Benefit-Cost Analysis of Large-Scale Transmission for Renewable Generation: Principles & California Case Study

Keith E. Casey
Market Monitoring Unit, CAISO
Benjamin F. Hobbs
Johns Hopkins University and CAISO Market Surveillance Committee
Dariush Shirmohammadi
Transmission South, CAISO
Frank A. Wolak
Stanford University and CAISO Market Surveillance Committee

STANFORD UNIVERSITY

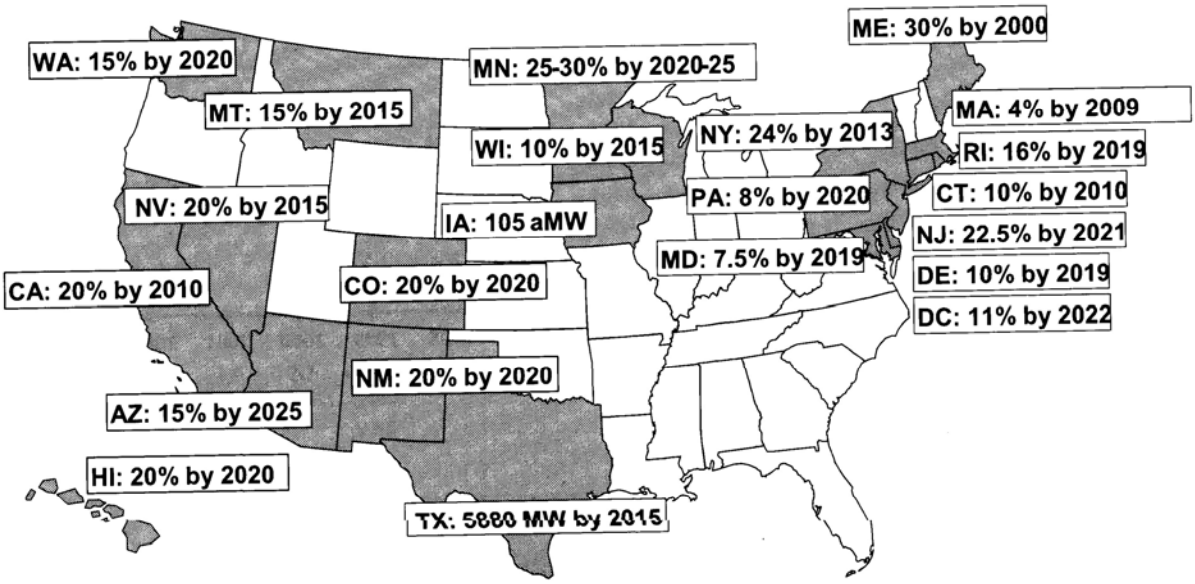
CALIFORNIA ISO

JOHNS HOPKINS UNIVERSITY

Outline of Talk

1. Renewable portfolio standards
2. Solving the Chicken-and-Egg quandary: "Third Category" of Transmission
3. The California TEAM methodology
4. Challenges in B/C analysis of renewables
5. Applications: Sunpath, Tehachapi

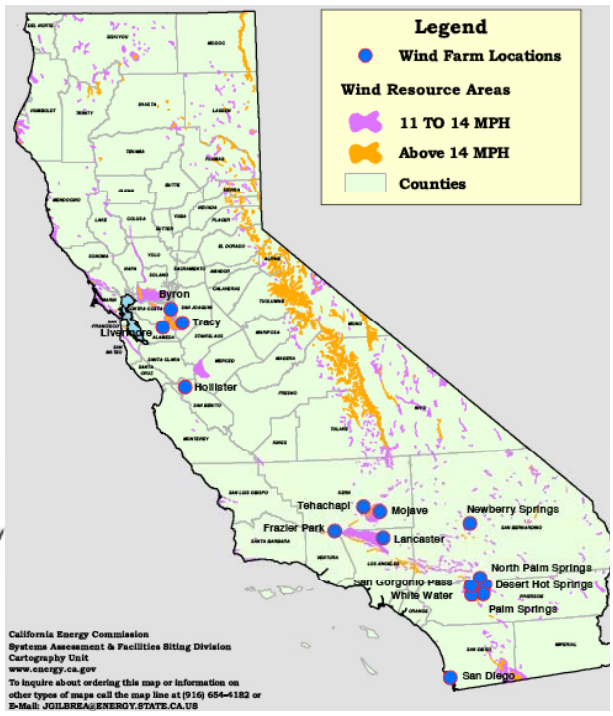
1. Renewable Portfolio Standards
Status of State Programs



