# DOCKETED

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# Renewable Energy Transmission Initiative v2.0

## Transmission Technical Input Group Update

TTIG Meeting
29 July, 2016

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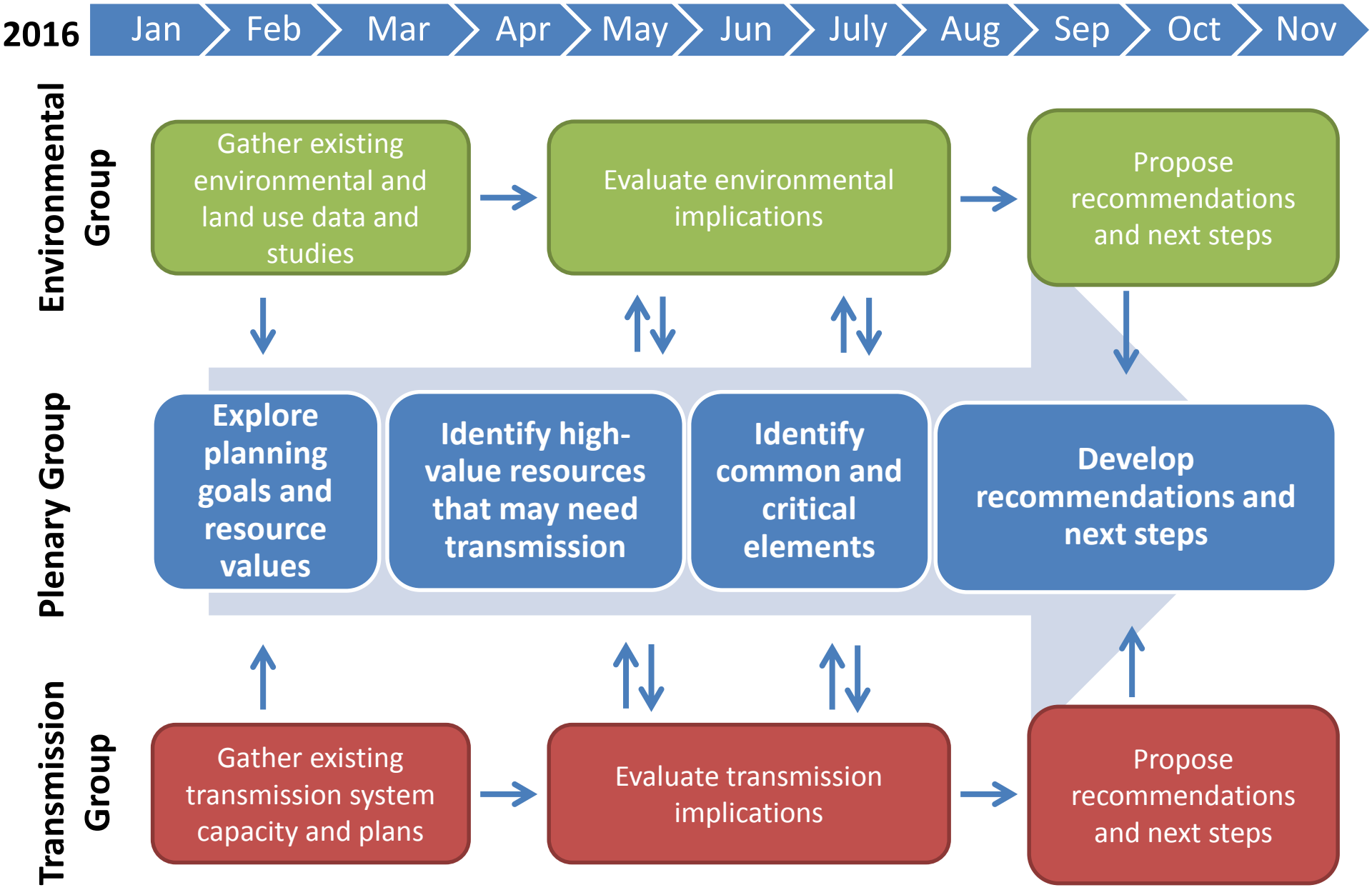
California Energy Commission

California ISO

# RETI Background

- Cooperative project of four state and one federal agency
- Statewide, non-regulatory planning effort to help meet statewide GHG and renewable energy goals.
- Explore combinations of renewable generation resources in California and throughout the West that can best meet goals
- Build understanding of transmission implications of renewable scenarios, and identify common transmission elements
- Identify land use and environmental opportunities and constraints to accessing these resources
- Accelerated, agency-driven, high-level assessment to inform future planning and regulatory proceedings

# RETI 2.0 Process and Timeline



# TTIG Background

**Goals and Objectives:**

The Transmission Technical Input Group will assemble relevant in-state and west-wide transmission capability and upgrade cost information to inform resource development conservations on the reasonably-needed transmission system implications and to assist in the developing potential corridor scenarios.

TTIG participants include all California Transmission Planning Entities

| | |
|---|---|
| Sacramento Municipal Utility District | California Independent System Operator |
| Imperial Irrigation District | Los Angeles Department of Water and Power |
| Silicon Valley Power | Turlock Irrigation District |
| Modesto Irrigation District | Western Area Power Administration - SNR |
| San Francisco PUC | Transmission Agency of Northern California |
| City of Santa Clara | Pacific Gas & Electric |
| Southern California Edison | San Diego Gas & Electric |

# TTIG Deliverables Status

| Identified Deliverables | Status |
|---|---|
| Characterize existing transmission system capacity and planned improvements/ changes and their implications for accessing additional renewable resources | Interim Report June 9, 2016 |
| Provide initial transmission input on likely in-state developments necessary to access potential renewable generation and refine the data as combinations of renewable resources are developed through other RETI groups' activities | Today |
| Provide planning level transmission cost estimates and any available information on environmental and other permitting issues for in-state requirements, using existing data to the greatest extent possible | Today |
| Compile transmission planning information on potential WECC-wide system reinforcements that may provide or improve access to renewable generation or to integration resources | WIEB outreach project; Aug-Sept |
| Work interactively with RETI Plenary Group to evaluate transmission implications for accessing potential renewable energy generation areas | Sept-Oct |

