Partners has a strong track record working with leading organisations across Europe in advising on strategy, policy, investments, business transformation and performance improvement**
- **Baringa's Energy Advisory practice has a long track record of energy model design and development with policy makers, regulators, public bodies and private enterprises**

Outline

- **Deep decarbonization modeling methodology**
  - PATHWAYS (E3)
  - RESOM (Baringa)
- **Comparison of results and lessons learned**
  - Comparison of CA and UK results
  - Key convergences and decision points
- **Insights and implications**

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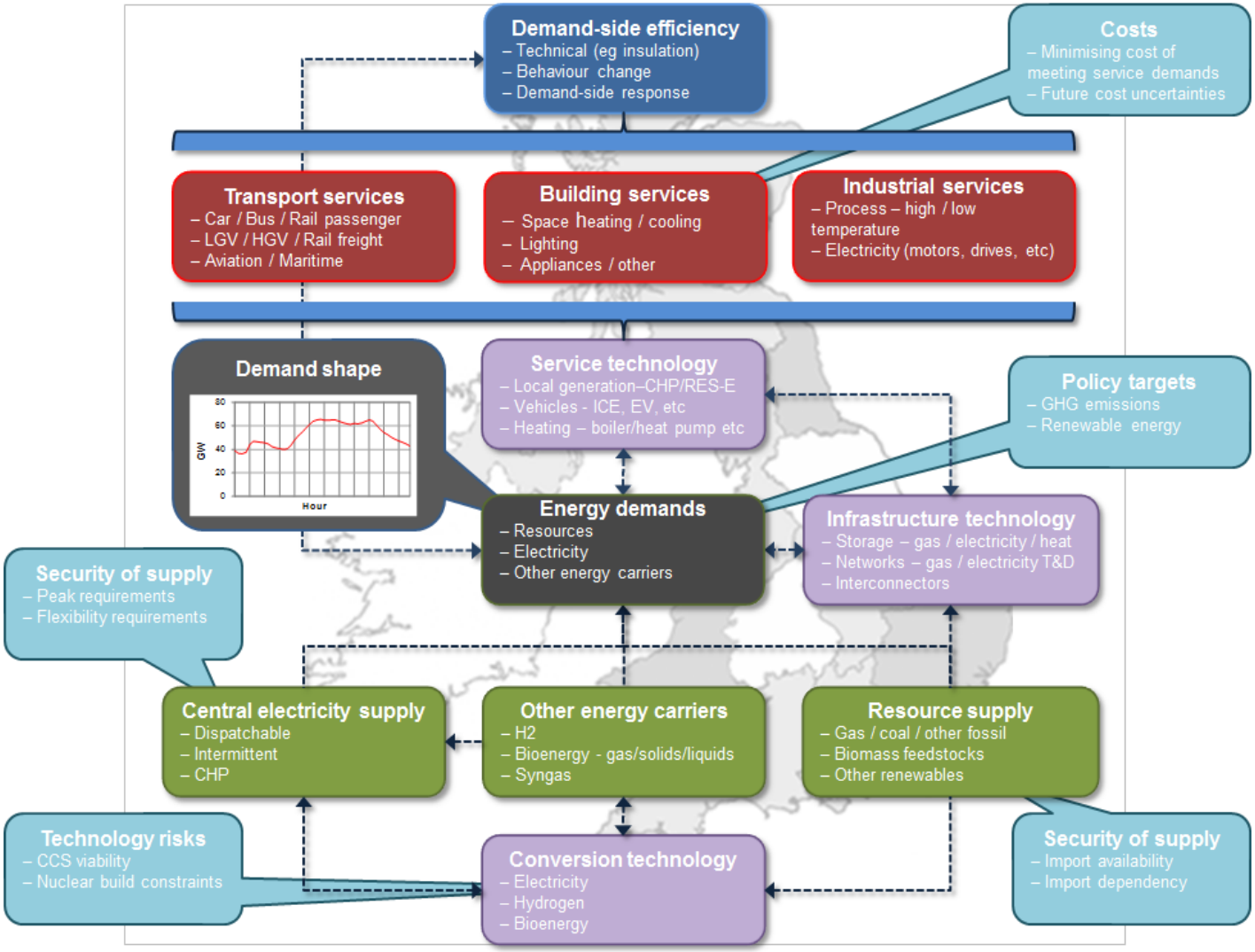
Modeling Methodology

RESOM: model methodology

- **RESOM is a Least-cost (LP) optimisation model of the UK system**
  - Captures interaction and trade-offs in and between sectors, + across all years simultaneously
- **Models the pathway from now to 2050**
  - 5-year steps, with 5 seasons and 6 diurnal timeslices
- **Model decides**
  - **What** technologies to build and **when, How** to operate them and **What** resources to use…
- **…to satisfy energy service demands cost effectively, whilst meeting constraints, e.g. :**
  - Renewables / CO2 targets
  - Security of Supply
  - Technology limits

