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## **EXPERT OPINION STATEMENT REGARDING POTENTIAL ENGINEERING SOLUTIONS TO ASSIST IN REGIONAL TRANSMISSION PLANNING**

Prepared by Utility System Efficiencies, Inc. for Western Resource Advocates  
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### **INTRODUCTION**

Utility System Efficiencies, Inc. (USE) was contracted to aid Western Resource Advocates (WRA) in developing an expert opinion statement regarding the draft programmatic environmental impact statement for the west-wide designation of energy transmission corridors. Ty Larson of USE is the principal author of this statement.

### **BACKGROUND OF TY LARSON**

Ty Larson currently holds fifteen years of electric system utility experience - specializing in both transmission system planning & operations engineering. Mr. Larson possesses extensive experience and a strong working knowledge of the analytical tools that support the system performance evaluation and capital planning processes used by electric utilities. In recent years as an Operations Engineering Manager at the California ISO, Mr. Larson mentored and coached other engineers in power engineering analysis. More recently Mr. Larson has joined Utility System Efficiencies, Inc. (USE) in July of 2005. Mr. Larson's employment resume spans over several sectors of the electric utility industry, and he is qualified to discuss material with this expert opinion statement.

### **THE ROLE OF ENGINEERING SOLUTIONS IN COMPREHENSIVE REGIONAL TRANSMISSION PLANNING TO ASSIST IN ASSESSING ENERGY CORRIDOR NEEDS AND POTENTIAL OPTIMAL PLACEMENT**

In the context of regional planning for the optimum location for energy corridors for the future location of thousands of linear miles of power lines in the Western United States, the following paper outlines a methodology that focuses on: (1) maximizing the use of the existing transmission infrastructure and utilizing the existing transmission/transportation rights-of-way; and (2) determining suitable locations for the construction of new transmission corridors for use in future transmission planning. While employing this methodology is one of several potential approaches to developing solutions for energy needs, the methodology discussed herein contains important steps in comprehensive regional transmission planning that may better inform both the need for and location of energy corridors for the future location of new or upgraded power lines. This expert opinion focuses on both the need for proposed energy corridors that may contain power lines in the future, as well as the review of a proposed solution. It is not the authors intent to infer that this proposed methodology is the only process or strategy to aid in this type of review, but rather to impart simply a method that could be used to help aid any existing process that may be currently engaged in finding a solution via regional transmission planning and the need for and location of energy transmission corridors.

From an engineering perspective, this paper focuses on opportunities to reduce the overall need for new power lines and thereby corridors and rights-of-way in which to locate them, namely by identifying potential engineering solutions and methodologies to follow in order to optimize components of the existing western power grid and enhance the current electric system's overall power carrying capacity to meet future power transfer needs. Employing these methodologies and applying technological engineering solutions in this fashion is a widely recognized industry practice as one component of transmission planning that in some instances may reduce or eliminate the need for new power lines and the impacts associated with associated rights-of-way and/or corridors.

## Project/Corridor Need

Project need is typically at the very core of all regional transmission planning issues and it is usually well documented in a power engineering study. Few good engineers would dispute that accurately understanding the driver for project need is critical in developing the best and correct project solution. Project need is usually conveyed through a series of well documented power engineering studies. A very basic question is does one really need this project? What is driving this need? Importantly, there is a direct correlation between project need – i.e., the need for an upgrade or addition to the electric power infrastructure – and rights-of-way and corridors in which to “house” a potential project. By first taking a hard look at whether a potential or specific project is needed, this may in turn answer a related question of whether the related ROW/corridor is also needed.

### *Power Engineering Studies*

The detailed modeling and measure of transmission system performance outlines the major role of most power engineering studies. Once the true performance of a particular transmission system is known, then one can attempt to improve or optimize transmission performance. Many power engineering experts consider this first phase of analysis very important for it can shed light on where and what criteria violations may surface ultimately yielding weaker area of the overall transmission grid. Once this information is known, the engineer can start to model various changes that could potentially be made to the transmission system. This could be considered phase 2; ultimately modeling and measuring transmission performance of various transmission solutions. All portions of the power engineering studies are based on a set of assumptions which ultimately can impact modeling accuracy.

