ORNL/TM-2015/638

The EPSA Project Finance Mapping Tool

Approved for public release.
Distribution is unlimited.

Stanton W. Hadley
Supriya Chinthavali

July 2016

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

ORNL/TM-2015/638

Electrical & Electronics Systems Research Division
Computational Sciences & Engineering Division

THE EPSA PROJECT FINANCE MAPPING TOOL

Stanton W. Hadley
Supriya Chinthavali

Date Published: July 2016

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6283
managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

CONTENTS

Page

LIST OF FIGURES

Figure **Page**

LIST OF TABLES

Table **Page**

LIST OF ACRONYMS

AEO	Annual Energy Outlook
AFUDC	Allowance for Funds Used During Construction
AMT	Alternative Minimum Tax
CF	Capacity Factor
CWIP	Construction Work in Progress
DOE	U.S. Department of Energy
DSIRE	Database of State Incentives for Renewables & Efficiency
DSR	Debt Service Reserves
EIA	Energy Information Administration
EIPC	Eastern Interconnection Planning Collaborative
EPSA	Office of Energy Policy and Systems Analysis
FERC	Federal Energy Regulatory Commission
IRS	U.S. Internal Revenue Service
ISO	Independent System Operator
ITC	Investment Tax Credit
LEP	Levelized Energy Price
LEPR	Levelized Energy Price + REC Price
MACRS	Modified Accelerated Cost Recovery System
MWh	megawatt per hour
NEMS	National Energy Modeling System
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
O&M	Operating and Maintenance
P&E	Plant and Equipment
PFMT	Project Finance Mapping Tool
PTC	Production Tax Credit
PV	Photovoltaic
REC	Renewable Energy Credit
ROD+E	Return on Debt and Equity
ROE	Return on Equity
RTO	Regional Transmission Operator
WACC	Weighted Average Cost of Capital
WC	Working Capital

ACKNOWLEDGMENTS

We would like to thank Malikarjun Shankar, Olefemi Omitaomu, Sreenivas Sukumar, and Linda Sylvester. Their guidance, suggestions, and support helped in defining the project and providing data for the work. We would especially like to thank the sponsors of this work, Eric Hsieh, Stephen Hendrickson, and Rebecca Dell of the DOE Office of Energy Policy and Systems Analysis. Their support, suggestions, and assistance have been invaluable to the development of this project.

OPERATIONS QUICKSTART

Below are initial steps to open and run the Excel and server version of the Project Finance Mapping Tool (PFMT). Additional details on operations including more complex activities are covered in Section 6.

To run the Excel version of PFMT for a single parameter:

1. Open the PFMT Excel workbook. The version described here Is PFMTV4d.xlsm (or ...xlsb)
2. Make changes to desired inputs (brown cells only) on the FINModule, TechnologyInputs, StateInputs, and/or Dashboard worksheets.
3. Go to the Dashboard and click on the Green button. The model will quickly (~5 seconds) calculate the new results for all states and update the map to show the results.
4. The cash flow chart will show the project's inflow and outflow for the state specified in cell B5. Type a new state (or select from the dropdown list) to see a different state.
5. The FINModule will give financial details for the state specified in Dashboard!B5.
6. The map's data presented can be changed in cell K5, followed by tapping the ReColor Map button.

To run the Excel version of PFMT for multiple values:

1. Open the PFMT Excel workbook.
2. Set the base input values desired in (brown cells only) on the FINModule, TechnologyInputs, StateInputs, and/or Dashboard worksheets.
3. On the MultiCase sheet select the variable to change, minimum value, maximum value, and number of cases in cells C3:C6.
4. Select the technologies to be graphed in cells A9:H9. If fewer than eight are desired, leave the remaining cells blank.
5. Click on the green button to run the cases for each of the technologies selected. This may take a while depending on the number of cases and technologies.
6. Select the state to be shown in the graphs in cell C12. If not all cases are showing or there is #N/A in the graphs' x-axes, then click on the pink button followed by the blue button.

There is further information on operating the Excel model in Sections 6.1 through 6.3.

To run the server version of Tableau:

1. Open a browser and select the web location http://infoviz.ornl.gov:8080/#/signin?redirect=%2Fprojects%2F4%2Fworkbooks
2. Sign in with the appropriate user name and password.

3. Open the workbook PFMT_PrecomputedDashboards.

4. Make changes to desired inputs in the left pane on the PPA Map Dashboard and Net Cash Flow Dashboard. The values available for selection are either listed in the radio buttons or in the dropdown lists for the different variables.

5. The visualizations should automatically update the map, and the cash flow chart will show the project's inflow and outflow for selected states on the map or the region filter.

Note 1: There are a number of different worksheets (dashboards, maps, input listings, plots, and linecharts). Key diagrams of interest are: PPA Map Dashboard, Net Cash Flow Dashboard, ITC-SA-D1, ITC-SA-D2, ITC-SA-D3, ITC-SA-D4, ITC-SA-D5, D6-ITCMaps, D7-PTCMaps, D8-TaxDepLifeMap,CurrentIncentives-D9,NoIncentives-D10.

Note 2: In the precomputed dashboards, the data were preset from an Excel set of scenarios. The user may select from the various parameters that were included in that set of Excel cases (for example, changes in tax credits or rates, technology, returns on equity, etc.) but not make other changes and associated calculations within the server version.

ABSTRACT

The Energy Policy and Systems Analysis Office of the U.S. Department of Energy has requested a tool to compare the impact of various Federal policies on the financial viability of generation resources across the country. Policy options could include production tax credits, investment tax credits, solar renewable energy credits, tax abatement, accelerated depreciation, tax-free loans, and others. The tool would model the finances of projects in all fifty states, and possibly other geographic units such as utility service territories and RTO/ISO territories. The tool would consider the facility's cost, financing, production, and revenues under different capital and market structures to determine levelized cost of energy, return on equity, and cost impacts on others (e.g., load-serving entities, society.) The tool would compare the cost and value of the facility to the local regional alternatives to determine how and where policy levers may provide sufficient incremental value to motivate investment. The results will be displayed through a purpose-built visualization that maps geographic variations and shows associated figures and tables.