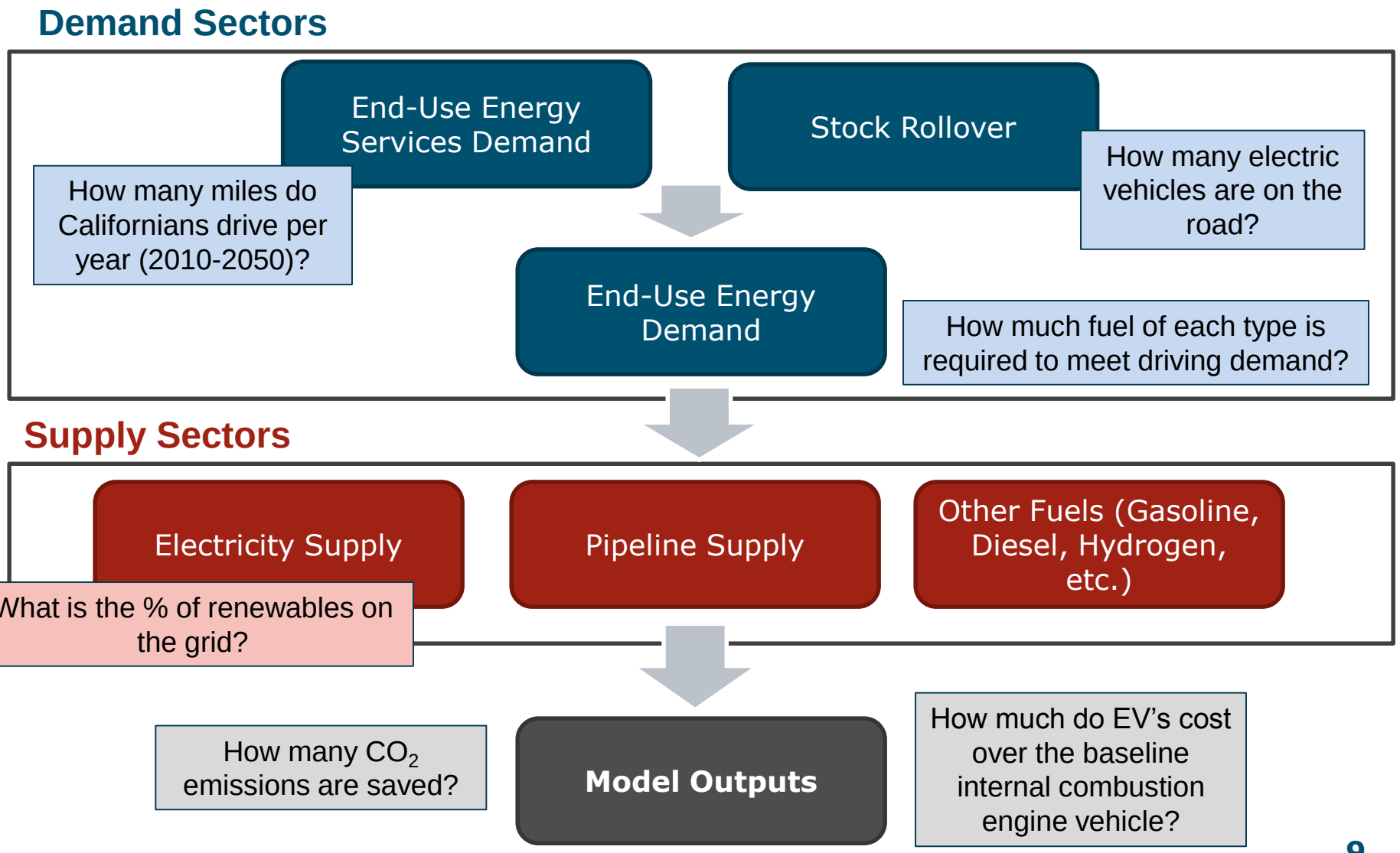
Optimisation Model Framework



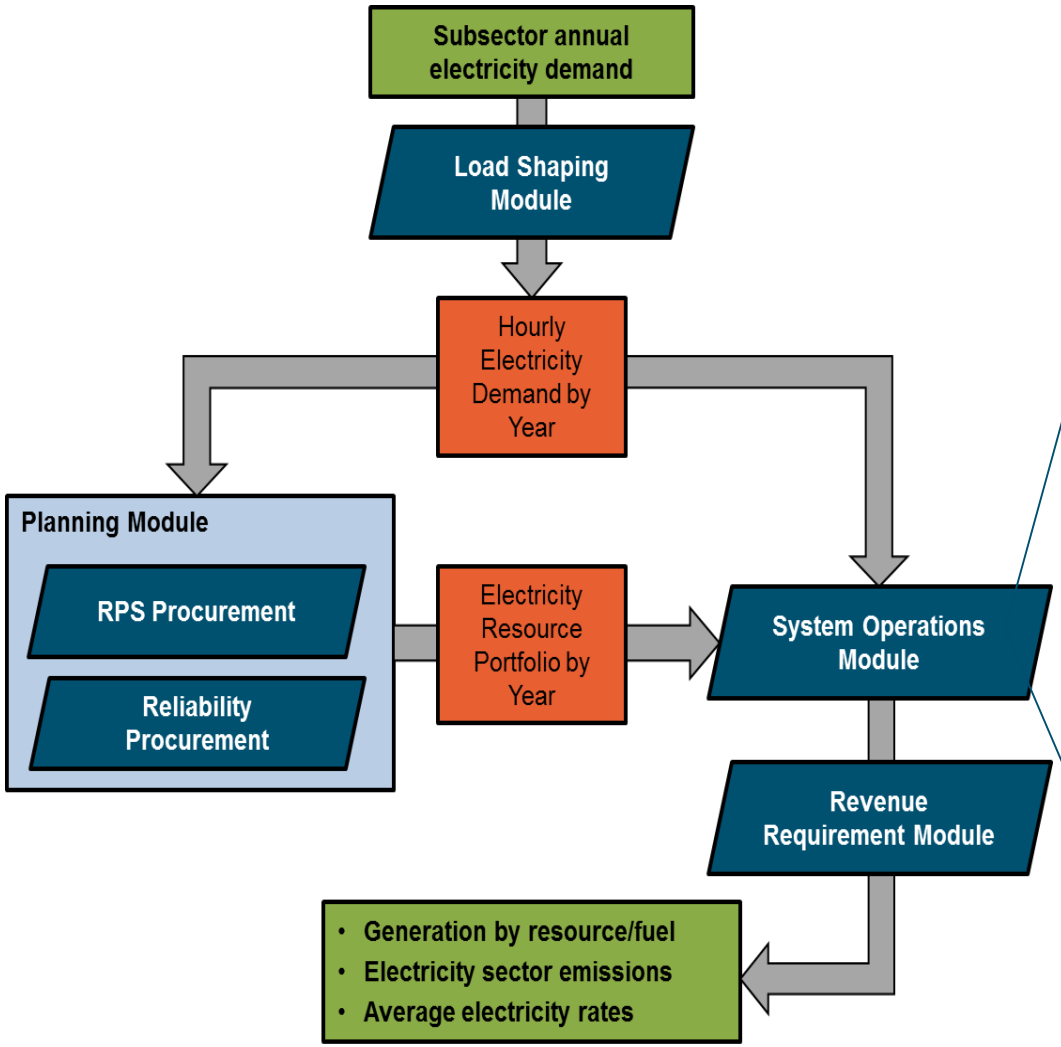
PATHWAYS: modeling approach

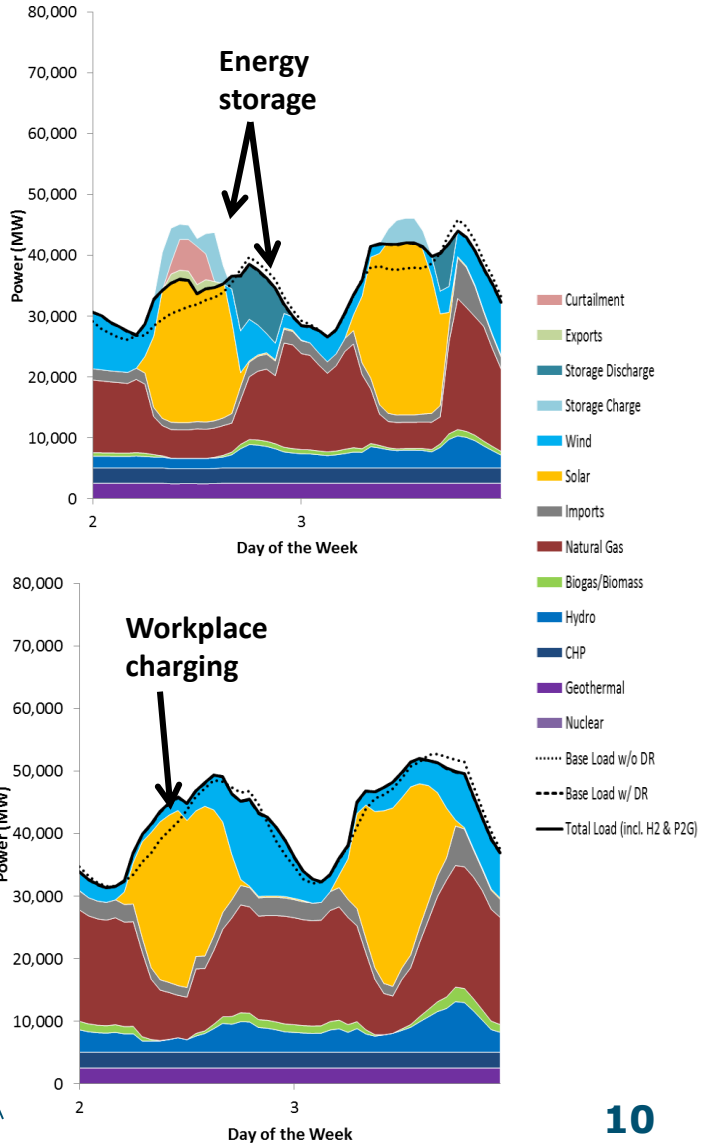
- **PATHWAYS is a California-wide, economy-wide infrastructure-based GHG and cost analysis tool**
  - Adoption rates of technologies are defined by user, stock turn-over rates are based on lifetime of equipment
  - Energy & infrastructure costs are tracked
  - Not a macroeconomic model, costs & technologies are not endogenously defined, not an optimization model
- **"Bottom up" forecast of energy demand by end use, driven by:**
  - Population, residential & commercial square footage, space heating/cooling, water heating, lighting, etc.
- **Hourly electricity demand & supply detail simulates planning, system operations, and cost**