### *Power Engineering Assumptions*

Most power engineering studies make a certain set of assumptions for various grid conditions that are to be represented in the study. It is safe to say that the overall transmission model accuracy is greatly improved with assumptions that best resemble accurate real life transmission grid conditions. It should be know that just minor changes in assumptions can have major impacts on the overall transmission grid performance. The role of assumptions should not be played down in their overall potential to influence power engineering studies results. Therefore it is in everyone’s best interest to make sure that all study assumptions are reasonably accurate and their sources and values are well documented in power engineering studies. The following list-of-assumptions are but just a few, but the strategy of Q & A regarding them could be applied to many different assumptions. The principles are the same. This information is readily available in transmission planning circles and a rigorous examination of the following factors is an important preliminary step in terms of identifying current and future power grid needs including anticipated needs for new or expanded ROW and corridors.

### *Key Assumptions*

**Load Growth** is an example of one key assumption that will typically influence the measure of power-grid performance under various conditions. Interested parties may ask many different questions regarding load growth, for if load growth is inaccurately modeled the effects may throw off the timing of the project need. This could result in project solutions being proposed late or too early. The following are good rule of thumb questions that I typically ask regarding a studies load growth projections.

1. What was the focal area of studies load growth?
2. How were the load growth projections done?
3. What data was used in calculating load growth projections?
4. How was the data collected?
5. What load growth was actually measure for the last 10 years?
6. When was it measured (Peak, Partial Peak, etc.)

7. What type of customer load does this represent (Residential, Commercial, and Industrial)?
8. What is the average Power-Factor for the loads represented in the study area?
9. To what extent have future load growth assumptions factored in efficiency gains in the residential and commercial sectors that can reduce overall load growth? Reducing load through efficiency gains, as well as the application of distributed power sources, can result in reductions in the amount of generation needed to meet future load growth, which may in turn affect and possibly lessen overall transmission and corridor needs.

**Generation Pattern** modeled in the study is another key assumption that can affect the modeling and measure of power-grid performance. Understanding the modeling of both existing and planned future generation commitment and output levels in a power engineering study is important. Inaccurate key assumptions regarding a studies generation pattern can skew power study results and ultimately impact timing of project need. The affects of inaccurate timing again can result in project solutions being proposed late or too early. The following questions are aimed at understanding the generation pattern modeled in the power engineering study.

1. What was the breakdown of all existing resources? Are these levels of commitment and output truly realistic?
2. What output levels and commitment strategy was used when modeling hydro generation? Does this pattern represent actual witnessed grid conditions?
3. How was the data collected?
4. What output levels and commitment strategy was used when modeling wind generation? Does this pattern represent actual historic grid conditions?
5. How was the data collected?
6. How are future new generation interconnections modeled in this study? Was all queued generation modeled? Was a cluster study involved? What was the overall strategy of new generation commitment and level of output based on?

Load growth and the generation pattern modeled in a power engineering study are just some of the assumptions that can easily influence the timing and outcome of a project need. Many other power-engineering study assumptions not listed in this section also require the same level of understanding to allow the engineer to obtain the best most accurate study results that ultimately can lead to accurately determining project need and timing. Fleshing out good project solutions, including the need for any expanded or new ROW or corridors for power line location, typically comes after understanding detailed project need and timing.

### **Engineering Solutions to Address Needs: Maximizing the Power Transfer Capacity of the Current Grid System through Engineering Analyses and Capacity Upgrades**

The implementation of project solutions to upgrade a transmission grid typically involves a broad spectrum of approaches to solve a transmission grid challenges. One could add new equipment (build new lines/install new substations) or leverage or upgrade existing transmission assets, including the utilization of some of the new technologies that are now becoming available, as possible solutions. The approach followed – including the preceding two scenarios that are poised at opposite ends of the transmission planning spectrum – may result in reducing or eliminating the need for new transmission ROW/corridors and their attendant impacts on the natural environment. The bottom line is that some project solutions are more elegant than others. Cost and actions with the least amount of impact are usually at the top of most transmission planning engineer's lists when it comes to attempting to compare or optimize different project solution options. The selection of a good project solution is critical and will ultimately impact a variety of variables that go beyond project cost. Experience has shown that typically solution

projects are more cost effective and less environmentally invasive on many levels if the project solution employs leveraging or upgrading an existing grid asset.