1. INTRODUCTION

The Project Finance Mapping Tool (PFMT) has been requested from the U.S. Department of Energy's (DOE's) Office of Energy Policy and Systems Analysis (EPSA) to allow a user to quickly evaluate the financial impacts of select policy choices for new power projects in each of the fifty states. One key portion is the financial calculations that are conducted in an Excel workbook. Below is the description of the workbook and its operation.

The full model consists of technology and market input data, a financial module, case output storage, a visualization dashboard of key results, and scripts or macros for operation of multiple regions and scenarios. The initial model is written entirely in Microsoft Excel, but the final product uses the Tableau software either as a standalone application or in conjunction with Excel and possibly other software systems.

The model is based on an analysis done for the U.S. Congress as a requirement of the Energy Policy Act of 1992, *Report on the Study of Tax and Rate Treatment of Renewable Energy Projects* (Hadley, Hill, & Perlack, 1993). In it, the finances of a variety of renewable and non-renewable energy technologies were modeled to determine the impact of various accounting, tax, and rate policies on the relative costs of each. For the PFMT, the model was upgraded to include more recent practices and expanded to allow the rapid analysis of projects in multiple regions.

1.1 EXCEL AND TABLEAU VERSIONS

The PFMT comes in two versions. The first one developed is coded in Microsoft Excel. It provides a platform for rapid development and detailed analysis of the different calculations. The second is a combination of Tableau software and the R statistical package. It provides graphical results for ease of understanding but does not easily show the detailed calculations involved. The models are benchmarked to each other to insure duplicate results.

1.2 DATA INPUTS

Input data for the process cover a span of information regarding technologies, financial parameters, and state and federal tax policies. The sources for the data will vary and are listed for those that are readily available. Some inputs have been pre-calculated from recognized data sources; the calculations will be described in this report and either contained on separate sheets within the workbook or made available in separate workbooks.

Currently, the model conducts its calculations on a state-by-state basis. The input data for states include various tax and incentive policies, wholesale prices, and marginal mix of production. Renewable incentives are collected from the Database of State Incentives for Renewables & Efficiency (DSIRE). Inputs that are both technology- and state-specific, such as expected capacity factors or capital cost adjustments, are also captured.

Multiple types of technologies can be entered into the tool. The current set of ten technologies includes a mix of solar, wind, other renewables; natural gas; and nuclear. Base values for each technology cover cost and production characteristics such as capital cost, construction schedule, size, operating costs, fuel costs, efficiencies, and lifetime. Tax and policy factors such as tax credits and tax lives are also included.

Financial and policy inputs include such factors as interest rates, debt rates, desired return on equity, fixed price life, and sale/leaseback configuration. While base values for these are entered, these can be adjusted to better understand their impact (as can all input values.) Further information on inputs are provided in Sections 3 and 4.

1.3 FINANCIAL CALCULATIONS

The finance calculations are largely based on the idea of an independent project structure. A fixed price (with possible escalation factors) is typically calculated such that the resulting lifetime return on equity equals the input desired level. Alternatively, a combined debt plus equity return can be set to represent the capital requirements of the project. Furthermore, a fixed price can be set to see the resulting financial impacts. The equity portion of investment can split between a lessor and lessee to represent a sale and leaseback of the plant at the beginning of operations.

Debt calculations have been simplified to assume that at the start of operation the ratio of debt to total assets equals an input value. Debt is then repaid in equal portions over the life of the debt, consequently lowering the ratio of debt to assets. Besides plant and equipment assets, reserve accounts are established for working capital and debt service. Taxes are calculated using accelerated depreciation schedules, with the differential accrued as deferred taxes. Financial statements for the project (income statement, balance sheet, sources and uses of funds) are calculated on an annual basis within the model.

Revenue can include energy sales and renewable energy credits. Operating costs include fixed and variable portions, and these portions can be split between labor and materials (though currently set at 50% each).

Cash flows are calculated on an annual basis for the project and its customers, debt holders, equity holders, labor and other supplies (including construction), and state and federal government, as shown in Figure 1. Included in the project assets are the undepreciated plant and equipment plus the reserve accounts for debt and operating costs. As the plant is built, funds come in from the debt and equity holders and are used to purchase the labor and material, as well as to build up the capital accounts. Once the plant starts operating, revenue comes from sales and any tax credits, and funds go out for purchases, tax payments, debt retirement, interest on debt, and dividends. Capital accounts will also change as the debt and operating cost levels change.

Asset value will rise during construction and then slowly decline over the life of the plant, ending at zero. If the cash flow components in and out of the project are plotted over time, the sources in and out balance out each year (Figure 2). Total assets peak in 2018 at $633 million and decline to zero by 2049. If the perspective of the equity holder is taken, then cash flow appears as in Figure 3; costs are negative during construction but profits are returned through dividends. This cash flow is what is used for determining the return on equity (rate of return that makes the net present value equal aero.) Alternatively, the cash flow for debt + equity (the two investor classes) is combined and used to determine the combined return.

