

Application No.: 16-10-012
Exhibit No.: _____
Witness: Nebiyu Yimer
ALJ: MacDonald
Commissioner: Randolph

In the Matter of the Application of DCR
Transmission, LLC for a Certificate of Public
Convenience and Necessity for the Ten West
Link Project

Application 16-10-012

**TESTIMONY OF NEBIYU YIMER
ON BEHALF OF
THE CALIFORNIA INDEPENDENT SYSTEM OPERATOR CORPORATION**

December 20, 2019

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1 **I. INTRODUCTION**

2 **Q1. What is your name and by whom are you employed?**

3 **A1.** My name is Nebiyu Yimer. I am employed by the California Independent System
4 Operator Corporation (CAISO), 250 Outcropping Way, Folsom, California as a Regional
5 Transmission Engineer Lead for Southern California.

6 **Q2. Please describe your educational and professional background.**

7 **A2.** I hold a Master of Science degree in Renewable Energy from Carl von Ossietzky
8 University of Oldenburg, Germany and a Bachelor of Science degree in Electrical
9 Engineering from Addis Ababa University, Ethiopia. I have over 20 years of
10 Transmission Planning experience in California, Canada and Ethiopia. I am a licensed
11 Professional Electrical Engineer in the Province of Alberta, Canada.

12 **Q3. What are your job responsibilities?**

13 **A3.** I am one of a group of engineers responsible for planning the CAISO controlled
14 transmission system in southern California to meet reliability requirements and state
15 policy goals in a cost effective manner. I am responsible for the analysis the CAISO
16 performed to estimate the capacity benefits of the Ten West Link Project (Proposed
17 Project) that is part of the updated cost-benefit analysis presented in this proceeding.

18 **Q4. What is the purpose of your testimony?**

19 **A4.** My testimony provides detailed information regarding the analysis the CAISO performed
20 to estimate the capacity benefits associated with the proposed Ten West Link Project.
21 My testimony also provides the basis for renewable portfolio adjustments the CAISO
22 applied in its updated production cost benefits analysis presented in Mr. Zhang's
23 testimony and the capacity benefits analysis presented herein.

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1 **Q5. Please describe the methodology the CAISO used to estimate the capacity benefits of**
2 **the Proposed Project.**

3 **A5.** The Proposed Project’s capacity benefits arise from its ability to increase the amount of
4 cost-effective out-of-state resources in the Southwest in general—CAISO grid connected
5 solar and solar-storage hybrid resources in western Arizona in particular—that can count
6 for resource adequacy. The CAISO performed the analysis to estimate the capacity
7 benefits of the Proposed Project in three steps as follows.

- 8 • **Step 1:** The CAISO used the resource optimization tool that the Commission uses in
9 its Integrated Resource Planning (IRP) process (RESOLVE) to determine the amount
10 of Arizona solar resource potential that can directly connect to the CAISO
11 transmission system (hereafter Arizona Solar) that is economically selected to achieve
12 the 42 MMT by 2030 emissions target. The CAISO also used the RESOLVE model
13 to estimate the associated savings in resource cost.
- 14 • **Step 2:** The CAISO used its existing deliverability methodology to estimate the
15 incremental MW capacity of the economically selected Arizona Solar that can
16 become deliverable and hence count for resource adequacy as a result of the Proposed
17 Project.
- 18 • **Step 3:** The CAISO calculated the economic value of the incremental capacity of the
19 economically-selected Arizona Solar that can count for resource adequacy as a result

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1 of the Proposed Project based on the avoided cost of battery storage as well as based
2 on locational renewables cost savings obtained from RESOLVE.

3 **II. RESOURCE RE-OPTIMIZATION USING RESOLVE TO INCLUDE ARIZONA**
4 **SOLAR AS A CANDIDATE RESOURCE**

5 **Q6. Please describe the RESOLVE Version used in your analysis and any adjustments**
6 **you made including the rationale for each change.**

7 **A6.** The CAISO used the RESOLVE Model downloaded from the Commission’s website.¹
8 Below are descriptions of the Excel-based User Interface, Scenario and Results Viewer
9 used.

