# Costs and Benefits of Distributed Solar Generation on the Public Service Company of Colorado System

## A Proposed Study Plan Drafted by Public Service Company of Colorado and the Colorado Governor's Energy Office

### Objectives

Public Service's objective in this study is to investigate and document the costs and benefits of distributed solar generation ("DSG") on its electric supply system at current penetration levels and projections for near-term penetration levels. The results of the study can be used to inform future rate design and guide current and future Public Service distributed solar generation acquisition programs (e.g., Solar*Rewards and programs developed to acquire solar generation resulting from HB10-1342, "Solar Gardens").

The Governor's Energy Office's ("GEO") objective in this study is to investigate and document winning business cases for utility ownership and examples of cost recovery of DSG investments.

### Scope – Public Service

Public Service will investigate the costs and benefits of DSG at current levels of installed capacity (roughly 60 MW DC) and levels expected by the end of 2014 (roughly 140 MW DC).[1] Public Service has selected a future date of 2014 since this comports with recent changes in CRS 40-2-124 (1)(e)(2)[2]and since dates farther into the future have higher levels of uncertainty around expected installed DSG levels and expected DSG system and program costs. Costs and benefits associated with both current DSG levels and expected 2014 levels will be examined over a twenty (20) year life for installed DSG systems which corresponds to the current Renewable Energy Credit purchase terms of Public Service's Solar*Rewards program.

DSG is defined as any solar photovoltaic generation interconnected to Public Service's distribution system at primary voltage or lower (typically < 44 kV). For purposes of this study, DSG is assumed to be photovoltaic only. DSG may be physically net-metered or not.

Benefits are defined as those quantifiable, solar generation attributes that tend to reduce or displace program participant and/or non-participant costs for electric utility service; benefits are impacted by the correlations between the solar generation profile, and customer, distribution feeder, and/or substation load. Benefits may include, but are not limited to: avoided utility bill payments, avoided electric system energy costs, avoided electric generation capacity costs, reduced electric transmission and distribution line losses, avoided or deferred electric transmission and distribution capital expenditures, and avoided ancillary services.

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[1] Expected 2014 levels of installed DSG are based on Exhibit PJN-2 provided in Public Service's 2010 RES Compliance Plan.

[2] HB10-1000 amended CRS 40-2-124 (1)(e)(2) with the addition of paragraph (c) which reads, in part, "Distributed generation amounts in the Electric Resource Standard for the years 2015 and thereafter may be changed by the Commission for the period after December 31, 2014, if the Commission finds, upon application by a Qualifying Retail Utility, that these percentage requirements are no longer in the public interest."

Costs are those quantifiable, solar generation attributes and solar acquisition program charges that tend to increase program participant and/or non-participant costs for electric utility service. These may include, but are not limited to: participant's installed system and ongoing costs, rebate and REC payments made by the utility to program participants, and increased utility system costs resulting from the intermittent and non-dispatchable nature of the solar generation resource (e.g., increased ancillary costs and power quality issues).

Costs and benefits will be examined from the perspective of both Public Service's program participant (e.g., Solar*Rewards participants) and non-participant customers.

Public Service will empanel a Technical Review Committee ("TRC") comprised of industry experts to review and provide input to the proposed study methodology, to periodically review the results of the study tasks, and to review and comment on a draft of the final report. The TRC will meet as necessary to review study results. Upon completion of the final study report, the results will be presented to the Colorado Public Utilities Commission.

**Scope - GEO**

The GEO anticipates that it will identify and contract with a third-party consultant to conduct its portion of the Study. The GEO also anticipates that it will vet its consultant's methodology and findings through a separate TRC which may or may not contain the same members as the TRC empanelled to review Public Service's portion of the Study; Public Service will be a member of the GEO's TRC.

**Study Tasks**

1. **Survey and summary of prior DSG studies (Public Service)**

The final study report will include a compilation of prior studies regarding distributed solar generation conducted on the Public Service system as well as studies on other utility systems in the United States with similar loads and generation resources along with a summary of the major findings of those studies.

2. **Characterize solar generation and determine correlation to load (Public Service)**

Several potential DSG benefits are directly impacted by the level of correlation between the solar generation profile and customer, distribution feeder, substation, and/or total system load. Previous studies of the costs and benefits of DSG employed typical, hourly solar generation and typical hourly customer load profiles in assessing this correlation. Typical solar generation profiles from a wide variety of geographic locations, PV module types, and array mounting configurations can be obtained from publicly-available models such as NREL's Solar Advisor Model ("SAM") program.[3] These models employ typical meteorological year ("TMY") data that is intended to capture the actual hourly variation in the solar resource that has occurred on daily, monthly, and annual time frames. Typical customer load profiles can be obtained from a utility's load research group; these load profiles are collected from historical load data for multiple customers across customer classes. Given the chronological differences between TMY solar

[3] https://www.nrel.gov/analysis/sam/

resource data and historical customer load data, potential mismatches between load and generation might occur that result in over or under estimation of costs and benefits. In addition to this potential mismatch, modeled hourly solar generation may not accurately capture real DSG system performance resulting from shading or other environmental factors (e.g., snow cover).

Since existing TMY data are averaged over an hourly basis, solar generation models utilizing these data do not capture any sub-hourly variations in photovoltaic generation. As a result of these shortcomings, to the greatest extent possible, the Company will leverage solar resource and solar generation data obtained from existing solar systems and available solar resource monitoring stations to estimate the total solar generation profile on individual distribution feeders at current and near-term solar penetration levels.