Source: R. Wiser et al., "The Experience with Renewable Portfolio Standards in the U.S., *Electricity J.*, May 2007

- 33% in California by 2020
- National portfolio (15% by 2020) part of 2007 Energy Act?
  - *Not in June 2007 Senate bill*

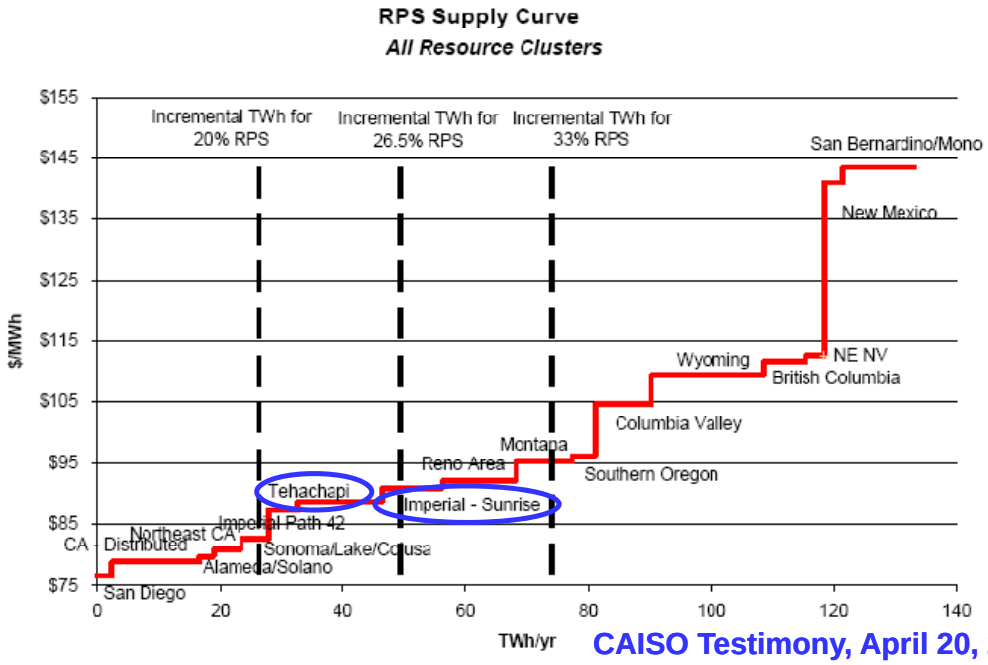
CA Renewable Resource Locations



Source: California Energy Commission

Supply Curve of Renewables Available to California

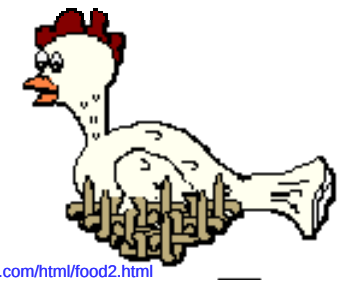
Figure 4.3. Supply curve of potential resources for meeting California's RPS after accounting for differences in transmission delivery point