- 10 • Name of User Interface file: *RESOLVE_User_Interface 2018-04-*
11 *17_ED_TxUpdate.xlsm*
- 12 • Name of Scenario: *42mmt_Ref_20181101_2017_IEPR*
- 13 • Name of Results Viewer file: *RESOLVE_Results_Viewer 2017-10-24.xlsm*

14 The RESOLVE model is the final model developed in the Commission’s 2017-2018 IRP
15 cycle, which was used to inform the CAISO’s 2019-2020 transmission planning process.
16 The CAISO used the *42mmt_Ref_20181101_2017_IEPR* scenario, as obtained from the
17 Commission’s website, as a starting point for its analysis. This scenario did not have
18 Arizona Solar enabled as a candidate resource. In order to determine the amount of
19 Arizona Solar that can be economically selected, the CAISO ran this scenario as is and
20 with Arizona Solar enabled. The changes the CAISO made to RESOLVE in order to
21 enable Arizona Solar are described below, along with the rationale for each change.

22 1. Enabled Arizona Solar as a candidate resource

23 Enabling Arizona Solar as a candidate resource was accomplished by changing the “Out-
24 of-State Renewable Filter” (Cell M42) in the “REN_Candidate” tab of the User Interface

¹ <https://www.cpuc.ca.gov/General.aspx?id=6442460043>

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1 to “1”. This allows Arizona Solar resources to be considered in the resource
2 optimization which could lead to substantial resource cost savings. According to the
3 RESOLVE Documentation for the Commission’s 2017 IRP,² solar resources in Arizona
4 have 8.3% lower capital cost and on average 13.6% lower levelized cost of energy
5 (\$/MWh) than solar resources in California with a similar capacity factor. Similarly,
6 compared to southern Nevada solar resources, the RESOLVE documentation indicates
7 Arizona solar resources are 5.4% cheaper in terms of capital cost and 15.2% cheaper in
8 terms of levelized cost of energy. Similar regional capital cost variations can also be seen

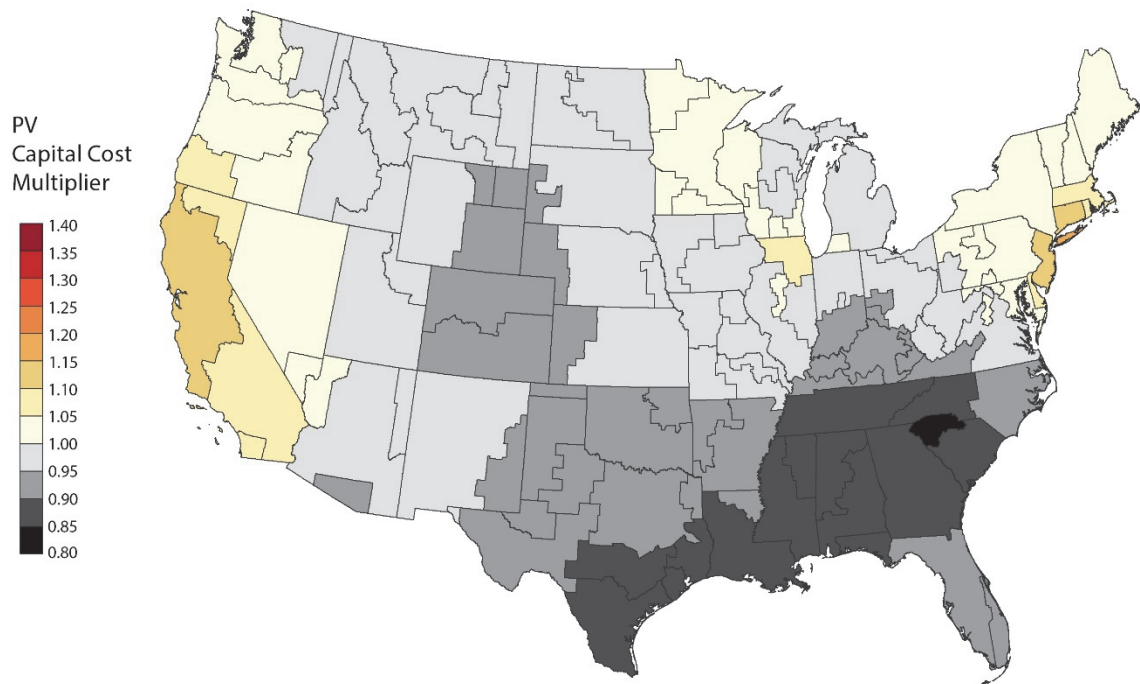
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https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/AttachmentB.RESOLVE_Inputs_Assumptions_2017-09-15.pdf