# Transmission Assessment Focus Area Map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# Transmission Assessment Focus Areas

| Study Ranges<br>Hypothetical additions of new renewable resources | |
|---|---|
| **Delivery Area or path** | **Study Range of New Capacity (MW)** |
| Tehachapi | Up to 5000 |
| Victorville/Barstow | Up to 5000 |
| Riverside East | Up to 5000 |
| Imperial Valley | Up to 5000 |
| San Joaquin Valley | Up to 5000 |
| Solano | 1500-3000 |
| Sacramento River Valley | 1500-3000 |
| Lassen / Round Mountain | 1450-2450 |
| Path 46 / Palo Verde / Delaney | Up to 3000 |
| Path 46 / Eldorado / Marketplace | Up to 3000 |
| Path 66 / California-Oregon Intertie | Up to 2000 |
| Central/Northern Sierra (Path 76; Path 24; Path 52) | Up to 500 |

# Methodology to Assess/Design Transmission for California Planning Areas

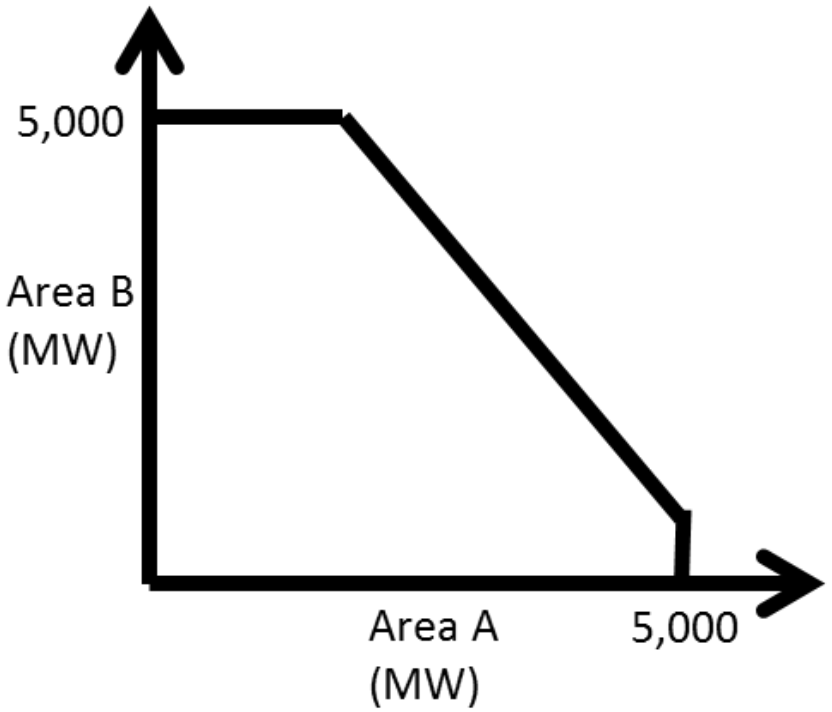
- Collaboration of affected Transmission Planning Areas for assessing TAFAs
- Transmission information from prior/existing studies and analyses
- Potential transmission upgrade information limited to *conceptual* transmission development identified in prior studies.
- Costs provided for conceptual mitigations are very *high-level* estimates

***Note: The transmission implications were evaluated with an assumption of incremental resources with FCDS (Full Capacity Deliverability Status) because this assumption allowed us to look at conceptual upgrades which were based on FCDS studies. TTIG is not indicating a specific preference towards FCDS procurement in future.***

# Interaction Between TAFAs

**Not all capacity from all transmission areas is simultaneously available**

- Transmission capacity is dynamic – resources additions in one area may impact transmission availability in another area
- Mitigating a constraint that limits multiple TAFAs can benefit two or more renewable development areas
- The TAFA capacity assumes all incremental MW in each area to be FCDS (for the purpose of identifying conceptual upgrades)
- Specific studies will be required to estimate impact of a mix of resources across TAFAs