CAISO Testimony, April 20, 2007

2. Quandary: Which comes first? The transmission or the wind generation?

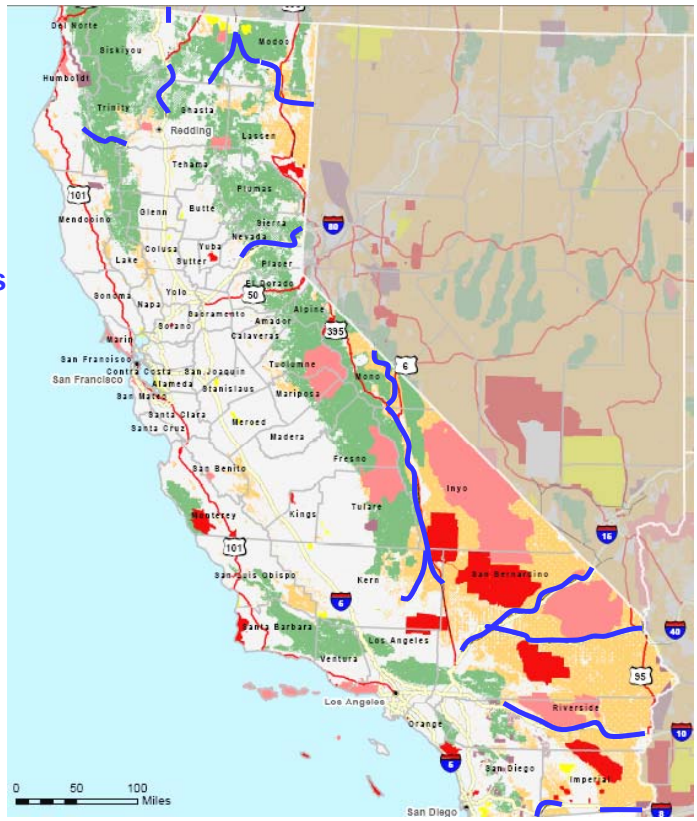
- **FERC policy until 2007: The ISO has two types of transmission**
  - ***Generation interties*—paid for upfront by the generator**
  - ***Network facilities*—paid for by the ratepayer**
- **Problem with previous FERC policy**
  - **Gen-ties too costly for small renewables:**
    - **Most efficient scale of transmission >> size of individual wind developments**
    - **Classic infrastructure market failure**
  - **Not a network facility**



www.cartooncottage.com/html/food2.html

Addressing the Market Failure

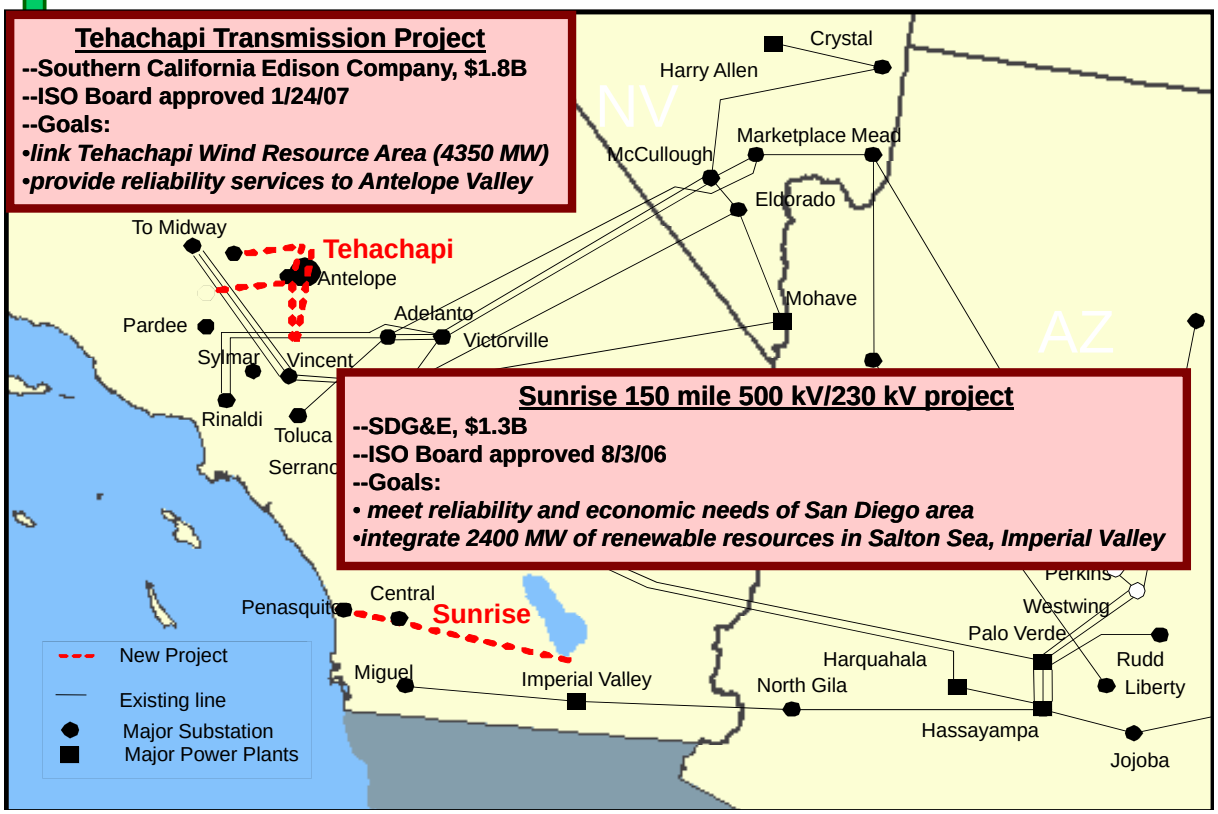
- Merchant Transmission?
  - Earn $ from:
    - contracts with wind generators
    - granted CRRs
  - No proposals due to risks of $billion investment
- State transmission development agencies?
  - Texas "Competitive Renewable Energy Zones" (CREZ)
  - NM "Renewable Energy Transmission Authority"
  - Not in California
- Federal Western "Energy Corridors" (EPAct 2005)?
  - Might facilitate proposals that cross federal land