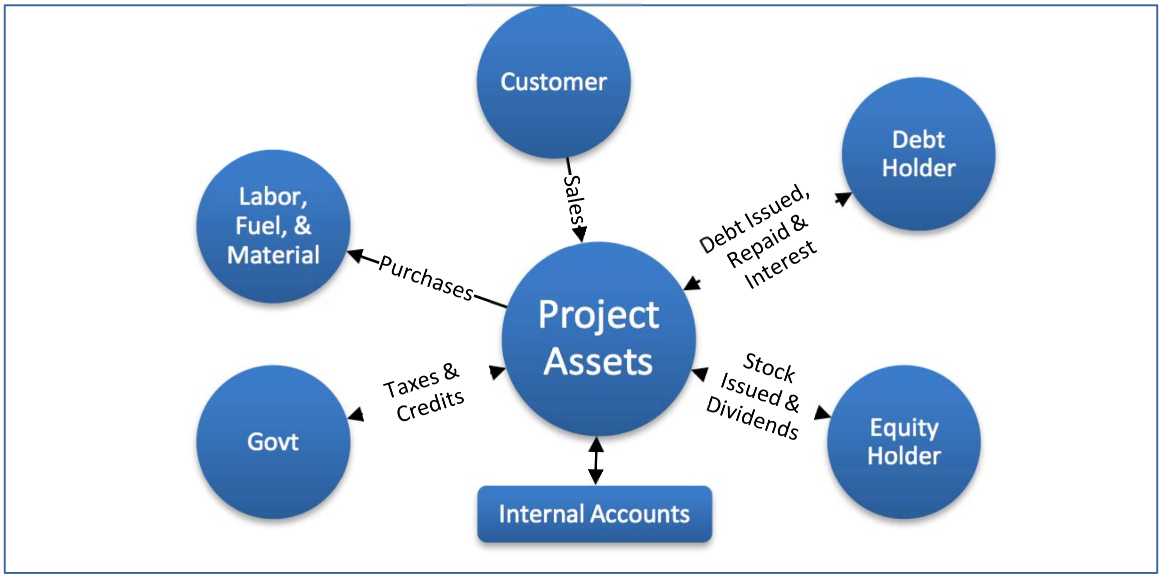


Figure 1. Cash flow process for Project Finance.

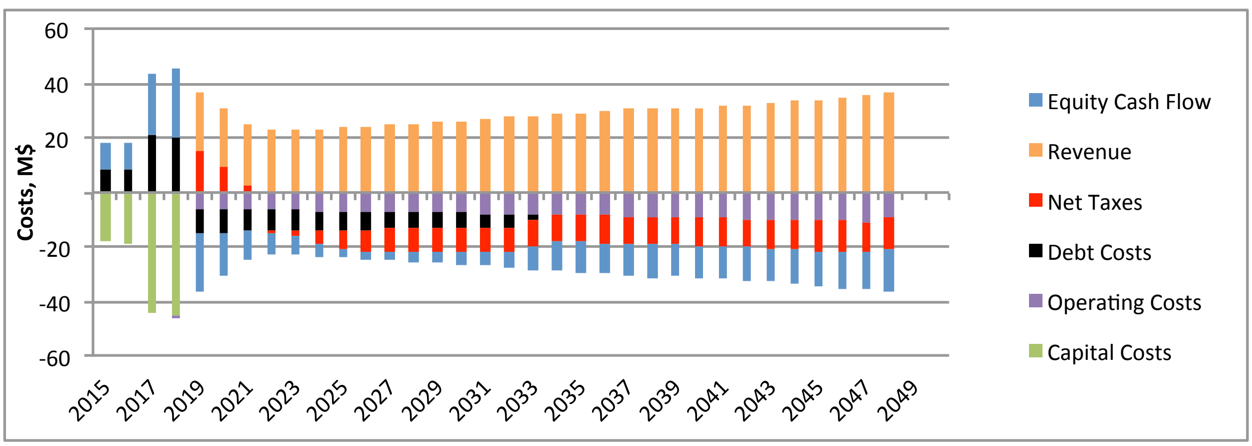


Figure 2. Project annual cash flow for Geothermal in Idaho.

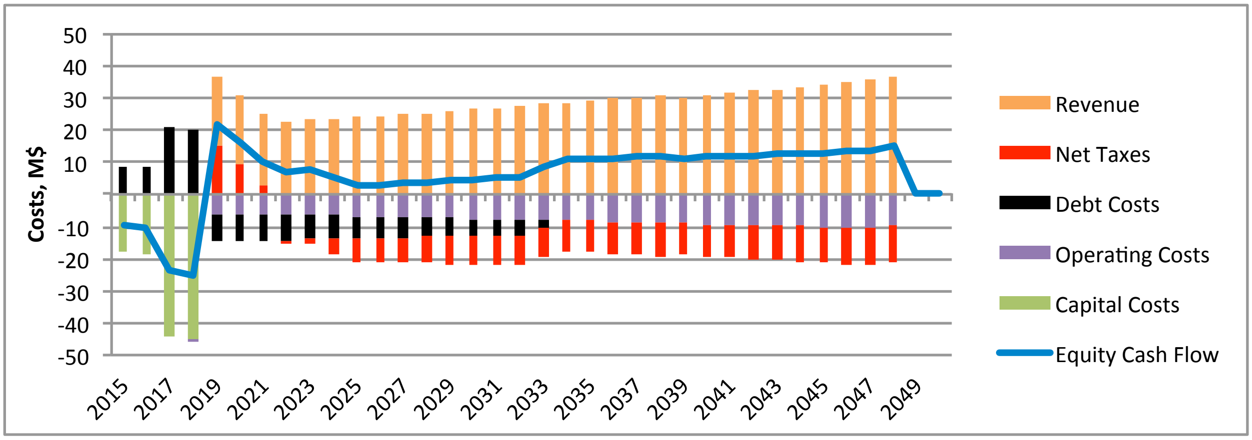


Figure 3. Equity annual cash flow for Geothermal in Idaho.

1.4 OPERATION

1.4.1 Excel Operation

The tool is contained within a single workbook with several sheets that contain the main results, calculations, various inputs, stored outputs, and data files for Tableau. On the main results sheet, called the Dashboard, some of the key variables for consideration, titles, descriptions, and flags for other inputs are included to identify the inputs to be used for the calculations. It also includes key output data and a chart for a specific region/case. A map presents color-coded results for all fifty states and a plot of the calculated price versus the state's input wholesale price. The map can show different results and even the difference between the current and any stored case.

On the left side of the Dashboard sheet are several macros that are used to run the tool. Essentially, the model internally calculates only for a single region and at a set price. The macros adjust the input price using an Excel goal-seek function so that the desired return on equity or return on debt + equity are achieved. The macros are split between running for just the one region (following any changes to inputs desired) and running the calculations for all states, storing the main results of each for the maps and charts. There are also two macro buttons for storing and loading cases.