Basic Energy Modeling Framework



Overview of Electricity Dispatch Module in PATHWAYS





Key market factors

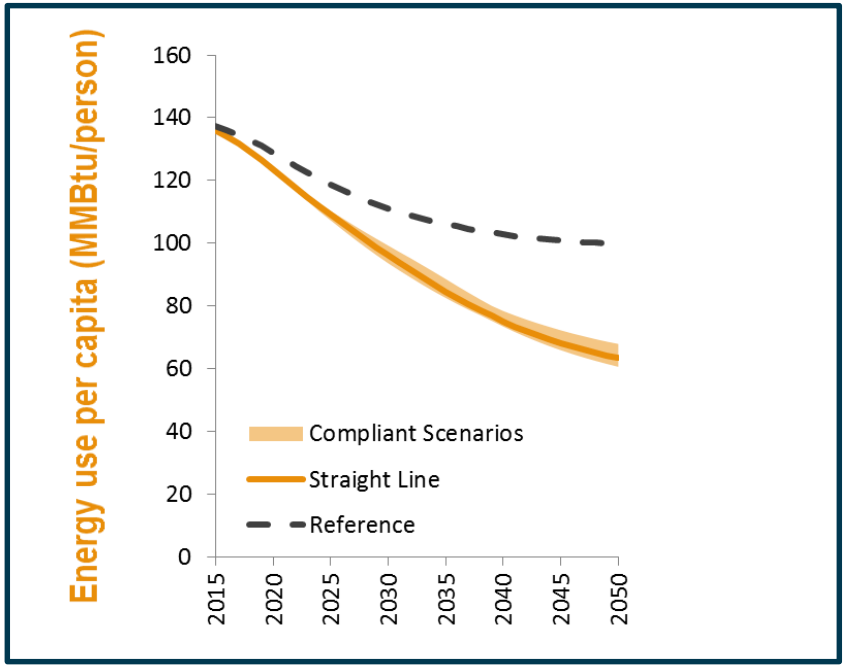
	California	United Kingdom
Demographics	Population: ~38 million Area: ~425,000 km2 Number of households: ~14 million Number of cars: ~24 million GDP: ~$2 trillion	Population: ~64 million Area: ~245,000 km2 Number of households: ~23 million Number of cars: ~30 million GDP: ~$2.6 trillion
Sector Demands	Final Energy Demand ~140 mmBTU/person • Commercial ~ 19.5% • Domestic ~ 19.5 % • Industry ~ 23% • Transport ~ 38%	Final Energy Demand ~85 mmBTU/person • Commercial ~ 15% • Domestic ~ 30.5% • Industry ~17% • Transport ~ 37.5%
Policy Environment	2020: Renewable energy target = 33% 2030: Expected to be approved in 2015: 50% Renewable energy target; 50% reduction in petroleum use; 50% increase in building efficiency. 40% reduction in GHG emissions below 1990 levels 2050: 80% reduction in GHG emissions economy wide	2020: Renewable energy target = 15% 2030: EU Decarbonisation target = 40% reduction compared to 1990 2050: UK Decarbonisation target of 80% reduction compared to 1990 (Note includes international aviation and shipping)