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1 from NREL’s Capital Cost Multiplier Map for Solar Photovoltaic resources shown in
2 Figure 1.³

3 **Figure 1: Regional Capital Cost Multiplier Map for Solar PV**



4

5 2. Limited candidate Arizona Solar potential to the amount currently in the CAISO
6 Generation Interconnection Queue

7 There are currently 6705 MW of western Arizona solar photovoltaic and hybrid projects
8 in the CAISO Generation Interconnection Queue that can connect directly to the CAISO
9 controlled grid. Table 1 below shows the list of the projects along with their capacity,

³ <https://atb.nrel.gov/electricity/2019/regional-capex.html>

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1 location and point of interconnection. The CAISO limited the candidate Arizona Solar
2 potential in RESOLVE to the amount in the interconnection queue by applying 6705 MW
3 as a “Potential Override” (Cell Z42) in the “REN_Candidate” tab of the User Interface.

**Table 1: Solar and Hybrid Projects in the CAISO Generation Interconnection
Queue⁴⁵**

Project Name	Queue Position	Net MWs			Location		Point of Interconnection
		Solar	Battery	MW Total	County	State	Station or Transmission Line
HARQUAHALA FLATS	1403	450	450	450	MARICOPA	AZ	Delaney-Colorado River 500kV Line/ Delaney 500 kV Substation
ATLAS SOLAR	1402	3200	1920	3200	LA PAZ	AZ	
CENTENNIAL FLATS	1529	514.55	257.28	500	LA PAZ	AZ	
MESQUITE SOLAR 3	1053	370		370	MARICOPA	AZ	Hassayampa 500 kV Substation
SUN STREAMS SOLAR 2	1189	150		150	MARICOPA	AZ	
DARLINGTON BALLEYSOLAR	1427	125	60	125	MARICOPA	AZ	
VULCAN	1534	225	28.5	250	MARICOPA	AZ	
MESQUITE SOLAR 5	1291	300	20	300	MARICOPA	AZ	
VIKTORIA SOLAR	1435	250	100	250	YUMA	AZ	Hoodoo Wash Substation 500 kV
WHITE WING RANCH SOLAR	1062	200		200	YUMA	AZ	
MCFARLAND SOLAR	1171	500		500	YUMA	AZ	
SIGNAL PEAK	1293	400		400	YUMA	AZ	
AGUA CALIENTE SOLAR 2	1222	20		20	MARICOPA	AZ	
Total		6,705	2,836	6,715			

6 3. Changed the “Out-of-State Renewable Transmission Cost Adder” for Arizona Solar

7 The generation projects in the CAISO Generation Interconnection Queue listed above
8 that are located in Arizona connect directly to the CAISO transmission system without
9 additional transmission for delivery to the California Border unlike most other out-of-
10 state resources. The Hoodoo Wash 500 kV bus is fully within the CAISO balancing area

⁴ <http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx>

⁵ MESQUITE SOLAR 3 (Queue no. 1053) has been recently downsized to 152 MW. The downsized project was energized on 10/17/2019.