1.4.2 Tableau Operation

Tableau operates in two ways: as standalone desktop software and as a server solution using a browser to connect with the end user. Because of the detailed calculations required, the tool also requires the operation of the R database software in server mode. Currently, the Tableau Connect server software can connect to the R server, but it has latency issues passing information between them and difficulties with multiple calls to R, so the desktop model is the most suitable for advanced interactive analysis. The server method works well for pre-computed scenarios that can be kept entirely within the Tableau software and that do not need R-server calculations.

2. FINMODULE CALCULATIONS

2.1 OVERALL STRUCTURE

In Excel, the financial calculations largely flow down through the FINModule worksheet. All inputs used in the calculation are included at the top followed by sections calculating Revenue, Operating Costs, Assets, Debt, Taxes, Sale/Leaseback, and financial statements. At the bottom of the sheet, the inputs and key results for multiple regions are gathered for copying to the Storage worksheet. These areas are each described in sections below.

2.2 INPUTS

At the top of the FINModule worksheet are the input data used for the calculations. Those that are brown are entered on this sheet. Those in purple are from the Technology Inputs worksheet. Those in teal are from the State Inputs worksheet. Those in yellow are from the dashboard. These are explained in more detail in the subsequent chapters.

Also shown in **yellow** is the "Levelized Energy Price ($/MWh)" (LEP) in initial year $. It represents the price for electricity in the initial year that escalates over the life of the fixed price period based on inflation and the price escalation factor. The value can vary for each state depending on the objective function selected for establishing prices, as described in Section 6.1. During normal viewing, it retrieves the price from the last time all fifty states were calculated to achieve the objective. However, on the Dashboard the user can select a price or have the model calculate a price either to meet the desired return on equity (ROE) or return on debt + equity (ROD+E). These calculate the energy price so that the net present value of total equity net cash flow equals $0 when discounted at the input "Desired Return on Equity," or debt + equity net cash flow equals $0 using the "Desired Return on Debt + Equity" on the Dashboard. Below the LEP is shown the Levelized Energy Price plus Renewable Energy Credit (REC) price (LEPR) that represents the full price the project receives for its production. (The model does not include any revenue for capacity nor ancillary services.)

The inputs on the FINModule sheet are shown in Table 1 and are largely financial and policy variables.

Table 1. Financial Inputs on FINModule

Variable	Representative Value		Variable	Representative Value
Fed. Income Tax Rate	35%		Debt Ratio	50%
AMT/Carry Flag	No		Debt Max Life	15
AMT Depreciation Life	20		Interest Rate	6%
General inflation rate	2.0%		Debt Serv Resrve (%year)	50%
Price Escal rate*	0.0%		Work Cap % of O&M	12.5%
Constr Escal rate*	0.0%		Sale/LeaseBack	No
O&M Escal rate*	0.0%		Rent Coverage Ratio	1.1x
Fuel Escal rate*	0.0%		Fixed Price Life	20
			REC Price Flag	National
			Natl REC Price, $/MWh	0
			Carbon Cost, $/T CO2	0

* Escalation Rates are +/- general inflation

The federal income tax rate is the rate applied to net income before federal taxes (but after state taxes). It applies accelerated depreciation in the calculation of expenses, as explained in Section 2.7.1. The

AMT/Carry Flag tells the model whether to apply an alternative minimum tax, carry forward early tax losses to later years to only offset taxable gains, or both. These are explained in Sections 2.7.4 and 2.7.5.

The General inflation rate applies to every future year as a base escalation factor to all costs and prices. In addition, various categories of costs and prices can be further escalated or de-escalated based on the four parameters below the general rate. For example, if general inflation is set at 2%, entering a −2% as the price escalation rate will offset this so that the energy price and REC price will not increase over time. System prices (used for years past the fixed price life) will also escalate at the general inflation plus price escalation rate. Any CO_2 cost will be added to the system price based on the state's marginal carbon intensity calculated in StateInputs.

There are four debt-related inputs. The debt ratio sets the fraction of debt to total assets at the beginning of operation. The maximum life is period over which the debt is repaid. The interest rate is what is paid on debt. And the debt service reserve is the fraction of next year's debt costs (interest plus debt repayment) that must be set aside as an asset account. These are explained in more detail in Section 2.6. The working capital percent is similar in that it is the fraction of next year's fuel and operating and maintenance (O&M) expenses that must be carried as an asset and is described in Section 2.5.

The Sale/Leaseback flag tells the model whether to do additional calculations to represent the developer selling the project to a third party at the start of operations and then lease the plant back. The rent coverage ratio is the inverse of the fraction of rent paid to the net operating income each year. More information is in Section 2.9.

The Fixed Price Life is the length of time that the project uses the input or calculated price to determine revenue from energy sales. Following that period, the project is assumed to sell power at the system average price. The project will continue to sell renewable energy credits throughout its lifespan. The REC Price flag tells the model whether to use the state-level REC prices as defined on the StateInputs sheet or whether to use the National REC Price listed in this input table. If they are set to National and $0/MWh, then no RECs are sold by the project.

Lastly, a carbon cost is defined. Currently, this price is applied immediately to any carbon emissions by the project and increases at the rate of inflation plus any price escalation. This price is also added to the system costs using the marginal carbon intensity for the state.

The initial year is also set on this sheet. The model assumes that all cost and price inputs are put in that year's dollar value.

2.3 REVENUE CALCULATION

Production is calculated by checking if the plant is operating, and if so:

$$Production = Capacity * 8760\ \mathrm{hr/yr} * Capacity\_Factor \quad \text{Eq. 1}$$

Energy price ($/MWh) is the escalated fixed price incorporating both inflation and escalation rates. Setting the price escalation to negative of the inflation gives a constant price over time.

$$Energy\ Price = Price_{year-1} * (1 + inflation + price\ escalation) \quad \text{Eq. 2}$$

Energy Sales Revenue (K$) is the Production times the price divided by 1000 to put it in thousands of dollars (K$).

$$Energy\ Sales\ Revenue = Production * Power\ Price/1000 \qquad \text{Eq. 3}$$

Similarly, RECs are calculated using the input REC price for a state, inflated and multiplied by the production.