In addition to the use of TMY and typical load profile data, Public Service proposes to examine two other methodologies for characterizing the correlation between solar generation and load: 1) match historical customer and feeder load data with whatever time synchronized solar generation data for the Public Service system that can be acquired and, 2) capture actual distributed solar generation and customer load from a sample of current Public Service customers with installed solar generation.

Data Collection Tasks

- Summarize installed Solar*Rewards customers' system information (customer class, system size and type, mounting orientation, geographic location, feeder circuit) captured in the Solar*Rewards database and create equivalent, composite systems that can be modeled in SAM,
- Conduct a field survey of a sample of installed systems to estimate reliability of customer's system information captured in the Solar*Rewards database,
- Poll all existing Medium and Large Program Solar*Rewards customers to determine solar generation and meteorological data collection capabilities,
- Acquire all solar and meteorological data (as allowed under PUC rules) that can be acquired cost-effectively from Solar*Rewards customers,
- Acquire historical typical customer load data for the same time periods as the solar resource and solar generation data acquired.

3. **Calculate costs and benefits to the distribution system (Public Service)**

Potential costs and benefits to be examined

- Additional and/or avoided/deferred capital expenditures,
- Extension or reduction in equipment life,
- Increased or decreased O&M costs,
- Reduction in distribution losses,
- Decreased system stability during transient events,
- Power quality issues.

Tasks

- Compile list of installed distributed solar generation by feeder circuit,
- Compile historical hourly feeder loads on those circuits with the highest penetration levels of distributed solar,
- Compile historical hourly substation loads on those substations with the highest penetration levels of distributed solar,
- Review capital budgets to determine feeders likely in need of capital expenditures in the near term,
- Compare correlation of feeder specific solar generation profile to feeder and/or substation load profiles,
- Compare currently installed solar systems resulting from standard offer Small and Medium Solar*Rewards programs and Large Solar*Rewards programs and feeders likely in need of near-term capital expenditures,
- Determine marginal distribution loss factors correlated to solar generation profiles,
- Conduct power quality measurements on feeder systems with the highest level of PV penetration existing today.

4. **Calculate costs and benefits to the transmission system (Public Service)**

Potential costs and benefits to be examined

- Additional and/or avoided/deferred capital expenditures,
- Reduction in transmission losses,
- Decreased system stability during transient events.

Tasks

- Determine marginal transmission loss factors correlated to solar generation profiles,
- Determine customer class share of monthly bill related to transmission costs,
- Review of capital budgets to determine near-term transmission upgrade projects that could potentially be delayed or cancelled.

5. **Calculate costs and benefits to the generation portfolio (Public Service)**

Potential costs and benefits to be examined

- Avoided energy costs (i.e., fuel, variable O&M, and fuel hedging) as a function of PV mounting orientation, tracking, and geographic location grossed up for avoided T&D line losses,
- Avoided generation capacity costs (i.e., capital costs and fixed O&M) as a function of PV mounting orientation, tracking and geographic location grossed up for avoided T&D line losses,
- Avoided emissions costs ($CO_2$, $SO_x$, $NO_x$) as a function of PV mounting orientation, tracking and geographic location grossed up for avoided T&D line losses,
- Increased integration costs (e.g., fuel, variable O&M, emissions etc) resulting from inaccuracies in solar resource and solar generation forecasting, and from the intermittent and non-dispatchable nature of the resource.

Data Needed

- Avoided energy and emissions costs at current and near-term levels of DSG penetration,
- Marginal transmission and distribution losses correlated to solar generation profiles.

Tasks

- Reevaluate Public Service's solar generation ELCC study to investigate reliability contribution from typical residential or commercial net-metered PV systems (i.e., fixed systems mounted at orientations representative of current installations),

6. **Investigate Winning DSG Business Cases (GEO)**

- Compile a list of existing business models for DSG among U.S. Investor Owned Utilities including overall program size (MW goals), degree of utility ownership, cost recovery mechanisms, and implementation methods.
- Identify the advantages and disadvantages of each of the identified business models.
- Identify any regulatory or statutory barriers Public Service faces, if any, to the implementation of the different business models.
- Develop a projection of the estimated point of DSG grid parity in Public Service's service territory given a range of future photovoltaic cost and utility cost of service estimates.

**Timeline - PSCo**

| Date | Days | Task |
|---|---|---|
| 8/18/10 | | Comissioner Information Meeting to Review Proposed Study Scope |
| 9/1/10 | 14 | Completion of Study Scope |
| 9/8/10 | 7 | Presentation of Study Scope and Study Methodology to TRC |
| 9/22/10 | 14 | Completion of Final Study Methodology and Start of Study Tasks |
| 4/10/11 | 200 | Completion of Study Tasks |
| 4/24/11 | 14 | Presentation of Study Findings and Draft Report to TRC |
| 5/8/11 | 14 | Completion of Final Study and Presentation to TRC |
| 5/15/11 | 7 | Presentation of Final Study to Commission |

## Timeline – GEO

| Date | Days | Task |
|---|---|---|
| 8/18/10 | | Comissioner Information Meeting to Review Proposed Study Scope |
| 9/1/10 | 14 | Completion of Study Scope |
| 9/15/10 | 90 | Issue RFP and Select Vendor |
| Week of 11/1/10 | | Convene TRC |
| 1/1/11 - 4/1/11 | 90 | Completion of Study |
| 4/15/11 | 14 | Presentation of draft findings to TRC |
| 4/30/11 | 14 | Completion of Final Study and Presentation to TRC |
| 5/15/11 | 7 | Presentation of Final Study to Commision |