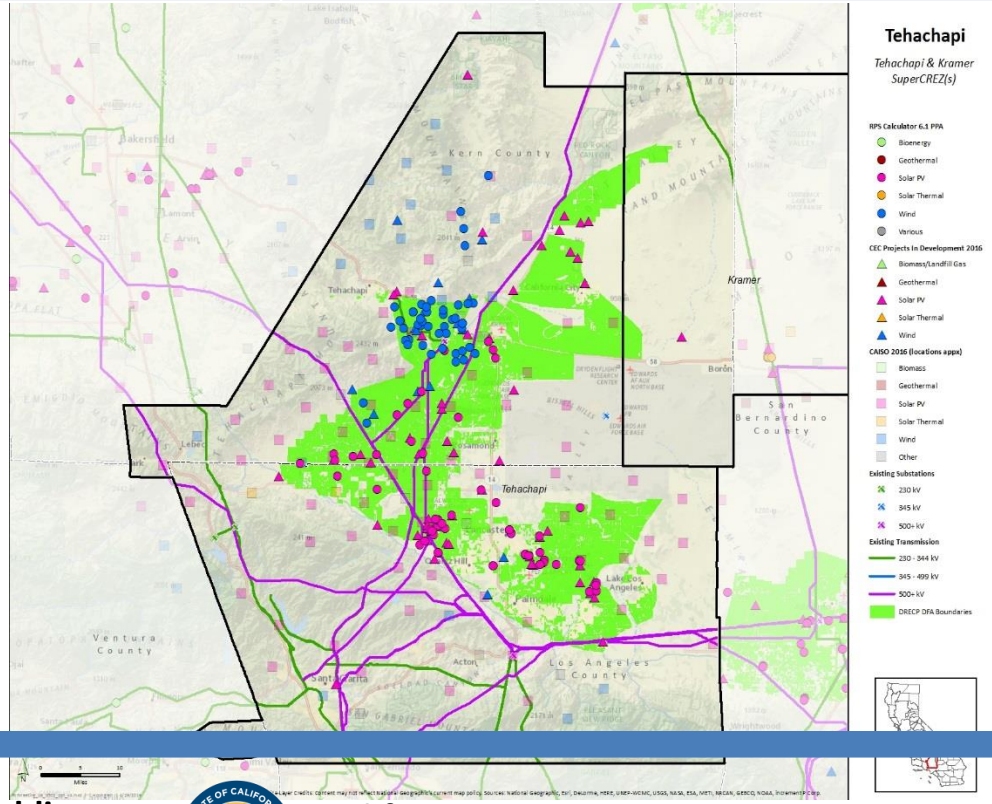
# Assessment Data

| TAFA assessments include the following information |
| --- |
| Impacted transmission system(s) |
| Data sources used |
| Proposed TAFA new capacity by technology (Solar/Wind/Geo) |
| Anticipated FC (Full Capacity)/EO (Energy Only) capacity (MW) |
| Current Interconnection Queue applications (for CAISO -through Cluster 8) |
| Existing Gen. in TAFA |
| Planned upgrades impacting transfer capability estimates |
| Transmission implications (Next conceptual upgrades/observations) |

# Tehachapi

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO | Interconnection Queue (through C8) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO | (1) CAISO cluster studies<br>(2) CAISO TPP<br>(3) CAISO RPS studies | 4,500 / 500 / 0 | 4,500 / 5,600 | ~4490 | ~5,200 | - TRTP<br>- Whirlwind Substation expansion (In-service)<br>- Whirlwind AA bank<br>- Northern Area 500 kV SPS<br>- Vincent SCD mitigation<br>- All the TPP approved projects |

- No major issues accommodating the prescribed amount of MW in this area
- Queued generation - high

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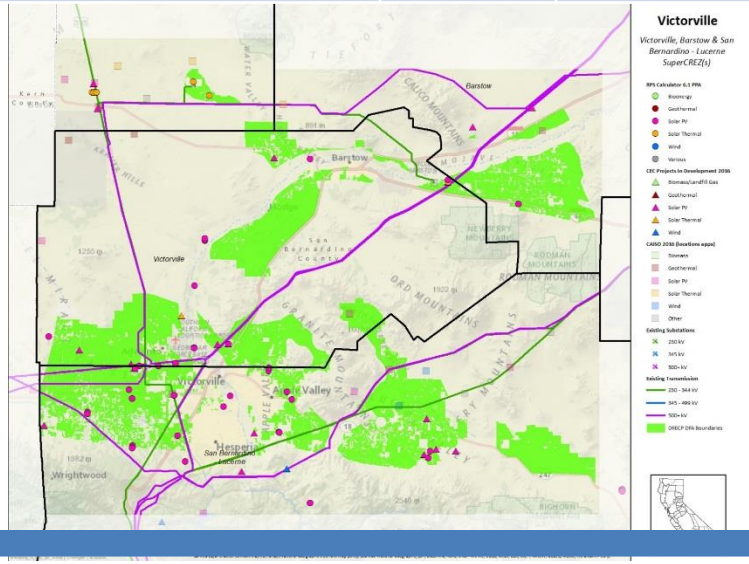
# Victorville/Barstow

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/ Geo) | Anticipated FC/EO | Interconnection Queue (through C8) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO, LADWP | (1) LADWP generation queue<br>(2) LADWP transmission projects mapped to queue info.<br>(3) CAISO cluster studies (North of Lugo)<br>(4) CAISO RPS studies | 4500 /<br>500 /<br>0 | <u>North of Lugo (NOL) Area:</u><br>• ~1,000 MW in entire NOL, (Can only accommodate up to ~470 MW North of Kramer)<br>• ~400 MW behind Calcite - Lugo constraint (Pisgah area)<br><br><u>East of Lugo (EOL) Area:</u><br>~5,500 MW to ~8,500 MW behind Lugo-Victorville 500 kV constraint (Eldorado area, and some parts of Riverside and Imperial) | <u>(1) NOL area:</u><br>~1083 MW<br><br><u>(2) EOL area:</u><br>~ 2,100 MW<br>~1000 MW at Marketplace 500kV bus (LADWP) would feed into Lugo (similar impact as EOL generation)<br><br><u>(3) LADWP area:</u><br>~1724 MW at Intermountain 345kV Bus would feed into Adelanto<br>~ 1700 MW near Owens Valley | <u>(1) NOL area:</u><br>~1,600 MW<br><br><u>(2) EOL area:</u><br>~1,100 MW<br><br><u>(3) LADWP area:</u><br>~250 MW | • Victorville-LA Basin Transmission System Upgrade (LADWP upgrade)<br>• Lugo-Eldorado and Lugo-Mohave 500 kV series capacitor upgrades<br>• Eldorado line re-route<br>• Lugo-Victorville SPS (only a partial mitigation) |

- Victorville TAFA is a combination of several smaller generation rich areas such as North of Lugo and East of Lugo (Eldorado-Mtn Pass)
- Queued generation - high



# Victorville/Barstow

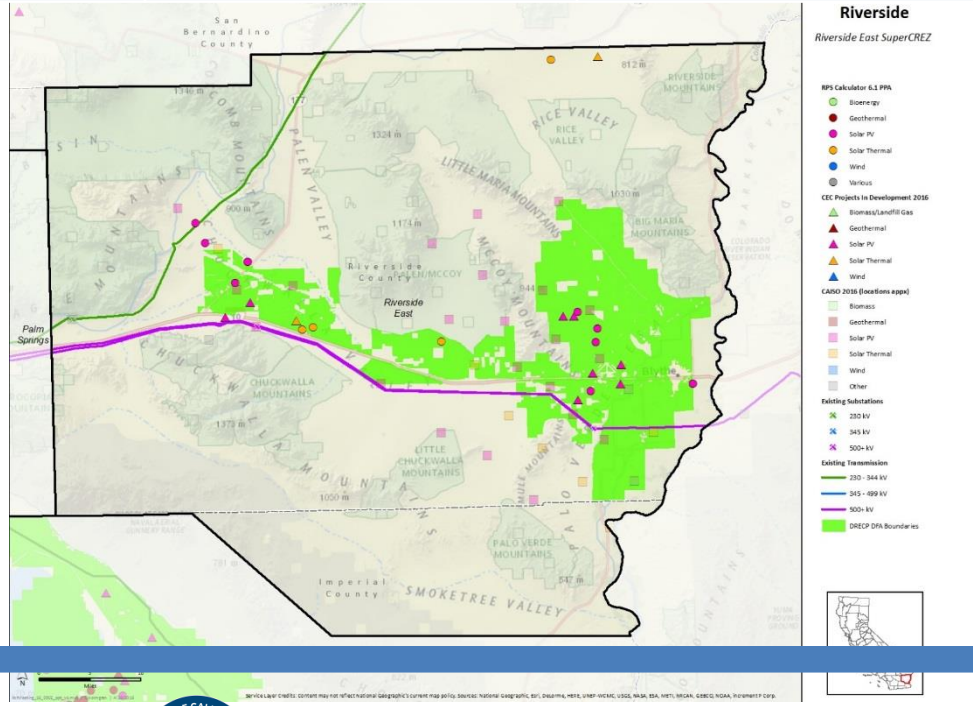
## Expected Transmission constraints and conceptual mitigations to Interconnect 5000 MW