Total revenue is the sum of the energy sales and REC sales. The tool currently does not include a capacity price in its revenue calculations. Regional system capacity prices are only available for certain regions of the country and have varied greatly between years. Availability of capacity-related revenue depends on a number of extraneous factors including the plant's availability to provide capacity on demand and multi-market pricing strategies of the owner.

2.4 OPERATING COST CALCULATION

Fuel costs in escalated $/MWh is calculated by conversion from fuel price to $/mmBTU and efficiency (in the input section) and escalating by inflation and any fuel escalation rate. This is multiplied by the production to get costs in thousand $ (K$).

$$Fuel\ Price_{Yearone} = Fuel\ price\left(\frac{\$}{mmBTU}\right) * \frac{3.412mmbtu}{MWh}/efficiency \qquad \text{Eq. 4}$$

$$Fuel\ Price\ = \ Fuel\ Price_{year-1} * (1 + inflation + fuel\ escalation) \qquad \text{Eq. 5}$$

$$Fuel\ Cost_{year} = Fuel\ price_{year} * Production\ _{year}/1000 \qquad \text{Eq. 6}$$

Operating costs are input and allowed to have separate escalation rates for labor and materials. These costs are also input as both fixed ($/kW) and variable ($/MWh) in the inputs. Each cost factor is escalated and multiplied by production or capacity. Then they are summed to get the total O&M cost. It is assumed that state labor and material taxes are imbedded in the O&M cost input value. These are removed from the O&M costs by dividing by (1+tax rate); the taxes are added later to the total state taxes by multiplying the amount by the tax rate.

$$O\&M\ Var.\ Price_{Yearone} = O\&M\ Variable\ Cost\left(\frac{\$}{MWh}\right) * \left[\frac{\%Labor}{1 + LaborTax} + \frac{\%Material}{(1 + MaterialTax)}\right] \qquad \text{Eq. 7}$$

$$O\&M\ Fixed\ Price_{Yearone} = O\&M\ Fixed\ Cost\left(\frac{\$}{kW}\right) * \left[\frac{\%Labor}{1 + LaborTax} + \frac{\%Material}{1 + MaterialTax}\right] \qquad \text{Eq. 8}$$

$$O\&M\ Var.Price\ = \ O\&M\ Var.Price_{year-1} * (1 + inflation + O\&M\ escalation) \qquad \text{Eq. 9}$$

$$O\&M\ Fixed\ Price = \ O\&M\ Fixed\ Price_{year-1} * (1 + inflation + O\&M\ escalation) \qquad \text{Eq. 10}$$

$$O\&M\ Cost_{year} = \left(O\&M\ Var.price_{year} * \frac{Production_{\ year}}{1000}\right) + \left(O\&M\ Fixed\ Price_{year} * \frac{Production_{\ year}}{CapacityFactor * 8760}\right) \quad \text{Eq. 11}$$

In Eq. 11 the fixed price is multiplied by production divided by the capacity factor and number of hours in the year so that it is only charged in the years the plant is operating.

2.5 ASSET CALCULATION

Assets for the project are those items of worth and can be physical assets or financial accounts. The PFMT summarizes these into five categories although more detailed financial models will have more categories.

$$Assets = CWIP + Net\ P\&E + WC + AFUDC + DSR \quad \text{Eq. 12}$$

where:

CWIP = Construction Work in Progress
Net P&E = Net Plant and Equipment
WC = Working Capital
AFUDC = Allowance for Funds Used During Construction
DSR = Debt Service Reserves

CWIP and P&E accounts contain the physical cost for project assets. These are calculated by summing the capital cost of the project during construction (properly escalating for inflation and other factors). To build up to these values, the annual capital outlays must be determined. The total capital cost in first year dollars is found by adjusting the average cost from the technology inputs worksheet (based on the technology selected) times the state cost factor for that technology (from the state inputs worksheet.)

$$Capital\ Cost\left(\frac{Yearone\$}{kW}\right) = Input\ capital\ cost * (1 + State\ factor) \quad \text{Eq. 13}$$

The technology inputs include the years it takes to build the plant and a spending proportion per year up to the start of the plant. (This model assumes that production starts on January 1 of first year of production.) The input spending proportions total to 100%, but these are all in first year $. With inflation, the fractions in later years will increase based on the construction cost escalation plus general inflation. Their sum likely will not equal 100%.

$$Capital\ (\%Yearone\$)_{year} = Capital\%_{year} * (1 + inflation + construction\ escalation)^{year-yearone} \quad \text{Eq. 14}$$

Annual capital outlays are then the combination of capital cost per kW, capacity, and spending stream.

$$Capital\ outlay_{year} = Capital\ Cost\left(\frac{\$}{kW}\right) * Capital\ (\%Yearone\$)_{year} * \text{Capacity (MW)} \quad \text{Eq. 15}$$

During construction, annual costs are placed into the CWIP account. Upon startup, they are transferred to the Gross Plant & Equipment account. This account presents the total amount spent on plant and equipment. Depreciation then reduces the gross P&E to create the Net P&E. Book depreciation is defined as a straight-line depreciation over the life of the project with no residual value, so the annual depreciation is the Gross P&E divided by the book life of the plant. Net Plant & Equipment is the amount after depreciation is subtracted, and it represents the actual asset value at any point in time.

$$Gross\ P\&E = \sum_{1}^{Start\ of\ Operation} Capital\ outlay_{year} \quad \text{Eq. 16}$$

$$Book\ Depreciation_{year} = Gross\ P\&E/Life \quad \text{Eq. 17}$$

$$Cumulative\ Depreciation_{year} = Cumulative\ Depreciation_{year-1} + Book\ Depreciation_{year} \quad \text{Eq. 18}$$

$$Net\ P\&E_{year} = Gross\ P\&E_{year} - Cumulative\ Depreciation_{year} \quad \text{Eq. 19}$$

The developer may need to borrow funds during construction (as described in the next section). The interest payments during the construction are not expensed but rather accumulated and capitalized in the asset account Allowance for Funds Used During Construction (AFUDC). These costs are included in the asset value that receives the Investment Tax Credit. The accumulated costs are depreciated over the book life of the P&E for both normal and taxable net income; accelerated depreciation for taxes does not apply.