Addressing the Market Failure

- CAISO: "Third Category" of Transmission for dispersed generation
  - Proposed to FERC 1/07 as general principle
  - PTO (Participating Transmission Organization) puts $ up front
    - As development proceeds, generators pay *pro rata* share
    - Ratepayers bear "stranded asset" risk
  - Safeguards:
    - Proposal subject to ISO review ("TEAM methodology")
    - Showing needed (25-30% of capacity subscribed; another 25-35% reasonably expected)
    - Cap on amount that ratepayers pay for such facilities (15% of total high-voltage plant)
  - FERC Declaratory Order 4/19/07
    - "Proposal is not unduly preferential or discriminatory and would be just and reasonable"
- Issues with third category
  - Favoring large concentrated development: Eggs in one basket
  - Implicit subsidy claimed to discriminate against local renewables

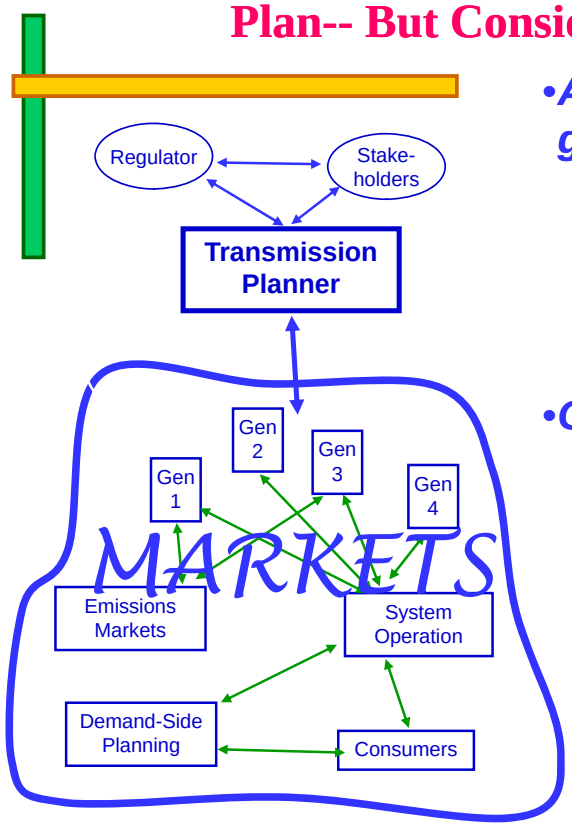
California "Third Category" Proposals: 230kV/500kV Additions



3. California ISO Transmission Economic Assessment Methodology (TEAM)

- **In a market environment, economic benefits include:**
  - *Savings in resource operation & construction costs*
  - *Efficiency gains due to market power mitigation*
    - Improve supplier access to markets
      ⇒ lower bid markups
    - Less incentive for strategic withholding of inexpensive generation (replaced by higher cost imports/competitive generation)
  - *Transmission-DSM-Generation substitution*
- **TEAM attempts to calculate these benefits**

Plan-- But Consider Market Response!