| Transmission Implications | Cost |
|---|---|
| **North of Lugo Area** | |
| (i) Lugo 500/230 kV banks constraint<br>==> **Upgrade**: A new 3rd AA bank at Lugo | ~$150 million |
| (ii) South of Kramer constraint<br>==> **Upgrade**: Coolwater-Lugo 220 kV transmission line | ~$480 million |
| (iii) Calcite-Lugo transfer constraint<br>==> **Upgrade**: Calcite - Lugo 220 kV segment of Coolwater - Lugo 500 kV line | ~$260 million |
| Assuming that at least 1,500 MW out of the prescribed range shows up in NOL, all these upgrades may be needed. The constraints and mitigations identified here address the Inyokern area resources assuming these resources will connect to SCE's North of Kramer system. | |
| | |
| **Desert Area Constraint (East of Lugo, Riverside and Imperial)** | |
| (i) Lugo-Victorville 500 kV overload for the N-1 of Lugo-Eldorado 500 kV and for N-2 of Lugo-Eldorado and Lugo-Mohave 500 kV lines<br>==> **Upgrade**: Lugo-Victorville 500 kV line (coordination between LADWP and CAISO underway). This upgrade will add > 2,000 MW transmission capability to the existing capability estimate in Riverside TAFA. | ~$34 million |
| (ii) The next likely constraint will be normal overloads on Devers – Red Bluff 500kV lines and Alberhill - Valley 500kV line<br>==> **Upgrade**: A new Mira Loma - Red Bluff 500 kV line | > $1 billion |

# Riverside East

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/ Geo) | Anticipated FC/EO | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO<br>LADWP | (1) CAISO cluster studies (Riverside and Imperial)<br>(2) CAISO RPS studies<br>(3) IID generation interconnection studies<br>(4) IID transmission capability estimates | 2000-4000 / 500-1000 / 0 | Riverside: ~800 MW / ~4,754 MW<br><br>East of Lugo, Riverside and Imperial: ~5,500 MW to 8,500 MW behind Lugo-Victorville 500 kV constraint (Eldorado area, and some parts of Riverside and Imperial) | ~6,000 | ~1,500 | - WOD upgrades<br>- Colorado River Corridor SPS<br>- Red Bluff AA bank<br>- Colorado River AA bank<br>- Lugo - Eldorado upgrade<br>- Lugo - Mohave upgrade<br>- Eldorado 500kV line re-route |

- Once West of Devers upgrades are in service, deliverability is limited by Lugo - Victorville constraint
- Queued generation - high



# Riverside East

## Expected Transmission constraints and conceptual mitigations to Interconnect 5000 MW

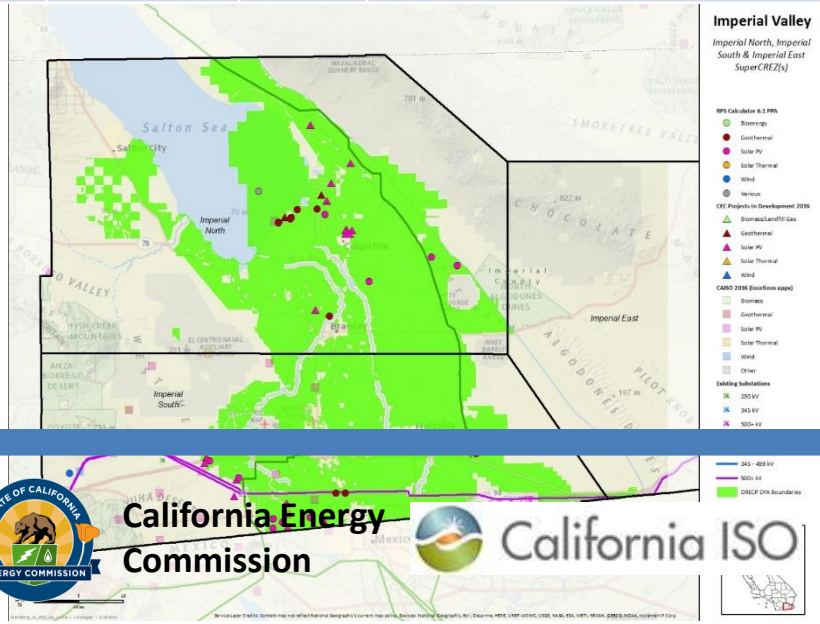
| Transmission Implications | Cost |
|---|---|
| **Desert Area Constraint (East of Lugo, Riverside and Imperial)** | |
| (i) Lugo-Victorville 500 kV overload for the N-1 of Lugo-Eldorado 500 kV and for N-2 of Lugo-Eldorado and Lugo-Mohave 500 kV lines<br>==> **Upgrade**: Lugo-Victorville 500 kV line (coordination between LADWP and CAISO underway). This upgrade will add > 2,000 MW transmission capability to the existing capability estimate in Riverside TAFA. | ~$34 million |
| (ii) The next likely constraint will be normal overloads on Red Bluff - Devers 500kV lines and Valley - Alberhill 500kV line<br>==> **Upgrade**: A new Mira Loma - Red Bluff 500 kV line | > $1 billion |