Comparison of Model Results

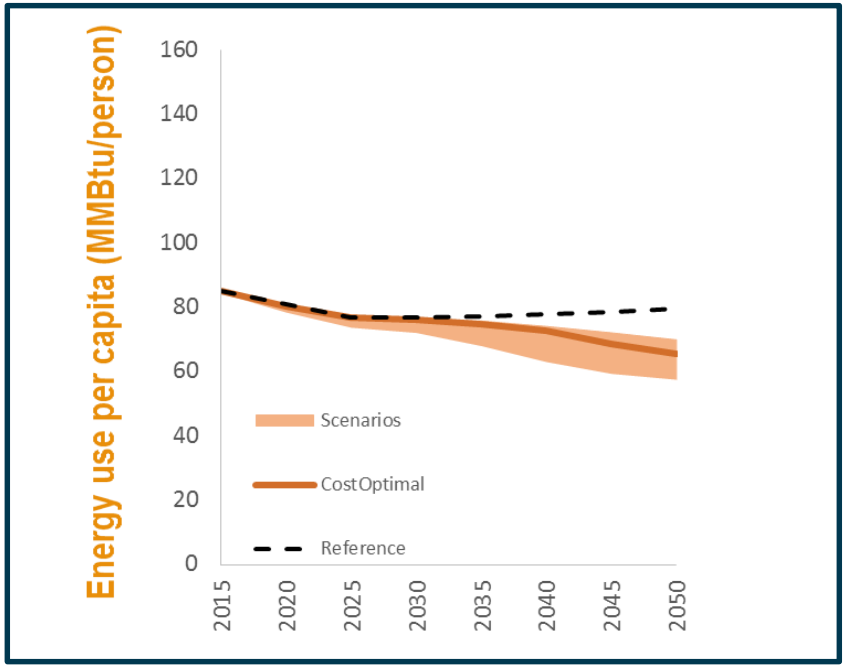
Decarbonizing economy depends on four energy transitions

1. Efficiency and Conservation

California/PATHWAYS



UK/RESOM

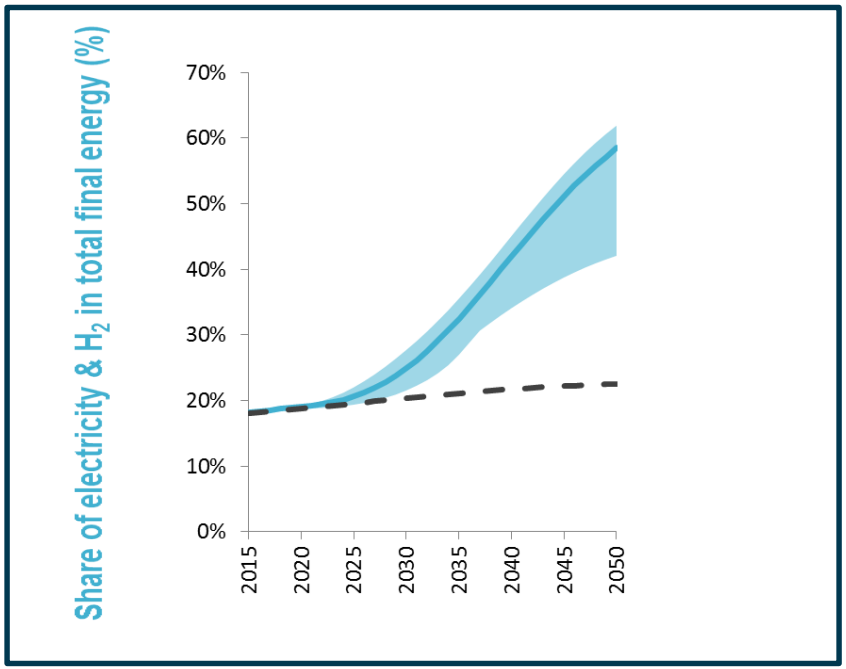


Projected long term energy use per capita is similar in California and the UK but California experiences steeper reductions compared to today