- ***A "multilevel" (Stackelberg) game:***
  - ***Upper level:*** **planners (& regulator, stakeholders), who anticipate reactions of …**
  - ***Lower level:*** **market response of consumers, generators**
- ***Commodities to consider:***
  - ***Energy:*** **Δ dispatch, bidding behavior (market power)**
  - ***Gen capacity:*** **resource adequacy mechanisms**
  - ***Ancillary services:*** **consider needs of intermittents**
  - ***Renewable portfolio credits:*** **not yet implemented in California**
  - ***Emissions allowances:*** **RECLAIM,CO_2**

TEAM Principles

1. **Benefits framework: Multiple perspectives**
   - ***Consumers; Generators; Grid operators; Societal***
   - ***No one perspective is "right"***
   - ***Exclude reliability benefits (hard to monetize)***
2. **Full network representation (linearized DC)**
3. **Market-based pricing**
   - ***Recognize how upgrade might mitigate market power***
4. **Recognize uncertainty**
   - ***Transmission as insurance against extreme events***
   - ***Different parties have different probabilities***
5. **Resource (supply/DSM) substitution**
   - ***Simulate market response to changed prices***
   - ***Account for savings in all resource costs***

TEAM Total Societal Benefit

The increase in social surplus as a result of the upgrade:

$$TS = \Delta CS + \Delta PS + \Delta TR$$

Where,
TS = Total Societal
CS = Consumer Surplus
PS = Producer Surplus
TR = Transmission Rental

= The difference in total system cost before and after upgrade

- If zero price elasticity

4. Challenges in B/C Analysis of Renewables Transmission

a. How should joint costs and benefits of renewable development be treated?

b. What is the appropriate "counterfactual" concerning the transmission and generation system?

c. What is the appropriate "counterfactual" concerning state and federal policy?

a. Treatment of Joint Costs and Benefits

- Can benefits of transmission to new renewables be considered separately from the benefits of the generation?
- Basic principle: All alternatives in B/C analysis should be feasible
  - Physically
  - Legally
- If generation could not be sited there without transmission, & transmission would have no benefits without the generation, then *all* benefits are joint
  - Must consider benefits together

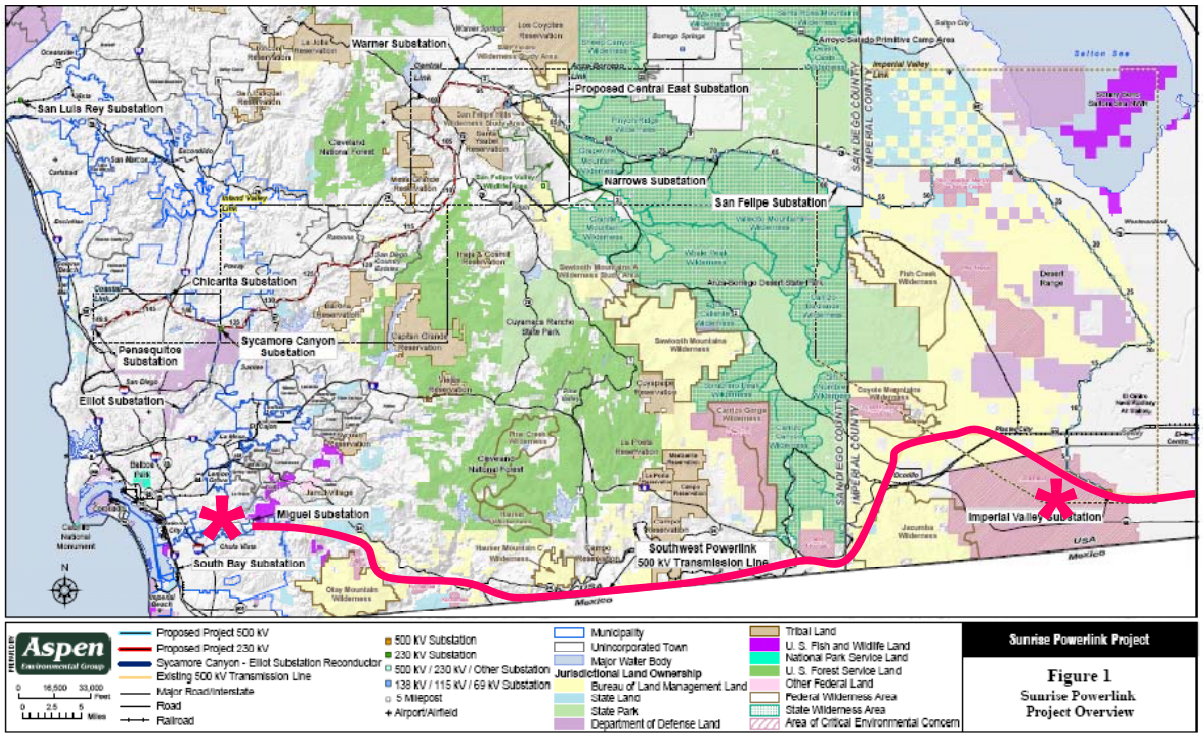
b. "Counterfactual" concerning the G&T system?