### *Power Engineering Project*

From an interested party perspective, understanding why different study project solutions or alternatives are proposed is important. It is good to know why and how the favored project solution was arrived at. The following set of questions can be beneficial to verifying if the best project solution was truly chosen while reviewing engineering studies. At times the following through the actual process of Q and A of the following question tree can expose some low-lying fruit that may be beneficial in fleshing out an even a better project solution than was listed in the most current engineering studies or reports.

While there are many different approaches one can take in terms of finding a solution for an anticipated need, my professional expertise is that a rigorous examination of the following questions is an important initial step in transmission planning that first seeks optimization of existing electric grid assets before turning to higher-impact solutions such as new power lines and associated ROW/corridors. In other words, optimization of current electrical grid assets, i.e., the major components of substations, transformers, conductors (lines) and other equipment, particularly through the use of state of the art electrical engineering analysis and solutions, can address additional power transfer needs by using/upgrading the existing transmission system which has the environmental benefit of utilizing already-impacted areas.

1. **Existing grid assets leveraged** -are they leveraged to their fullest capability?

Examples of leveraging existing grid assets are:

- a. **Equipment Re-rates** – The re-rating of existing grid equipment (examples may be transmission line or transformer bank) may be an answer to solving criteria violation(s) or grid issue(s) resulting from excessive flows over existing equipment ratings. My experience has shown in the past that the re-rating existing equipment is typically cheaper than installing new equipment, so the leveraging of existing grid assets in this manner can be very cost effective.
  - i. What is the current position of the utility or system operator in the study area in regards to administering existing grid equipment re-rates?
  - ii. Is there a written policy regarding the re-rating of existing grid equipment?
  - iii. Has the utility or system operator already set a precedent by re-rating existing grid equipment in the past?
  - iv. Has the solution option of re-rating of existing grid equipment been evaluated in the engineering study?
  - v. What is the condition of the existing grid equipment?
    1. Transformer banks:
      - a. When was the last time a dissolved gas analysis was performed on the transformer?
      - b. What is the status of the last dissolved gas analysis of the bank?
      - c. What are the historic temperature trends of the transformer bank (Top winding)?
    2. Transmission lines:

- a. When was the last time the line underwent maintenance?
  - b. Is the line current in its maintenance cycle?
  - c. What is the practice of the utility or system operator regarding transmission line maintenance?
  - d. What are the surrounding ambient air conditions of the line?
  - e. Is the line located in an air district where insulator contamination is an on-going concern?
  - f. Is there an insulator wash cycle?
  - g. When was the last time the line was patrolled?
  - h. How is the visual inspection of the line?
  - i. What is the status of all insulators, shoes, clamps, sleeves and connectors?
  - j. Is there appropriate ground clearance during peak-loading of the line?
  - k. When was the last infrared scan done on the transmission line?
  - l. Did the scans reveal any hot spots or outline any concerns regarding risk to line integrity?
  - m. What is the written policy or practice of the utility or system operator regarding transmission line ratings?
  - n. What are the engineering assumption with regards to ambient temperature and wind-speed (2 ft/sec, 3 ft/sec or 4 ft/sec)?
- b. **SPS or RAS** - Can the criteria violation or grid issue(s) driving the need and timing of the project be solved by installation of a special protection scheme (SPS) or remedial action scheme (RAS)? If the criteria violation or grid issue(s) are due to excessive flows over existing emergency equipment ratings, then one example in solving the problem may be to have an automatic scheme ramping back or tripping generation or even tripping customer load.
- i. What is the current position of the utility or system operator in the study area in regards to employing the use of an SPS or RAS?
  - ii. Is there a written policy?
  - iii. Has the utility or system operator already set a precedent by using other SPS or RAS?
2. **Upgrading Existing Grid Assets** –in a lot of cases existing assets can be partially upgraded to see some real gains in overall increased capability. The upgrade of existing transmission lines are strong examples of this.
- a. **Circuit Re-conductoring with Conductor of Higher Capability** – Re-conductoring limiting circuits with larger conductor will in most cases upgrade circuit transfer capability. The right of way and corridor are already in use. In many cases, this simple fact can make the process of

re-conductoring faster and more cost effective, and at times more environmentally friendly than embarking on the construction of a new line.