Decarbonizing economy depends on four energy transitions

2. Fuel Switching

California/PATHWAYS



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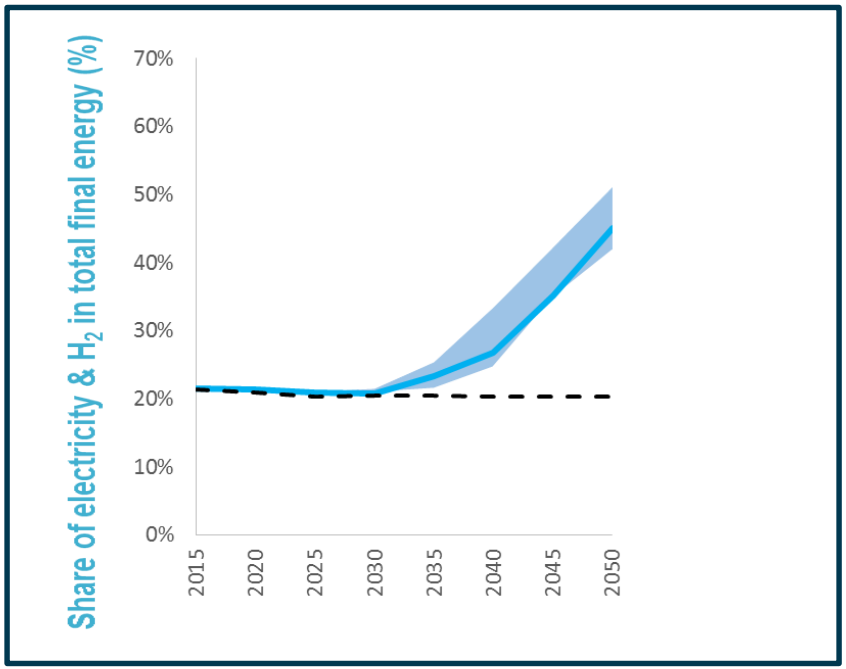
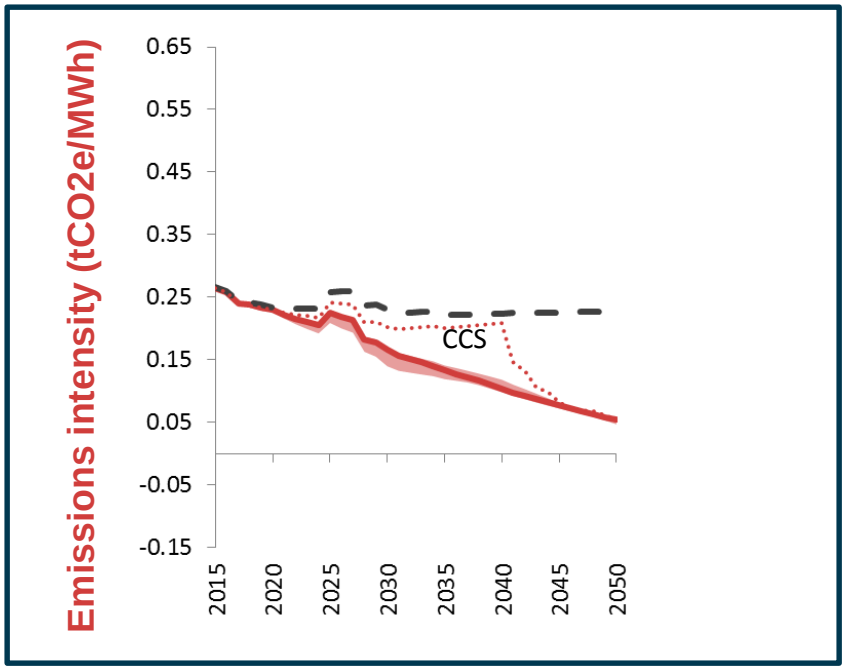


Studied scenarios show similarity in trends towards increased use of electricity and hydrogen but absolute share level is expected to be higher in California

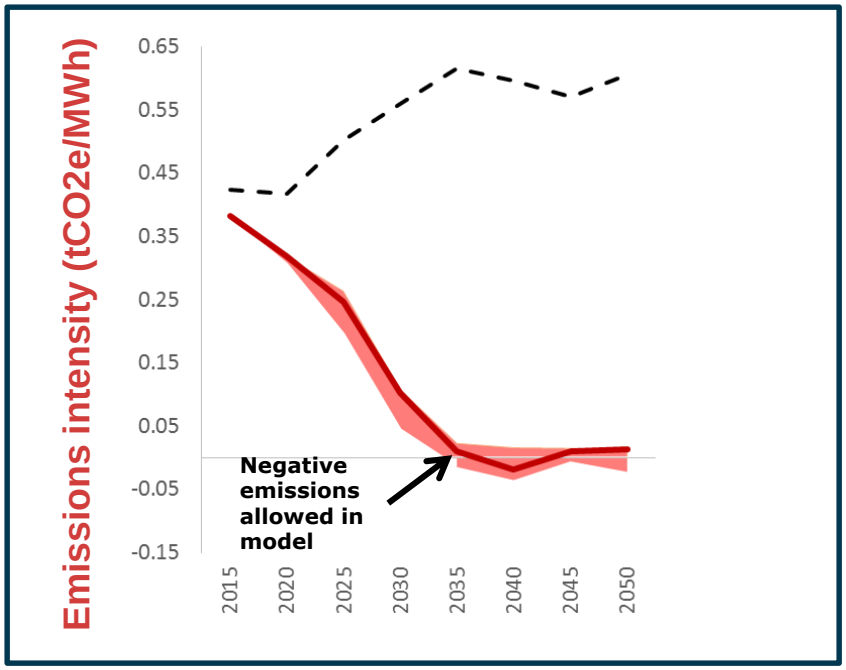
Decarbonizing economy depends on four energy transitions