- In the absence of the transmission project, what would be the configuration of the G&T?
  - Would renewable resources still be sited at the same location but "bottled up" more frequently?
  - Or would they have been sited elsewhere or even not developed at all?
- The answers to these questions significantly affect the scope of the market and environmental analysis
- Remember the basic principle: All alternatives in B/C analysis should be feasible

c. "Counterfactual" concerning state & federal policy?

- **Basic principle: assume that economic benefits are to be maximized subject to state policy constraints, such as renewable standards**
  - **Otherwise: you're assessing the net benefits of these standards**
  - **Without externalities, would be negative (otherwise, why is RPS necessary)?**
    - **Should ISO value CO_2 & pollution reductions, …?**
- **How about policies that don't yet exist, but are possible/likely?**
  - **E.g., CO_2 trading in California ….**
  - **…and states that export power to California?**

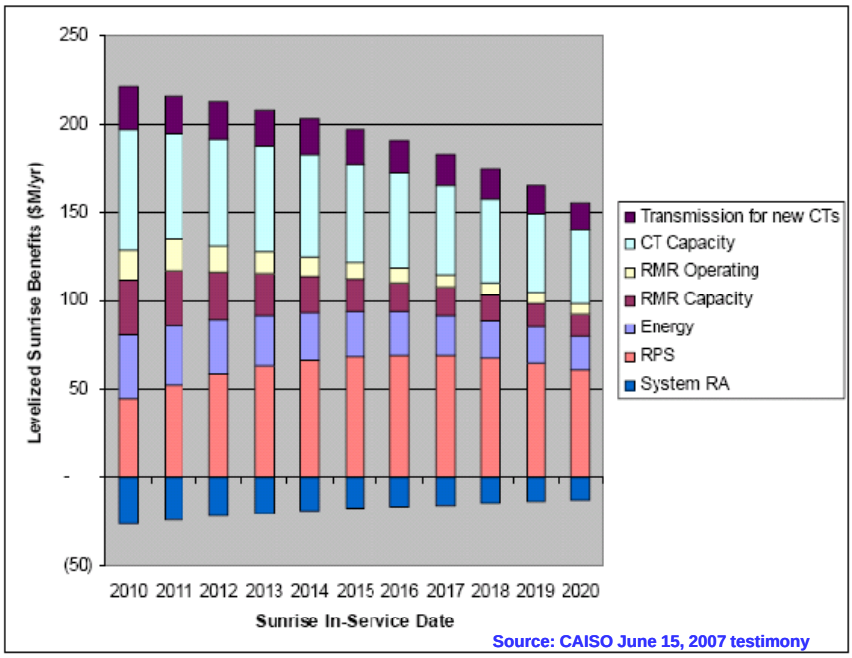
5. Examples
Sunrise Powerlink Project



One of many alternative routes considered

Categories of Sunrise Benefits: The Cost of Meeting Constraints

- Lower cost of meeting energy constraint
  - Lower energy payments by CAISO customers
- Lower cost of meeting reliability constraint
  - Avoided CT costs and RMR payments
- Lower cost of meeting renewables constraint
  - Assumes that renewables are paid full cost, as premium above LMP



Source: CAISO June 15, 2007 testimony

Figure 3: Levelized Benefits Incorporating 4/20/07 Estimate of RPS Benefits (does not include the change in construction costs from deferring transmission)

Summary of Sunrise Benefits & Costs (One Variant)