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1 (BA). In addition, the CAISO has made arrangements with the respective adjacent
2 balancing authority to allow generation projects connecting to Delaney and Hassayampa
3 500 kV substations the opportunity to be in the CAISO BA. For example, the CAISO has
4 made arrangements with Arizona Public Service (APS) to change the BA boundary
5 between APS and CAISO to reflect the addition of the Delaney Switchyard once the
6 Proposed Project is completed. The proposed configuration of the Delaney 500 kV
7 substation is shown in Figure 2. The diagram also shows how the BA boundary at
8 Delaney Substation will be amended as generating facilities are built that desire to be in
9 the CAISO BA.⁶

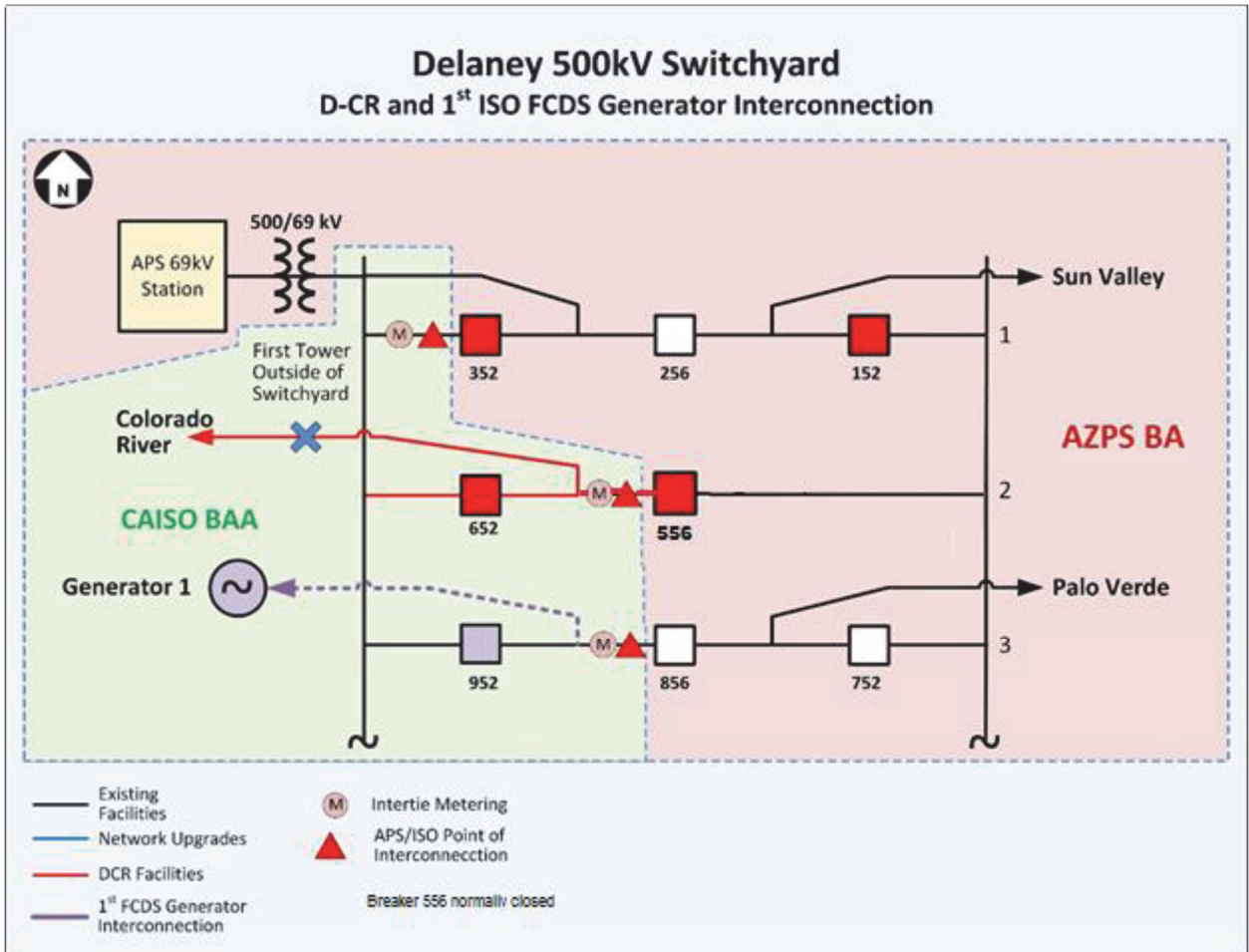
10 Based on these considerations, the “Out-of-State Renewable Transmission Cost Adder”
11 in the “REN_Tx_Costs” tab of the User Interface, which reflects transmission cost for
12 delivery to the California border, was changed for Arizona Solar (Cell F8) from \$26/kW-