In the years during construction, the change in AFUDC is simply the interest charges in that year, where interest is charged for a full year on the debt at the beginning of the year. After operation starts, no more debt is issued. (An earlier version included a half year of interest on new debt, but this added extra complications on several calculations and distortions on net present valuing.)

$$Interest_{year} = i * Debt_{year-1} \quad \text{Eq. 20}$$

where:

i = Interest Rate
$Debt_{year-1}$ = Debt level at end of previous year

So before operation,

$$AFUDC_{year} = AFUDC_{year-1} + Interest_{year} \quad \text{Eq. 21}$$

After operation begins until debt is repaid,

$$AFUDC_{year} = AFUDC_{year-1} - \frac{Gross\ AFUDC}{Debt\ life} \quad \text{Eq. 22}$$

Working capital is an asset that is the amount of funds needed on hand at the end of the year to pay for an input fraction of the next year's operating costs (fuel plus O&M). The current example uses 45 days or 12.5%, though this can be varied by the end user.

$$Working\ Capital_{year} = Working\ Capital\% * (Fuel\ Cost + O\&M\ Cost)_{year+1} \quad \text{Eq. 23}$$

Change in working capital is simply the difference in working capital between the current and previous year and requires an infusion of cash flow to pay for any increase. In the year before operation, the bulk of these funds are collected. Smaller amounts are then collected each year as escalation drives up the operating costs. In the last year of operation, the asset value reduces to zero and the funds are used to pay a portion of the current year's operating costs.

The Debt Service Reserve (DSR) is the asset that represents the amount of funds needed to be kept in reserve to pay a fraction of the next year's interest charge and principal repayment. The current example uses 50% to represent six months in reserve, but this is modifiable in the inputs.

$$DSR_{year} = Debt\ Service\ Reserve\% * (Interest + Debt\ Retired)_{year+1} \quad \text{Eq. 24}$$

Change in the reserve is simply the difference in the Debt Service Reserve between the current and previous year. In the year before operation, the largest amount of these funds is collected. During the life of the debt, the asset required is reduced (with lower interest payments) and the asset value declines. In the last year of the debt life, the remaining funds are used to pay a portion of the remaining debt and interest, and the asset value reduces to zero.

2.6 DEBT CALCULATION

Debt represents borrowed funds by the equity holder to help pay for the construction of the project. There could be several ways to calculate the amount of debt that can be issued. A simple method is to base it on an input fraction of total assets. For large firms with multiple projects, this fraction can be relatively constant, but with an individual project that has debt payments and lives shorter than the life of the facility, the ratio will vary over time. To simplify, the tool applies the input ratio to the asset value at the beginning of operation. As debt is paid off, this ratio will drop, going to zero once the debt is paid off.

As described above, assets consist of five categories: CWIP, Net P&E, working capital, AFUDC, and debt service reserves. Although the first three categories are calculated strictly from the construction and operating costs and the AFUDC is based only on the debt level at the beginning of the year, the DSR is a function of the debt amount itself. This requires a more complex equation to determine the debt level at the end of each year.

$$Debt_{year} = DR * Assets = DR * (P\&E_{year} + WC_{year} + AFUDC_{year} + DSR_{year}) \quad \text{Eq. 25}$$

where:

$Debt_{year}$ = Debt level at End of Year

AFUDC is the collection of interest charges during construction (for later depreciation during operation) and is described in Section 2.5 above. Debt Service Reserves are also defined above. For calculating debt amounts during construction, the Debt Retired factor will only apply in the year before operation begins. Both factors include the debt amount, so they must be factored.

$$Interest_{year+1} = i * Debt_{EOY} \quad \text{Eq. 26}$$

The capital outlays for the next year are readily available. The change in working capital is also pre-defined. In the last year of construction, the project will build up its WC based on the operating costs, and in the first year of operation the amount will increase to reflect the escalation of operating costs. These equations can all be combined to form the equation for the final construction year as:

$$Debt_{year} = DR * (CWIP_{year} + P\&E_{year} + WC_{year} + AFUDC_{year} + DSRR * \left(Debt_{year} * i + \frac{Debt_{year}}{life}\right) \quad \text{Eq. 27}$$

where:

DSRR = Debt Service Reserve Required (%)

This can be reconfigured so that in the last year of construction the debt level is defined as:

$$Debt_{year} = DR * (CWIP_{year} + P\&E_{year} + WC_{year} + AFUDC_{year})/(1 - DR * DSRR * \left(i + \frac{1}{life}\right) \quad \text{Eq. 28}$$

For the years prior to the final construction year, the factor 1/life does not apply, so it can be dropped from the equation. With the debt level determined, the debt issued each year can be calculated based on the difference between years. Once the project begins operating, the debt is retired in equal portions over the life of the debt. Depending on the revenue, operating costs, taxes, and other factors, there may be years during operation when additional capital is needed to pay all cash outflows, but this is assumed to come from new equity rather than new debt.