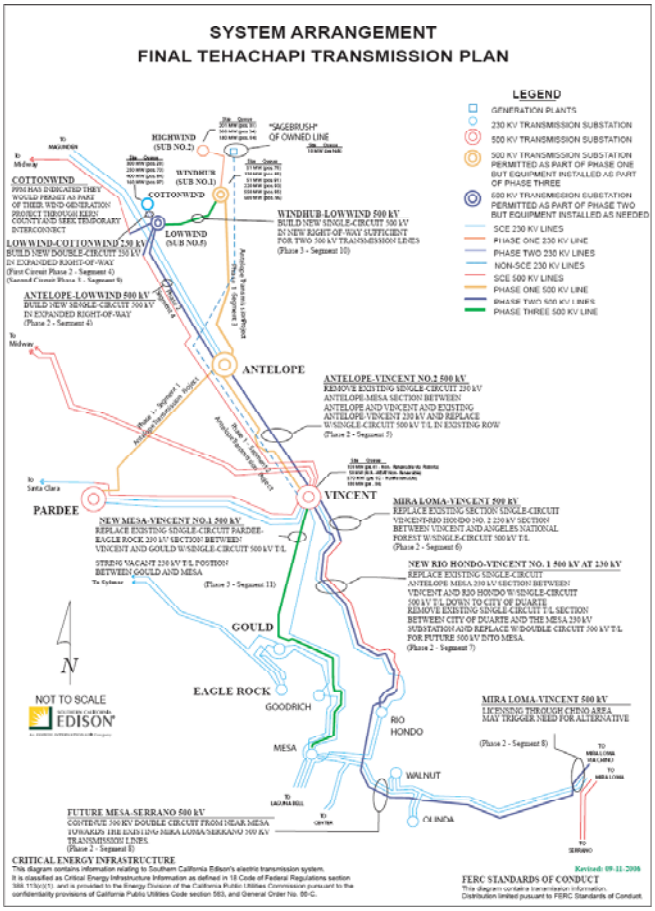
Table 6: Levelized costs and benefits by alternative assuming Supplemental Non-Local Capacity Purchases, the $27/kW-year RA price floor, Exclusion of Non-TAC paying utilities, and Revised Local Capacity Requirements

Summary of Levelized Costs and Benefits	A	B	C	D	E	F	G
	Costs				Net Benefits		
	Base Case	Sunrise	South Bay	Green Path + LEAPS	Sunrise	South Bay	Green Path + LEAPS
Energy and Reliability Costs							
Customer Payments from Gridview	15,750	15,629	15,697	15,708	121	53	42
Less CAISO congestion cost (reduces TAC)	(124)	(88)	(102)	(110)	(36)	(21)	(13)
Less URG Margin (reduces URG bal acct)	(4,748)	(4,714)	(4,724)	(4,739)	(34)	(24)	(9)
Less IOU excess loss payments	(809)	(793)	(803)	(800)	(16)	(6)	(9)
Subtotal Energy Cost and Benefit	10,070	10,035	10,069	10,060	35	1	10
RMR Capacity Payments - Levelized	90	58	120	79	32	(30)	11
RMR Operating Payments - Levelized	60	42	60	55	18	-	5
CT Capacity Costs - Levelized	93	26	48	52	67	45	41
Transmission cost for new CTs-Levelized	33	9	17	18	24	16	15
Remediation cost to provide reactive support	-	-	-	-	-	-	-
RA Costs to replace CTs and RMR contracts	-	26	-	(8)	(26)	-	8
Subtotal Reliability Cost and Benefit	276	162	245	196	114	31	81
Total Energy and Reliability Benefits					150	32	91
RPS Procurement Cost							
Adjusted RPS Cost	4,272	4,227	4,272	4,227	45	-	45
Total Benefits					195	32	136
Transmission Cost							
Levelized Cost of Transmission	-	157	9.3	205.2	(157.0)	(9.3)	(205.2)
Total Costs and Benefits	14,618	14,580	14,596	14,688	38	22	(70)

Source: CAISO June 15, 2007 testimony

Tehachapi Project

- Possible "counterfactual" framing: Tehachapi developed without transmission
  - Renewables bottled up, won't meet RPS
  - Higher CO_2 emissions
  - Higher energy costs in west
- Actual framing: Cost-effectiveness of transmission alternatives to link 4350 MW of Tehachapi wind
  - Assumes: Wind so cheap that it will be developed
  - Avoids need to consider any other benefits (although there might be others)



Conclusion

- Several possible solutions to Chicken-Egg quandary
  - California: "Third Category"
  - But carefully assess energy, capacity, RPS, and other benefits to be confident that proposal is the most beneficial
- Questions?