3. Decarbonize electricity

California/PATHWAYS



UK/RESOM



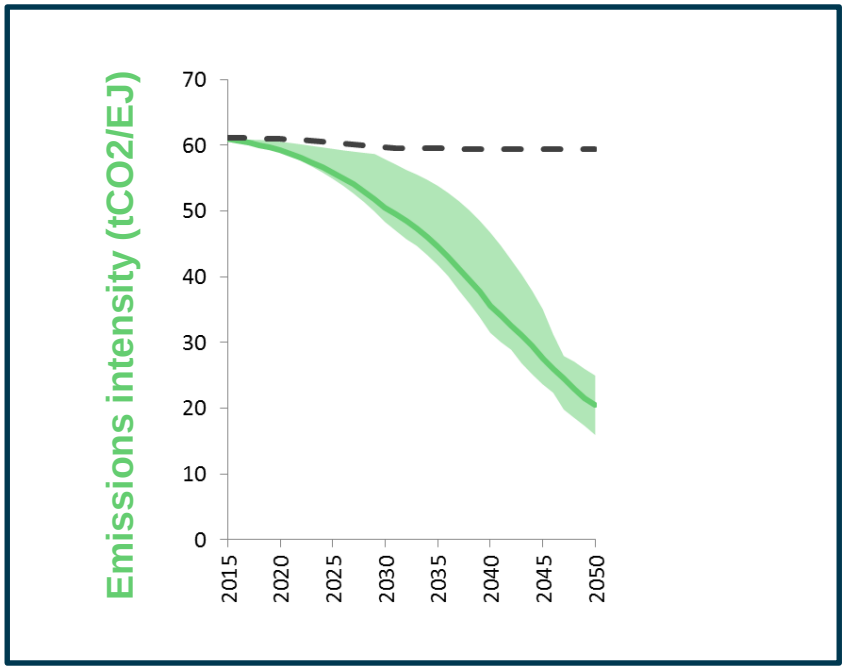
UK scenarios result in a steeper pathways for decarbonising the electricity sector whereas California scenarios show a more steady reduction until 2050

Decarbonizing economy depends on four energy transitions

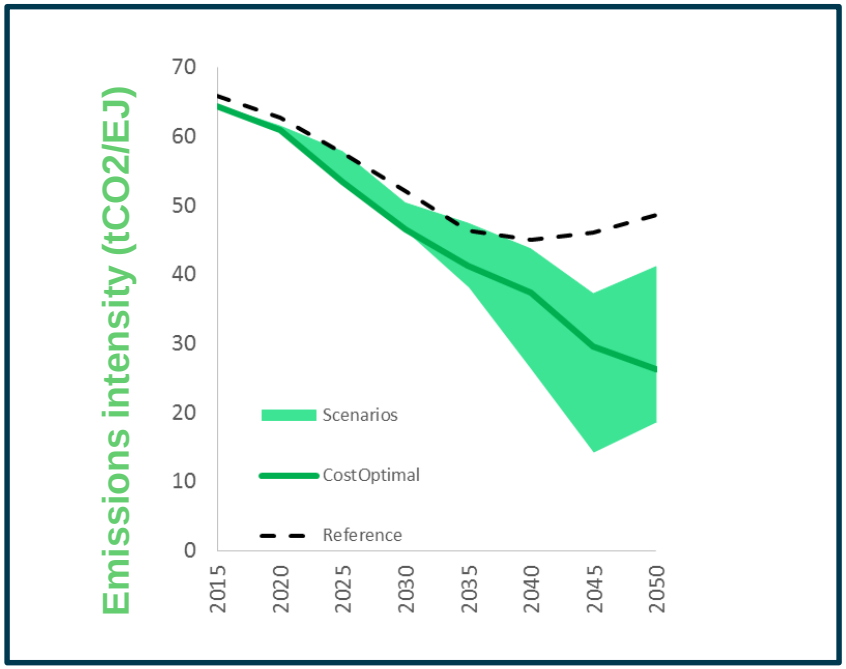
4. Decarbonize fuels (liquid & gas)

*Note includes international aviation and shipping

California/PATHWAYS



UK/RESOM



UK scenarios show a broader range of outcomes for fuel emissions intensity than CA scenarios