- i. In places where criteria violation or grid issue(s) driving the need and timing of the project, will re-conductoring of existing transmission line(s) with higher ampacity conductor help increase transfer capability in solving the transmission need?
    - ii. Has the utility or system operator compared transmission solutions that employ the re-conductoring of existing circuit(s)?
  - b. **Adding an Additional Circuit to Existing Towers** – At times inspection of existing towers along an existing critical transmission route may have a circuit vacancy. For example if a visual inspection reveals that there is no second circuit on the existing tower, this would lead to analyzing whether a second circuit would be a sensible solution. Or minor tower modifications can enable the addition of another circuit. This can equate to a real gain! The right of way and corridor are already in use – which would result in confining impacts to an already-disturbed area. In many cases, this simple fact can make construction faster and more cost effective, at times more environmentally friendly than embarking on the construction of a new line.
    - i. In places where criteria violation or grid issue(s) driving the need and timing of the project, is there a vacancy on the existing towers that can be leveraged help increase transfer capability in solving the transmission need?
    - ii. Has the utility or system operator compared transmission solutions that employ the addition of a second circuit?
  - c. **Upgrading the Voltage of an Existing Transmission line** – Upgrading voltage class of an existing transmission line can also yield possible increases in circuit capability. Again as in the above example, the right of way and corridor are already in use. In many cases, this simple fact can make construction faster and more cost effective, at times more environmentally friendly than embarking on the construction of a new line.
    - i. In places where criteria violation or grid issue(s) driving the need and timing of the project, is there a lower voltage circuit that could be upgraded with minor tower modifications to help increase transfer capability in solving the transmission need?
    - ii. Has the utility or system operator compared transmission solutions that employ the change in circuit voltage class?
3. **Employing the use of new technologies**—in a lot of cases existing assets can be partially upgraded with newer technologies to see some real gains in overall increased capability. The re-conductoring of existing transmission lines with composite conductor are strong examples of utilizing the new technologies available currently today.
- a. **Composite Conductors** – Over the years vast improvements have been made in the construction of newer high-tech composite conductors. There are many different designs that can show as much as a threefold ampacity increase in circuits that have been re-conducted with this new material.

- i. In places where criteria violation or grid issue(s) driving the need and timing of the project, will re-conductoring of existing transmission line(s) with higher ampacity composite conductor help increase transfer capability in solving the transmission need?
  - ii. Has the utility or system operator compared transmission solutions that employ the re-conductoring of existing circuit(s) with composite type conductor?
- b. **Series Reactors or Series Capacitors** – In places where it makes sense to increase or limit flows on large transmission corridors. The use of reactive or capacitive device can be used. These devices do have the side of effect of changing voltage, but in the correct applications they can be used to influence the overall flow of power.
  - i. Has the utility or system operator compared transmission solutions that employ the series reactors or series capacitors?
- c. **Phase Shifting Transformers** – In places where it makes sense to increase or limit flows on large transmission corridors. The use of phase shifting transformer has been employed. Transformers are able to manipulate the power angle by changing the setting and ultimately allowing more or less power to flow.
  - i. Has the utility or system operator compared transmission solutions that employ the phase shifting technologies?

### **Applying Engineering Solution Transmission Planning Principles to One Area in Southern Arizona and New Mexico**

The current west-wide corridor effort seeks to designate energy transmission corridors in 11 western states, including Arizona and New Mexico. My professional opinion is that employing the above analyses including a rigorous examination of system needs and potential engineering solutions would have been helpful in determining the optimum number, potential width and location of transmission corridors for the future location of power lines. In addition to the current status of electrical system components, comprehensive planning for new power line corridors could also incorporate available lands and wildlife constraints and proposals for new generation sources seeking grid interconnection. Indeed, this type of grid interconnection “queue” information that is readily available in the public domain can also shed light if one has a particular focus on adding generation sources of a particular type. This type of planning can be useful into addressing multiple concerns in a comprehensive fashion by incorporating information about generation type (e.g., renewable sources), corridor needs and locations and lands and wildlife concerns.