2.7 TAX CALCULATION

2.7.1 Tax Depreciation

The developer/operator may take advantage of U.S. Internal Revenue Service (IRS) rules in Publication 946 (IRS 2015) that allow for a more rapid depreciation than what is used in the regular financial books when calculating taxes, both in terms of the length of time to fully depreciate and the schedule of depreciation amounts. This is referred to as the Modified Accelerated Cost Recovery System (MACRS). Under MACRS, depreciable property has a tax depreciation life over which its cost is recovered of 3, 5, 7, 10, 15, 20, 27.5, or 31.5 years, depending on the type of property, and through use of statutory recovery methods. The property's class life or book depreciation life represents the length of its life for its general books (using normalized, straight line depreciation) while its MACRS life uses a declining balance method, either a double-declining balance method if the tax life is less than 15 years and a one-and-a-half declining balance for tax lives of 15 years or greater. The equation is:

$$Depreciation_{Double} = [Gross\ P\&E - Cum.Tax\ Depreciation] x\ 2 / Tax\ Depreciation\ Life \quad \text{Eq. 29}$$

Note: One-and-a-half declining balance would use 1.5 instead of 2 in the equation.

The tax code requires that the calculation assume that the plant starts in the middle of the first year of operation for tax depreciation. For example, a plant with a 5-year tax life would have depreciation of 20%

of its value in the first year. In the second year, the amount would be 32% (40% of the remaining 80%.) The third year would be 19.2% (40% of the remaining 48%.)

The double-declining balance equation depreciates an asset as a function of the undepreciated balance, so it never fully depreciates an asset. To compensate, the amount of depreciation using straight-line depreciation is also calculated. This straight-line calculation, however, only uses the net value of the plant and the years remaining in the tax life of the plant. Toward the end of the tax life, the straight-line value is higher than the double declining balance value. Once it becomes higher, this straight-line depreciation is used instead.

$$Tax\ Depreciation = Max\ [Depreciation_{\ Double}, (Gross\ P\&E - Cum.Tax\ Depreciation) / Years\ Remaining\ in\ Tax\ Life] \quad \text{Eq. 30}$$

To continue the example, in the fourth year the double-declining balance method sets the depreciation at 11.52%. The straight-line depreciation of the remaining 28.8% of the asset over two and a half years is also 11.52%. In the fifth year, the double-declining balance equation gives only 6.9%; the straight-line value of 11.52% is used again. In year 6, the final 5.76% is depreciated.

2.7.2 Tax Credit Calculations

There are two main types of tax credits available in the model: investment tax credits and production tax credits. These are available at both the state and federal level. The production tax credit (PTC) is a credit applied on the basis of the production of the project. Current federal rules allow it for the first ten years of operation, and it escalates at the inflation rate over this period. Currently, wind projects are the main beneficiary of these credits; geothermal and closed-loop biomass have also been eligible, but future projects are less likely to be so. Biomass only qualified for half of the PTC that others did. The values for any technology can be changed by the user to understand their impact.

The Investment Tax Credit (ITC) applies only to solar and geothermal, with solar plants at 30% and geothermal at 10%. Wind plants can take the ITC instead of the PTC, but it is up to the user to pick one to use. This amount is scheduled to drop to 10% for solar projects constructed post-2016, but the tool currently has a value of 30% for their reference. The values for any technology can be changed by the user to understand their impact.

The ITC is only applicable to specialized components of the project and not to such things as land, substations, liens. To account for this, an input variable call “ITC Applicable Capital” is allowed, currently set at 90% as a rough approximation. Another factor of consideration is that with the provision of the ITC, there is less capital to be depreciated for tax purposes. Currently, the model reduces the taxable asset by half of the ITC amount. This lowers the amount of MACRS depreciation and so lessens the impact of the ITC on the tax bill.

2.7.3 Income Tax Calculation

An income statement for tax purposes is created to determine the taxes payable. The net income before income taxes is the revenue minus expenses (fuel, O&M, interest, depreciation). Rather than straight-line book depreciation, the depreciation is based on using the accelerated depreciation of the project. This means that plants with high depreciation due to accelerated depreciation may show a profit on the regular income statement, but they will have large losses on the tax income statement. These losses are what are carried forward in the tax calculation.

In addition, state taxes (such as state-related non-income taxes) are removed. The model assumes that prices include collection of these taxes, but these are not taxable income since they must be paid to the state. The model then calculates the resulting state income taxes from the equation:

$$\begin{aligned}&Current\ State\ income\ taxes\\&\quad= (Revenues - operating\ expense - interest - tax\ depreciation\\&\quad- other\ state\ taxes) *\ state\ income\ tax\ rate\end{aligned} \quad \text{Eq. 31}$$

$$\begin{aligned}&Current\ federal\ income\ taxes\\&\quad= (Revenues - operating\ expense - interest - tax\ depreciation\\&\quad- other\ state\ taxes - current\ state\ income\ taxes)\\&\quad*\ federal\ income\ tax\ rate\end{aligned} \quad \text{Eq. 32}$$

Deferred taxes represent those taxes that would have been paid if the book depreciation was used for tax calculation instead of the MACRS depreciation.

$$\begin{aligned}&Deferred\ income\ taxes\\&\quad= (tax\ depreciation - book\ depreciation)\\&\quad*(federal\ income\ tax\ rate + state\ income\ tax\ rate)\end{aligned} \quad \text{Eq. 33}$$

This accumulates in the early years when tax depreciation is higher than book depreciation, and then decreases to zero once the tax life of the asset has been passed so that tax deprecation equals zero. The accumulated deferred taxes appear on the balance sheet as a liability since it must eventually be paid like any other debt. However, this liability has no interest charge associated with it, so it represents how accelerated depreciation is a type of no-interest loan.