# Imperial Valley

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| **CAISO** | | | | | | |
| Greater Imperial | (1) CAISO cluster studies (Riverside and Imperial)<br>(2) CAISO RPS studies<br>(3) IID generation interconnection studies<br>(4) IID transmission capability estimates | 3500 / 500 / 1000 | <u>Imperial:</u> 523* MW / 1,829 MW<br><br><u>East of Lugo, Riverside and Imperial:</u> ~5,500 MW to 8,500 MW behind Lugo-Victorville 500 kV constraint (Eldorado area, and some parts of Riverside and Imperial) | ~4375 (CAISO queue) | ~2,200 | - IV Phase shifting transformer<br>- Sunrise/SWPL series capacitor bypass<br>- Suncrest SVC<br>- Sycamore-Penasquitos 230 kV line |
| **Imperial Irrigation District** | | | | | | |
| IID North | (1) CAISO cluster studies (Imperial North)<br>(2) IID RPS studies<br>(3) IID generation interconnection studies<br>(4) IID transmission capability analysis | 1200/0/1000 | 1200/1400 | 1375/1000 (IID queue) | | • Path 42<br>• West of Devers |
| IID South | | 2300/ 500/ 0 | 200/370 | 3000/260 | | * IV Phase shifting transformer<br>* Sunrise/SWPL series capacitor bypass<br>* Suncrest SVC<br>* Sycamore-Penasquitos 230 kV line |

***** This number is subject to change. IID has recently provided the ISO with new study assumptions regarding its system that will require further study. The ISO 2016-2017 Transmission Plan currently under development will take into account the latest system conditions and provide information regarding additional deliverability expected to be available for IID and ISO connected Imperial area generation.

- IID distinguishes Imperial North and South, while CAISO combines these areas as Greater Imperial
- Queued generation - high

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# Imperial Valley

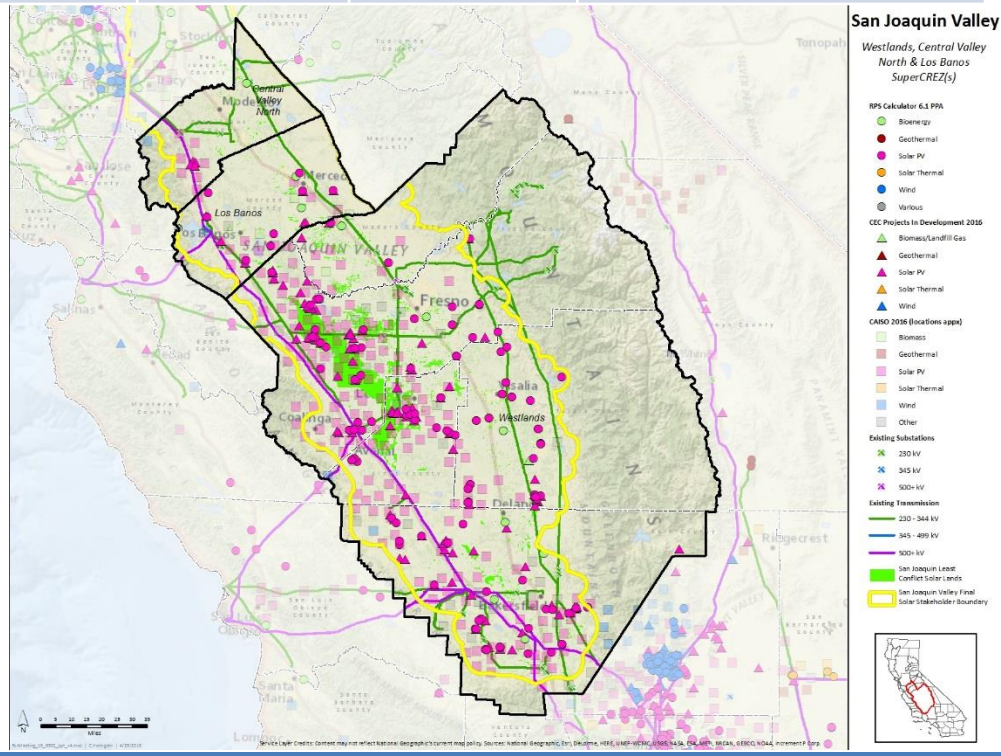
## Expected Transmission constraints and conceptual mitigations to Interconnect 5000 MW

| Transmission Implication | Cost ($ M) |
|---|---|
| **CAISO** | |
| **Imperial area:** | |
| East of Miguel constraint: Overload on Miguel 500/230 kV banks, ECO-Miguel 500 kV and Ocotillo-Suncrest 500 kV lines ==> **Upgrade**: New IV-Valley 500 kV line. | >$2 Billion |
| **Desert Area Constraint (East of Lugo, Riverside and Imperial)** | |
| (i) Lugo-Victorville 500 kV overload for the N-1 of Lugo-Eldorado 500 kV and for N-2 of Lugo-Eldorado and Lugo-Mohave 500 kV lines ==> **Upgrade**: Lugo-Victorville 500 kV line (coordination between LADWP and CAISO underway). This upgrade will add > 2,000 MW transmission capability to the existing capability estimate in Riverside TAFA. | ~$34 million |
| (ii) The next likely constraint will be normal overloads on Red Bluff - Devers 500kV lines and Valley - Alberhill 500kV line ==> **Upgrade**: A new Mira Loma - Red Bluff 500 kV line | > $1 billion |
| **West of the River Constraint:** | |
| Some prior studies have indicated that West of the River (Path 46) flows would approach the path rating and a path rating increase will have to be explored if enough renewable generation materializes. | |
| | |
| **IID** | |
| STEP 500 KV line from IID Midway to SCE Devers substation | $350 Million |

# San Joaquin Valley

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO (MW) | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO<br>LADWP | (1) CAISO cluster studies<br>(2) CAISO RPS studies<br>(3) San Juaquin renewables study | 5000 / 0 / 0 | 1823 / 3131 | ~3,500 | ~4,300 (Greater Fresno)<br>~3,500 (Kern area) | • Warnerville - Wilson series reactor<br>• Gates 500/230 kV transformer<br>• Kearney - Herndon 230 kV reconductor |