⁶ http://www.caiso.com/Documents/Mar15_2018_SecondAmendment_ABAOA_APS_ER18-1098.pdf

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1 yr to zero (this treatment is similar to how RESOLVE models Southern Nevada resources
2 that connect directly to the CAISO BA).⁷

3 **Figure 2: Future CAISO BAA boundary at Delaney Substation once the Proposed**
4 **Project is built**



5 **Q7. Please provide the RESOLVE results you obtained with Arizona Solar enabled as a**
6 **candidate resource.**

7 **A7. With Arizona Solar enabled as a candidate resource, RESOLVE economically selected**
8 **3,262 MW of Arizona solar in year 2022. The Arizona Solar resources replaced more**

⁷ “For the purposes of modeling in RESOLVE, resources located in Southern Nevada are assumed to interconnect directly to the existing CAISO transmission system. This assumption has been updated from the CPUC’s

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1 expensive solar resources in southern California and southern Nevada in the same year
2 and wind resources in the Southwest in 2030 as shown in Table 2. RESOLVE also added
3 59 MW/312 MWh of energy storage in 2026 and 2030 as shown in in Table 3.

4 **Table 2: Changes in 2030 Selected Renewables by Location (MW)**

RESOLVE Resource	Tx Zone	42mmt_Ref_2018 1101_2017_IEPR	42mmt_Ref_20181 101_2017_IEPR with AZ Solar Enabled	Change
Riverside_East_Palm_Springs_Solar	Riverside_East_Palm_Springs	1,001	-	(1,001)
Southern_Nevada_Solar	Mountain_Pass_El_Dorado	3,006	1,402	(1,604)
SW_Ext_Tx_Wind	Riverside_East_Palm_Springs	500	61	(439)
Arizona_Solar	Riverside_East_Palm_Springs	#N/A	3,262	3,262

6 **Table 3: Changes in 2030 Selected Energy Storage**

Li_Battery	42mmt_Ref_20181101_2 017_IEPR	42mmt_Ref_2018 1101_2017_IEPR with AZ Solar Enabled	Change
Capacity (MW)	2,011	2,070	59
Energy (MWh)	2,547	2,859	312

7
8 The resource shift resulted in resource cost saving of \$977 million in present value of
9 revenue requirements or \$58 million in terms of annual levelized cost, both in 2016
10 dollars, as shown in Table 4.
11

preliminary results, in which resources in Southern Nevada were assumed to require major transmission upgrades to deliver to CAISO.” (RESOLVE Documentation: CPUC 2017 IRP Inputs & Assumptions, September 2017)

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Table 4: Resource Portfolio Cost Savings Due to Arizona Solar