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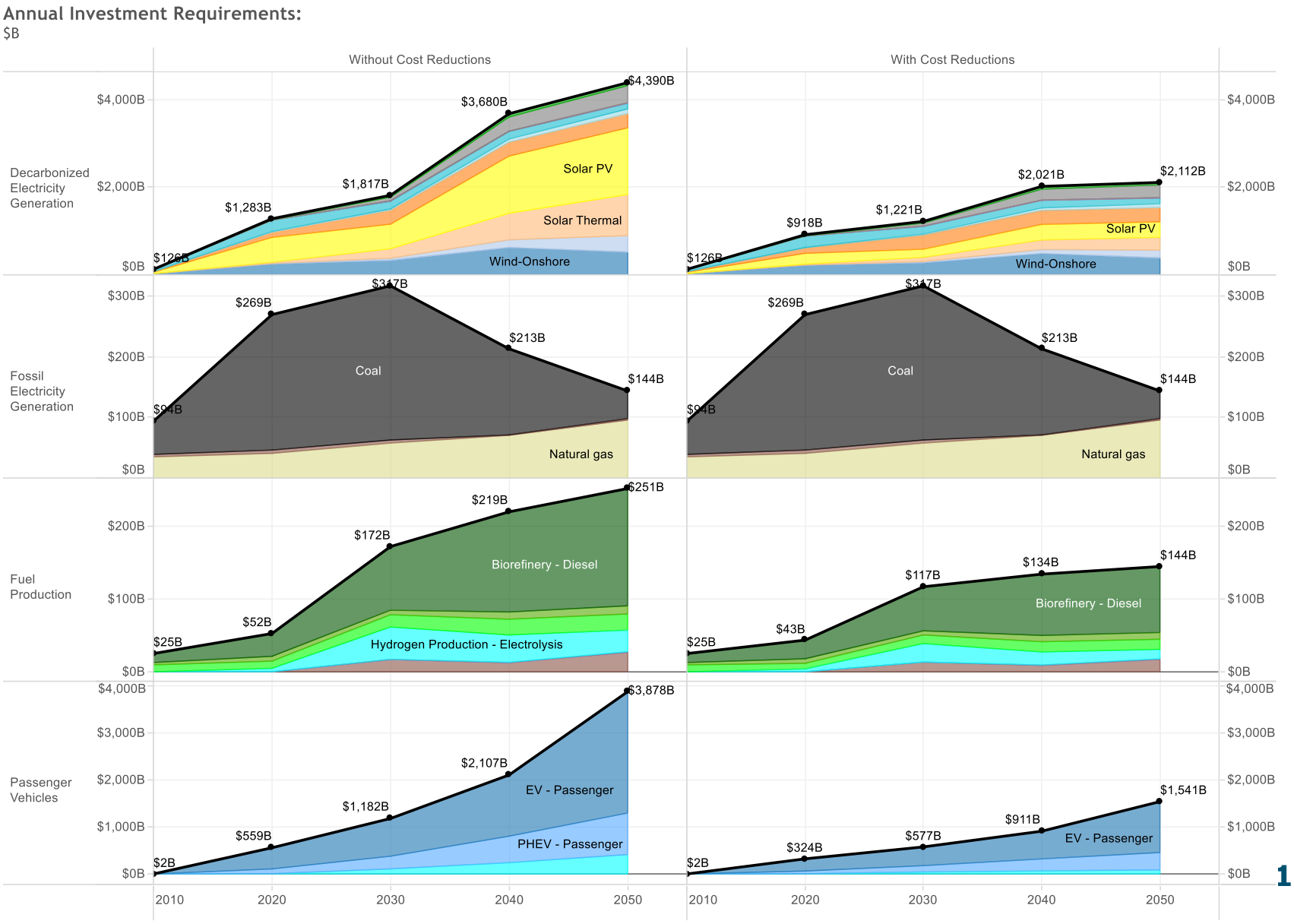
Cost Implications and Technology Risk

Opportunity for learning



Insights & Implications

Modeling Conclusions

- Multi sector bottom up modeling is necessary
- Major transformations are very similar in different countries with different models
- There are scenarios where modeling methodology and functional capability become important (e.g. integrating high renewables)
- Benefits to both modeling approaches and we can see good applications for both approaches

Where do we go from here

- Decarbonization of the energy sector over the next 30 years will represent one of the greatest transformations we have seen in history
- Important to frame the opportunities clearly and need to understand the critical tradeoffs and signposts along the way
- Modelers can play a key role in the learning process
- Critical need for collaborative and transparent modeling initiatives

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Thank You!

Energy and Environmental Economics, Inc. (E3)
101 Montgomery Street, Suite 1600
San Francisco, CA 94104
Tel 415-391-5100
www.ethree.com

Baringa Partners
Dominican Court
17 Hatfields
London SE1 8DJ
www.baringa.com