- At the prescribed level of generation in San Joaquin Valley, multiple 230 kV and local constraints were observed between Gates and Los Banos
- Queued generation - high

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# San Joaquin Valley

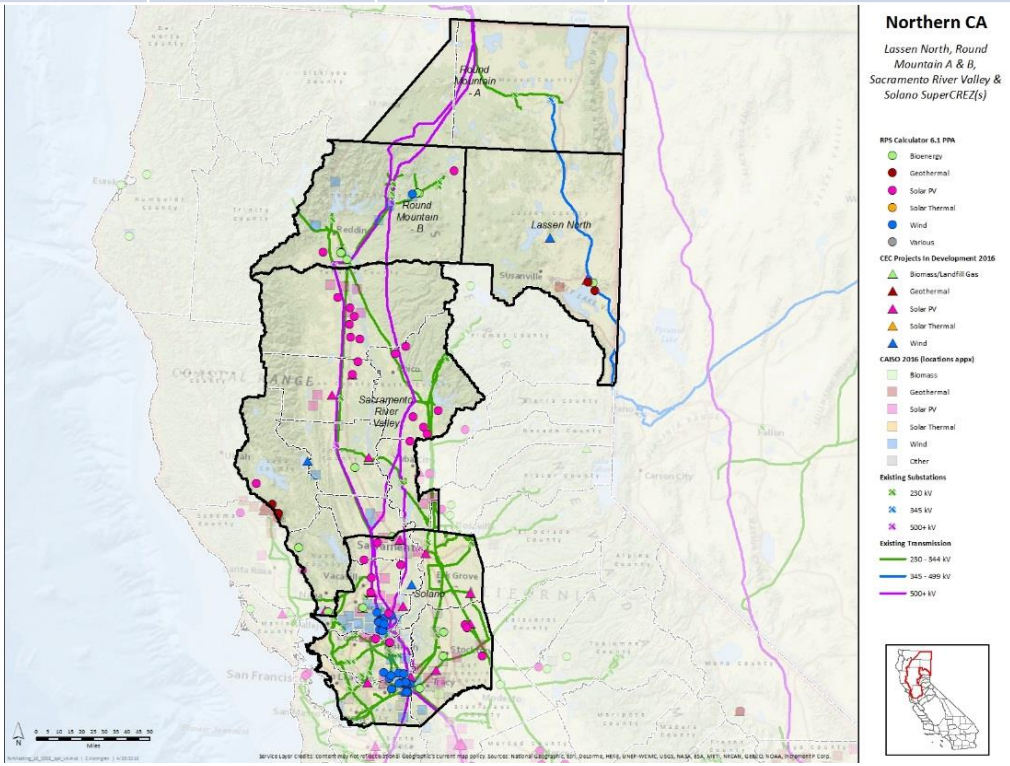
**Expected Transmission constraints and conceptual mitigations to Interconnect 5000 MW**

| Transmission Implications | Cost |
|---|---|
| | |
| Fresno area constraints: Several overloads on the 230 kV system between Gates and Los Banos<br>==> **Upgrade**: Multiple upgrades between Gates and Los Banos (230 kV and below) | ~$440 million |

# Solano

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO (MW) | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO | (1) CAISO RPS studies<br>(2) CAISO cluster studies<br>(2) CAISO TPP | 500-1000 / 0 / 0 | unknown / ~880 MW | ~1100 | ~5,800 | None at this time |

- Smaller facilities may be able to interconnect to existing network with minor upgrades
- Queued generation - moderate



# Solano

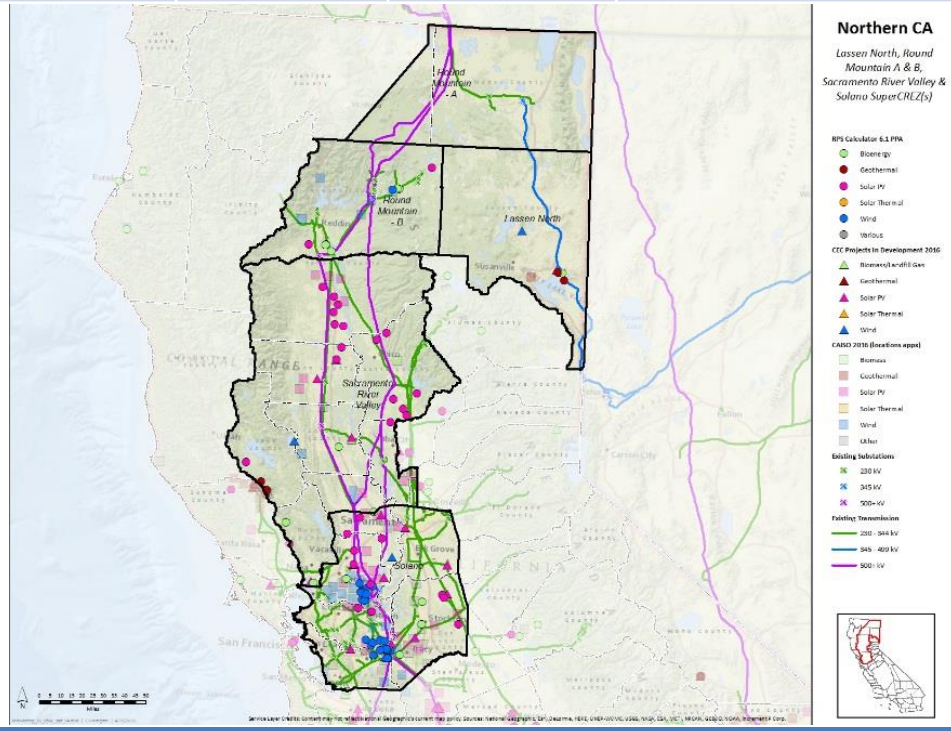
## Expected Transmission constraints and conceptual mitigations to Interconnect 5000 MW

| Transmission Implication | Cost |
|---|---|
| Smaller facilities may be able to interconnect to existing transmission network with minor upgrades | |
| Depending on size and specific location of the facilities, develop new 230-kV or 500 kV collector substation to interconnect facilities to the existing Vaca Dixon substation or Table Mountain-Tesla 500 kV line. | TBD |