	42mmt_Ref_201 81101_2017_IEP R	42mmt_Ref_201 81101_2017_IEP R with AZ Solar Enabled	Savings Due to AZ Solar
PV Revenue Requirement (\$MM)	\$ 27,965	\$ 26,988	\$ 977
New Renewables Fixed Costs	\$ 26,539	\$ 25,440	\$ 1,098
New Storage Fixed Costs	\$ 1,310	\$ 1,431	\$ (121)
New Thermal Fleet Fixed Costs	\$ -	\$ -	\$ -
New DR Fixed Costs	\$ -	\$ -	\$ -
New Transmission Costs	\$ 117	\$ 117	\$ -
Levelized Revenue Requirement (\$MM)	\$ 1,664	\$ 1,606	\$ 58
New Renewables Fixed Costs	\$ 1,579	\$ 1,514	\$ 65
New Storage Fixed Costs	\$ 78	\$ 85	\$ (7)
New Thermal Fleet Fixed Costs	\$ -	\$ -	\$ -
New DR Fixed Costs	\$ -	\$ -	\$ -
New Transmission Costs	\$ 7	\$ 7	\$ -

2

3 **Q8. Are these renewable resource cost savings attributable to the Proposed Project?**

4 **A8.** No, the renewable resource cost savings calculated above are based on the CAISO's
5 corrections to the IRP RESOLVE modeling to include western Arizona solar resources
6 that directly connect to the CAISO controlled grid in the resource optimization. The
7 CAISO's analysis assumes that the western Arizona resources can directly connect to the
8 CAISO controlled grid with or without the Proposed Project. However, the Proposed
9 Project will enable a significant amount of the Arizona Solar resource to be deliverable,
10 and therefore count toward load-serving entities' resource adequacy requirements. In the

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1 remainder of my testimony, I quantify and value the incremental portion of Arizona Solar
2 that will be deliverable with the Proposed Project.

3 **III. CAPACITY BENEFITS PROVIDED BY THE PROPOSED PROJECT**

4 **Q9. Please describe the deliverability assessment you performed to estimate the**
5 **incremental amount of economically-selected Arizona Solar that can count for**
6 **resource adequacy due to the Proposed Project.**

7 **A9.** The CAISO used the deliverability power flow model developed for its 2019-2020
8 transmission planning process to perform a deliverability assessment to estimate the
9 incremental amount of economically-selected Arizona Solar capacity that can count for
10 resource adequacy due to the Proposed Project used. This starting deliverability
11 assessment power flow model reflects the Policy-Driven Base Case portfolio the
12 Commission provided to the CAISO for the 2019-2020 transmission planning process,⁸
13 including the deliverability status of each resource. The CAISO's deliverability
14 assessment is based on the IRP Reference System Plan 42 MMT core case developed
15 with the RESOLVE model with some manual adjustments by Commission staff.

16 For the purposes of this deliverability assessment as well as the production cost
17 simulation addressed in Mr. Zhang's testimony, the CAISO modeled the resource shift
18 resulting from enabling Arizona Solar as a candidate resource in RESOLVE as
19 summarized in Table 5. Because the objective of the deliverability assessment is to
20 determine the amount of Arizona Solar capacity that can count for resource adequacy, all
21 of the Arizona Solar resources were modeled as seeking full capacity deliverability status
22 (FCDS).

8

https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/2018/IRP_TPP_ReliabilityAndPolicyBaseCase_ToBePosted.xlsx

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Table 5: Renewable Portfolio Adjustment Modeled⁹

RESOLVE Resource	Tx Zone	2019-2020 TPP Policy-Driven Deliverability Base Case	AZ Solar Deliverability Case	Change from Policy-Driven Deliverability Base Case
Riverside_East_Palm_Springs_Solar	Riverside_East_Palm_Springs	1,321	-	(1,321)
Southern_Nevada_Solar	Mountain_Pass_El_Dorado	3,006	1,402	(1,604)
SW_Ext_Tx_Wind	Riverside_East_Palm_Springs	500	61	(439)
Arizona_Solar	Riverside_East_Palm_Springs	#N/A	3,364	3,364

Note: Resources with #N/A were not made available to the model for this scenario

2

3 The deliverability assessment was performed with and without the Proposed Project. In
4 the deliverability power flow case with the Proposed Project, Arizona Solar was
5 distributed among Delaney (60%), Hassayampa (20%) and Hoodoo Wash (20%)
6 substations approximately in the same proportion as resources in the CAISO Generation
7 Interconnection Queue. In the case without the Proposed Project, the Delaney substation
8 share of Arizona Solar was distributed in equal amounts to Hassayampa and Hoodoo
9 Wash because the Delaney substation will not have a direct connection to the CAISO
10 transmission system without the Proposed Project.