Attached as Exhibit A is a map of Arizona and New Mexico. This mapping effort contains information readily available, in the public domain, to combine the geographic features including: land status, public interest group priority conservation areas, existing power lines and substations, and current interconnection queue data points, broken down by resource type and anticipated megawatts of newly installed capacity.

Attached as Exhibit B is a more specific map that zooms in on an area straddling the AZ/NM border in the Tucson AZ to Deming, NM general location. In addition to the above geographic features, proposed corridor 81-213 is depicted that would likely serve future power line needs between the Tucson and Deming locations. Between the Luna, Greenlee, Redtail substations and the Tucson area, numerous queue interconnections are shown, including 120 MW of solar power near Luna. For purposes of this demonstrative exercise in transmission planning, we are assuming that the “unknown” queue requests of 300 MW and 1000 MW in Greenlee and

northeast of the Redtail substation are all for renewable energy resources. Accordingly, in this general location as depicted on the Exhibit B, approximately 1,420 MW of renewable energy resources are seeking grid access. One further assumption is that this power can flow at time from east to west to potentially help serve growing load needs in the Tucson population center.

Employing the recommended engineering analyses and potential solutions outlined above as a demonstrative exercise yields the following qualitative assessments. After closing inspecting this potential future project from a comprehensive vantage, it would appear that leveraging or upgrading an existing 345kV transmission line between Luna New Mexico, Greenlee Arizona and Tucson Arizona might be another more cost effective and less environmentally invasive approach than building a new power line to carry this power in proposed corridor 81-213.

Answers to important questions would need to be assessed in a properly conducted power flow analysis to determine what capacity upgrades and technological solutions could possibly enable the current grid asset of the 345kV line to handle the proposed MW additions to the system. In other words, this would be the point where the above-enumerated methodologies and technological/engineering solutions would shed light on the ability of adding a second circuit, moving to a higher voltage class or re-conductoring or other solutions could allow for these proposed energy additions to be handled by upgrading existing grid assets.

The current corridor designation process could be improved upon by addressing these issues in a comprehensive fashion and employing these engineering-solution methodologies. In the current example, while, proposed corridor 81-213 does coincide with the existing 345 kV for approximately 30 miles west of the Luna substation, about 10 miles east of the Hidalgo substation, however, the power line departs the proposed corridor. From this point on all the way to the Tucson area, proposed corridor 82-213 appears to not follow areas containing existing power line and ROW infrastructure. From the point of departure with the existing 345 kV line, proposed corridor 81-213 appears to also bisect citizen proposed wilderness areas as well as high priority conservation areas identified by The Nature Conservancy. Accordingly, comprehensive transmission planning that combines geographic features with engineering analyses and solutions, may in this one example suggest other alternatives to transfer proposed power additions to the grid system other than any use of a new power line through proposed corridor 81-213. While this analysis is mostly qualitative, the purpose in this instance is not to provide a definitive engineering solution, but rather, to suggest in this example that employing these comprehensive transmission planning principles might obviate the need for this proposed corridor altogether and keep future impacts in already-impacted areas and outside of potential environmental constraints.

Additionally, upgrading the ties to Greenlee Arizona could provide potential additional benefits in a strengthened source to two northern 345kV ties from Greenlee Arizona to the Springerville and ultimately Four Corners. Also additional planned queued interconnection projects such as the proposed solar power plant located at in the Luna could be effective in feeding both Luna and Tucson loads. Other queued projects may site in this are due to high solar gain. While the Exhibit B shows the current snapshot in time concerning proposed additions to the grid system, high industry interest in this area for its solar potential and potential future projects also needing grid access would be relevant in terms of whether to upgrade the current line to a double-circuit 345 kV or moving to a higher voltage class (500 kV) or even possibly double-circuit 500 kV, as well as other new technologies that could be employed to increase the transfer capacity of the current system.