# Sacramento River Valley

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO (MW) | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO<br>SMUD<br>TANC | (1) CAISO TPP<br>(2) TANC 10 Year Plan<br>(3) Seasonal operating studies done by the OSS<br>(4) CAISO RPS studies<br>(5) CAISO cluster studies | 500-1000 / 0 / 0 | Unknown / ~2100 MW | ~18 | ~980 | None at this time |

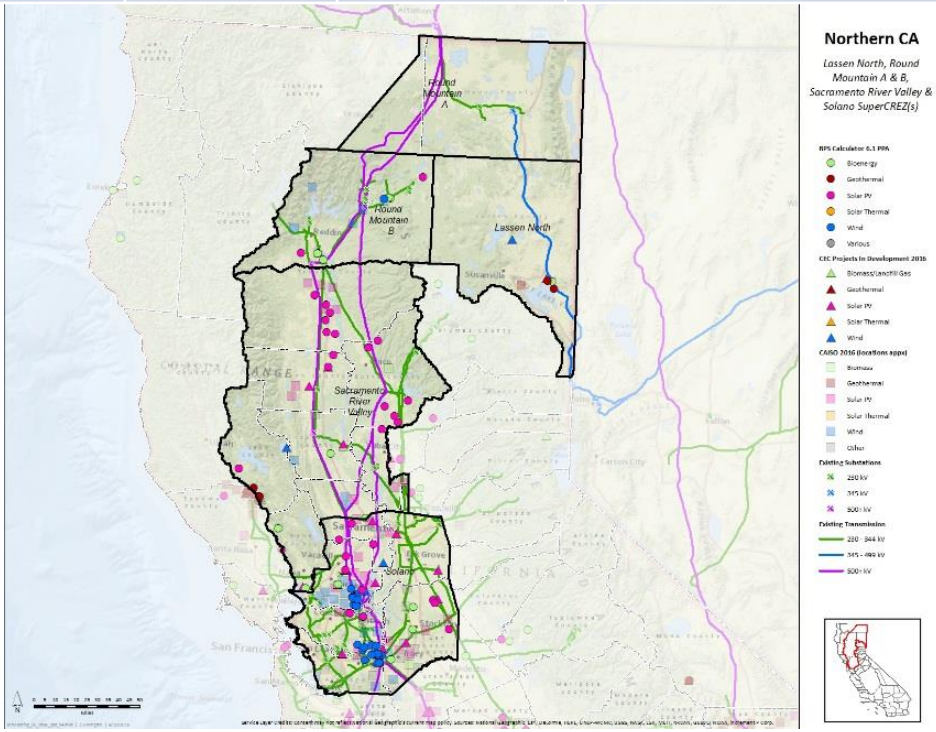
- Transmission capability estimate for FCDS resources in Sac River Valley is unknown at this point.
- Queued generation - low



# Lassen / Round Mtn.

| Impacted Transmission Planner/s | Data Sources | Proposed MW (Solar/Wind/Geo) | Anticipated FC/EO (MW) | Interconnection Queue (MW) | Existing Gen. in TAFA | Planned Upgrades impacting Tx Capability estimates |
|---|---|---|---|---|---|---|
| CAISO<br>SMUD<br>TANC | (1) CAISO TPP<br>(2) TANC 10 Year Plan<br>(3) Seasonal operating studies done by the OSS<br>(4) CAISO RPS studies<br>(5) CAISO cluster studies | 500-1000 / 500-1000 / 450 | Unknown / ~1,250 MW | ~200 | ~250 | None at present |

- Transmission capability estimate for FCDS resources in Northern CA is unknown at this point.
- Import transfer capability on COI is reduced currently when the northern California hydro generation output is high, in the 80% range or higher
- Queued generation - low



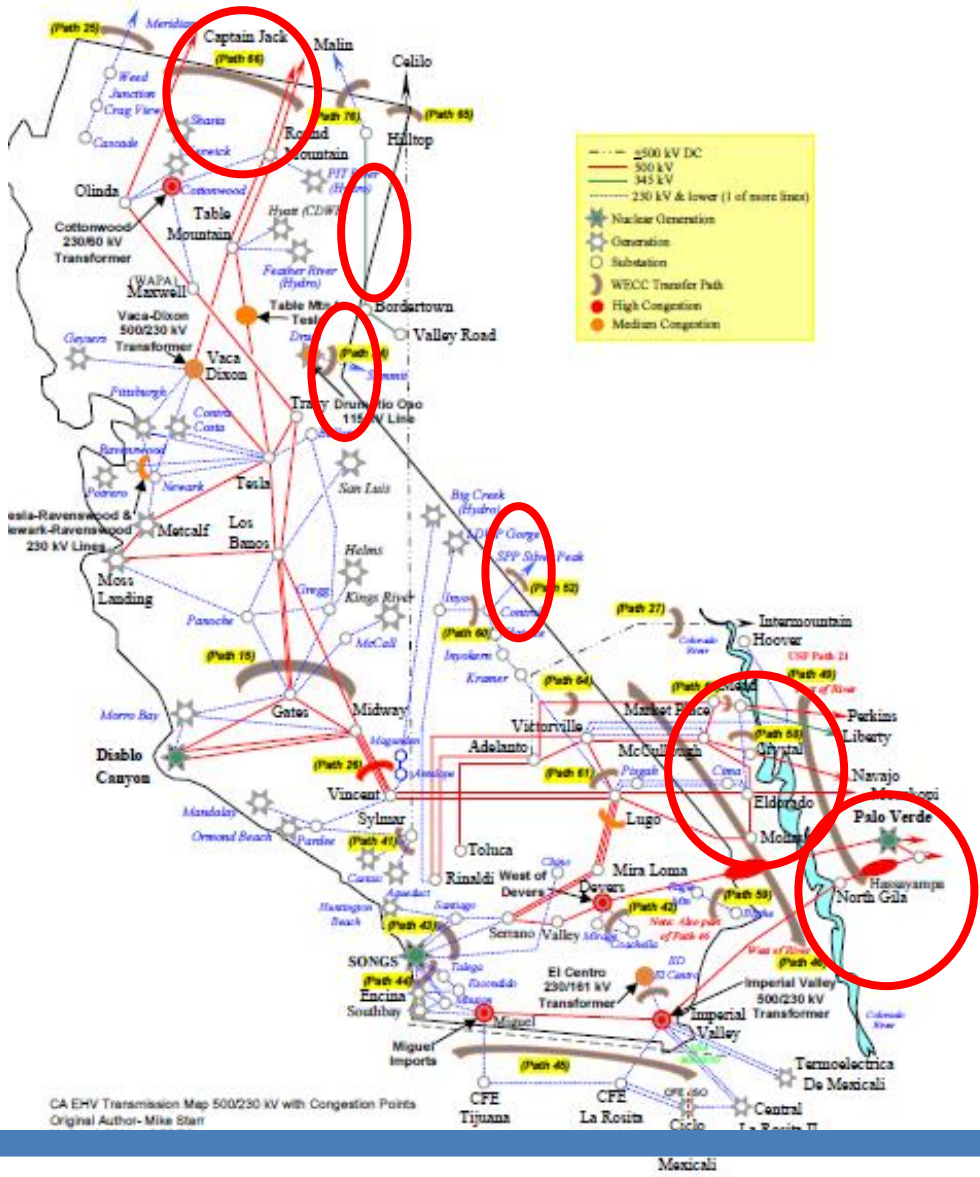
# Sacramento River Valley / Lassen / Round Mountain