11 The results indicate that the most limiting contingency is an outage of the Ocotillo–
12 Suncrest 500 kV line, which overloads the Eco-Miguel 500 kV line as shown in Table 6.
13 The constraint limits the amount of economically-selected Arizona Solar that can count
14 for resource adequacy to about 2,149 MW with the Proposed Project. Without the
15 Proposed Project, same constraint limits Arizona Solar deliverability to 1,180 MW. This
16 means that the Proposed Project provides an increase of 969 MW in deliverable Arizona
17 Solar capacity, as shown in Table 7.

⁹ The total amount of Arizona Solar modeled in the deliverability power flow model is somewhat higher than the amount RESOLVE selected because it is calculated as the sum of the resource shifts relative to the starting deliverability case as shown.

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Table 6: Arizona Solar Deliverability Constraints

Limiting Facility	Contingency	Loading (%)	
		With TWL	Without TWL
Eco -Miguel 500 kV line	Ocotillo - Suncrest 500 kV line with RAS dropping approximately 1,150 MW of SDG&E area generation	108.7%	116.5%

2

Table 7: Deliverable Arizona Solar Capacity Results

	With TWL	Without TWL
Total Economically Selected Arizona Solar	3262 MW	3262 MW
Deliverable Capacity	2149 MW	1180 MW
Incremental deliverable capacity due to the Proposed Project	969 MW (29.7% of total)	

3 **Q10. Please explain how you valued the capacity benefits provided by the Proposed**
4 **Project.**

5 **A10.** The CAISO used two approaches to monetize the capacity benefits provided by the
6 Proposed Project. The first approach is based on the avoided cost of battery storage
7 equivalent to the net qualifying capacity (NQC) of the incremental Arizona Solar
8 capacity that becomes deliverable due to the Proposed Project. The second approach is
9 based on the locational renewables cost savings from RESOLVE, as explained in Q&A
10 No. 7.

11 1. Capacity benefit based on avoided cost of energy storage

12 The Commission has adopted an effective load carrying capability (ELCC) methodology
13 to determine the resource adequacy value for solar resources. This means that for every
14 MW of installed, deliverable solar capacity, the Commission applies a discount to
15 determine the solar resource's actual contribution to meeting load requirements. Based
16 on the ELCC values for solar adopted in Commission Decision 19-06-026, the

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1 incremental deliverable capacity of Arizona Solar resulting from the Proposed Project,
2 *i.e.*, the 969 MW calculated above, translates to an NQC of 136 MW in effective resource
3 adequacy capacity in the peak month (September).¹⁰ This means that the Proposed
4 Project will allow 969 MW of Arizona Solar, which currently has an NQC of 136 MW, to
5 count for resource adequacy capacity that would otherwise need to be procured from
6 other resources.

7 Using interpolated cost projections for a lithium-ion battery energy storage system
8 (BESS) for year 2022,¹¹ the CAISO calculated the levelized annual capacity benefit
9 attributable to the Proposed Project on the basis of the avoided cost of energy storage that
10 would otherwise need to be procured without the Proposed Project. Table 8 shows that
11 levelized cost of 136 MW of BESS \$36.3 million per year.