## Expected Transmission Upgrades Required to Interconnect 3,500 MW

| Transmission Implication | Cost |
|---|---|
| In the recent past there have not been many generation interconnection requests in these areas. However, planning level studies done by the CAISO and TANC have provided information on allowable COI flows/NorCal hydro levels similar to those from the operating studies. These studies have indicated that the allowable total of COI flows and hydro output would be less than 8,000 MW. (Operating Study Subcommittee 2016 nomogram studies) | $2-4 billion<br><br>(estimated costs for modifications to the existing 500-kV grid and for a 4th 500 kV line between the California/Oregon border area and the Tracy/Tesla area) |
| The CAISO's 50% special study results indicated that approximately 3,400 MW of EO resources could be accommodated in this area, if steps were taken to mitigate the impacts of a number of pre- and post-contingency overloads on 230-kV and lower voltage facilities and if the total of COI flows/hydro production was limited below the levels discussed above. While studies have not been done to quantify such limitations; COI + Northern CA hydro may have to be curtailed by ~3,000 MW. | |
| Additional generation in Northern California would likely drive the need for transmission development to maintain the import transfer capabilities on COI and the deliverability of existing hydro resources unless the new resources were EO resources and were curtailed as required. The extent of such upgrades would need to be determined | |

# Import / Export Paths

- All imports will be subject to the transmission constraints of the TAFAs at their point of injection into the California grid
- Imports will compete with in-state resources for available transmission in respective TAFAs
- Export potential has not been looked at because we do not know enough about ability of neighboring system to absorb energy



# TAFAs of Import / Export Paths

| Delivery point or path | Potential MW | Affected TAFA |
|---|---|---|
| Eldorado/Mead/Marketplace | 3000 | Victorville (East of Lugo) and Riverside |
| Palo Verde/Delaney | 3000 | Riverside |
| California-Oregon Intertie / Path 66 | 2000 | Northern CA (Round Mtn, Lassen and Sacramento R.) |
| Central/Northern Sierra (Path 76; Path 24; Path 52) | 500 | NA |

# TAFA Evaluation Summary

| TAFA | Transmission Issues at the Prescribed Ranges | Basket of Conceptual Mitigations |
|---|---|---|
| Tehachapi | None | Current system can accommodate 5000 MW of FC/EO capacity |
| Victorville | Desert area constraint<br>North of Lugo constraints | Coolwater – Lugo 220 kV line + Lugo 500/230 kV bank<br>Lugo – Victorville500 KV upgrade<br>Red Bluff – Mira Loma 500 kV upgrade |
| Riverside | Desert area constraint | Lugo – Victorville500 KV upgrade<br>Red Bluff – Mira Loma 500 kV upgrade |
| Imperial | East of Miguel constraint<br>Desert area constraint<br>West of River constraint | IV – Valley 500 kV line<br>STEP (Midway – Devers 500 kV)<br>Lugo – Victorville500 KV upgrade<br>Red Bluff – Mira Loma 500 kV upgrade |
| San Joaquin Valley | Multiple 230 kV constraints | 230 kV system upgrades and local upgrades between Gates and Los Banos |
| Solano | Lack of a collector station | A 230 kV or 500 kV collector station |
| Northern CA (Sac River Valley, Lassen, Rnd Mtn) | COI import constraint | A new 500 kV line between the California/Oregon border area and the Tracy/Tesla area |

# Regional outreach project

- Goal is to gather regional stakeholders' input about existing and potential transmission capability to deliver out-of-state renewable energy to California (and for California to deliver out-of-state)

- Western Interstate Energy Board is conducting a "regional consultation" to solicit input from non-California entities on expected renewable supply and demand patterns in the Western U.S. and identify transmission implications of renewable developments

- Target audience/participants are state officials, utilities, renewables and transmission developers, environmental and other advocates

- WIEB will host meetings in Portland in August and Las Vegas in September 2016. WIEB will write report summarizing input for presentation to RETI 2.0

# Stakeholder discussion questions

1. Do you agree with the TAFA evaluations? including…
    1. Existing capacity
    2. Potential constraints
    3. Likely solutions

2. Please provide input on potential constraints and mitigations for combinations of TAFAs and import/export
    1. Northern California counties and the California-Oregon Intertie
    2. San Joaquin and the California "backbone" (paths 15 and 26)
    3. Victorville, Riverside, Imperial TAFAs and imports from Eldorado
    4. Victorville, Riverside, Imperial TAFAs and imports from Palo Verde
    5. Path 76 (Alturas line)