Table 8: Capacity Benefit of TWL Based on Avoided Cost of Battery Storage

Lithium-Ion BESS	Capital Cost (2018\$)	Levelized Cost (2018\$)
Unit Cost	1661 (\$/kW)	268 (\$/kW-year)
Cost of 136 MW BESS	\$225 million	\$36.3 million/year

13 2. Capacity benefit based on locational renewables cost savings

14 In this approach, the CAISO estimated the capacity benefit of the deliverable Arizona
15 Solar on the basis that, if the Proposed Project is not built, the equivalent of 969 MW or
16 29.7 percent of the economically-selected Arizona Solar capacity will have to come from
17 renewables located in less economic locations subject to deliverability constraints.

18 Accordingly, the CAISO calculated the capacity benefit attributable to the Proposed

¹⁰ The September ELCC value for solar resources is equal to 14% of the installed capacity (*i.e.*, the effective load carrying capability is equal to 14%).

<http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M309/K463/309463502.PDF>.

¹¹ https://www.sandia.gov/ess-ssl/wp-content/uploads/2019/07/PNNL_mjp_Storage-Cost-and-Performance-Characterization-Report_Final.pdf.

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1 Project as the percentage of the Arizona Solar that is deliverable multiplied by the total
2 resource cost savings realized by enabling the RESOLVE model to include Arizona Solar
3 in the resource optimization. The CAISO calculated the capacity benefit to be \$290.3
4 million in terms of present value or \$17.3 million in terms of levelized annual benefits
5 using this approach. The full results are shown in Table 9.

6 **Table 9: Capacity Benefit of TWL Based on Locational Renewables Cost Savings**

	Total Resource Cost Saving from RESOLVE due to AZ Solar (2016\$, \$MM)	Capacity Benefit @ 29.7% of Total (2016\$, \$MM)
Present Value of Revenue Requirement	\$977.3	\$290.3
Levelized Revenue Requirement	\$58.2	\$17.3

7 The CAISO recognizes that the capacity value of solar resources will likely continue to
8 decline in the future as more solar resources are added and post-sunset energy needs
9 become more predominant. For this reason, the CAISO-calculated capacity benefits may
10 be reduced over time, notwithstanding the Proposed Project’s capacity to increase
11 delivery of solar-storage hybrid projects located in Arizona that connect directly to the
12 CAISO system or other out-of-state renewables in the Southwest. In order to account for
13 this uncertainty, the CAISO calculated benefit-to-cost ratios based on one-third, one-half,
14 and two-thirds of the capacity benefit values calculated.

15 **IV. CONCLUSION**

16 **Q11. Please summarize your conclusions.**

17 **A11.** The proposed Ten West Link Project’s capacity benefits arise from its ability to increase
18 the amount of cheaper out-of-state resources in the Southwest in general, and solar
19 resources in Arizona that connect directly to the CAISO transmission system in

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1 particular, that can count for resource adequacy. The resource optimization performed
2 after enabling Arizona Solar as a candidate resource in RESOLVE indicated 3262 MW of
3 Arizona Solar can be economically selected to meet the renewable policy target.

4 The deliverability assessment results indicated that the Proposed Project increases the
5 capacity of the economically-selected Arizona Solar that can count for resource adequacy
6 by approximately 969 MW (which is 29.7% of the economically selected capacity) or
7 136 MW in NQC. This translates into a levelized annual saving due to the Proposed
8 Project of \$17.3 (2016\$) to \$36.3 million (2018\$) depending on whether locational
9 renewables cost savings, the cost of avoided energy storage or a combination of both is
10 used to value the capacity benefit.

11 The resource optimization results with Arizona Solar enabled and the resulting capacity
12 benefits in favor of the Proposed Project are utilized in the CAISO production cost
13 simulation and cost-benefit ratio calculations, respectively that Mr. Zhang is addressing
14 in his testimony. In the BCR evaluation, the CAISO applied one-third, one-half and two-
15 thirds of the capacity benefit value calculated above to account for the uncertainty
16 regarding the future capacity value of solar resources.

17 **Q12. Does this conclude your testimony?**

18 **A12.** Yes.