2.7.4 Alternative Minimum tax

The tool has the option to apply an Alternative Minimum Tax (AMT) on the profits of the project. It can be important if a corporation relies too much on tax benefits such as accelerated depreciation to lower its tax bill. The AMT reduces those tax advantages but uses a lower tax rate in calculating the alternative tax. The model calculates tax depreciation using the longer depreciation life specified in the tax code. It then determines an AMT Income based on normal revenues, expenses, and this new depreciation amount. It multiplies the AMT Income by 20% to find the AMT. If this amount is higher than the regular tax that would have been paid (or a smaller tax credit for operating losses), the AMT is used instead of the regular tax.

$$\begin{aligned}&Alternative\ Minimum\ Tax\\&\quad= \ (Revenues\ -\ Alternative\ Depreciation\\&\quad- Other\ Expenses)\ x\ 20\%\end{aligned} \quad \text{Eq. 34}$$

$$\begin{aligned}&Current\ Taxes\ Payable\\&= \ Maximum\ (Regular\ Current\ Taxes, Alternative\ Minimum\ Tax)\end{aligned} \quad \text{Eq. 35}$$

2.7.5 Carry Forward Calculation

Carryforward of operating losses is required if the equity holder does not have sufficient offsetting positive taxes elsewhere in its operations to use these operating losses. In this case, it must carry the losses forward until they can be used to offset positive taxes. Although tax law allows a carryback and carryforward of losses, with carryback preferred, the model uses only carryforward of losses. This is because losses generally occur at startup before there are positive taxes to offset the losses. The credits are not carried on the balance sheet as receivables but only taken as extraordinary gains if used.

For example, in year *t*, suppose net income before income taxes: is –$l00K, with state and federal income taxes of –$6K and –$33K, respectively. Because taxes could not be negative, the –$39K would be carried forward to apply against any positive taxes in the next year. In year *t* + 1, net income before income taxes is again –$l00K.The resultant –$39K in taxes would also be carried forward. In year *t* + 2, net income is +$60K. Taxes would be $23K. The model would use the carryforward from year *t* to offset these positive taxes first. This would leave year *t* carryforward at –$16K and year *t* + 1 at –$39K. At the end of year *t* + 15, any part of the remaining –$16K that had not been used to offset taxes would be lost to the corporation.

2.8 COMBINED EQUITY CASHFLOW

The combined equity cash flow section brings together the different cash revenues and expenses to determine the net revenue that equity holders would see. The “combined” includes both the lessor and lessee as a single entity if the sale/leaseback option is chosen. The worksheet breaks the calculation into two parts, the cash outflows and cash inflows (Table 2).

Table 2. Cash Outflows and Inflows for Project Cash Flow

Cash Outflows	Cash Inflows
Capital Outlays (Capital costs)	Energy Sales (Revenue)
Fuel Costs (Operating Costs)	Renewable Energy Credit Sales (Revenue)
O&M Costs (Operating Costs)	State Tax Credits (Net Taxes)
Change in Working Capital (Operating Costs)	Federal Tax Credits (Net Taxes)
Change in Debt Service Acct (Debt Costs)	Debt Issued (Debt Costs)
Interest (Debt Costs)	Stock Issued (Equity Cash Flow)
Debt Retired (Debt Costs)	
Federal Taxes (Net Taxes)	
State/Local Taxes (Net Taxes)	
Property Tax (Net Taxes)	
Dividends Paid (Equity Cash Flow)	

All of these costs are placed into the six main categories shown in Figure 1 on page 3 as indicated in the parentheses in Table 2. The sum of all cash outflows will equal the cash inflows in every year. Rearranging this to get the perspective of the equity shareholder, dividends paid minus stock issued will equal the remaining cash inflows minus cash outflows.

2.9 SALE/LEASE CALCULATION

With a sale/leaseback, the idea is that the project operator builds the plant, borrowing funds as needed. Upon completion, he or she sells the plant to a third party, along with the debt associated with it, and then leases the plant back from the new owner.

The total cash flow of the two parties is the same as the equity cash flow above. An additional transaction of rent is made between the two to balance the costs. The amount of rent is based on an input Rent Coverage Ratio that represents the amount of net operating income the lessee must have above the rent amount. The equation for the rent calculation is:

$$Rent = \frac{Revenue - fuel\ cost - O\&M\ cost}{Rent\ Coverage\ Ratio} \qquad \text{Eq. 36}$$

The lessor purchases the plant (along with the AFUDC and debt service reserve account) and takes over the debt from the lessee in the final year of construction. Rent is charged annually based on the net operating income (revenue – fuel – operating costs) times an input rent coverage ratio, typically a factor around 1.1. A macro button is included at the top of FINModule to calculate a coverage ratio that gives the lessee the desired ROE. If the consolidated equity is also receiving that return, then the lessor will also. There is a 10% rent prepayment equal to 10% of the tax depreciation in the last year of construction as well. The lessor is then responsible for paying all debt costs but receives the tax credit and accelerated depreciation benefits. Taxes paid are based on revenue from rent less depreciation, interest, and property taxes.

The lessee must pay for the capital construction plus costs during construction, but is reimbursed by the lessor when the plant assets and debts are sold prior to operations. The lessee then sells the power and RECs, and pays the operating costs, rent, other state-related taxes except property taxes, emissions taxes, and income taxes based on these revenues and costs. The lessee receives the revenue from any production tax credit. The primary asset of the lessee is just the working assets account since other assets have been transferred to the lessor.

2.10 FINANCIAL STATEMENTS

The financial statements for the consolidated owner of the project (the combination of the lessor and lessee) are calculated for each year, consisting of an income statement, balance sheet, and sources and uses of funds statement.

2.10.1 Income Statement

The income statement tracks the revenues and costs that are to be expensed each year. Table 3 shows a representative statement for the construction and first three years of a project. Capitalized costs, such as construction and interest during construction, are expensed through depreciation over the life of the project. Both taxes that are payable and taxes deferred are shown, although only the first category involves physical cash flow. At the bottom of the income statement, the dividend payout is subtracted to show the amount that is added to or subtracted from the retained earnings in the balance sheet. During construction, all costs are capitalized and no revenues are received, so no taxes or net income.

2.10.2 Balance Sheet

The balance sheet presents the assets, liabilities, and equity in the project for each year. Table 4 shows a representative statement for the construction and first three years of a project. As evidenced by the name, assets should balance against the liabilities and equity. Assets include CWIP (which ae transferred to the Gross P&E at the start of operation), the Gross P&E less the accumulated depreciation, the AFUDC, and the two capital accounts, working capital (to cover a portion of next year's operating costs) and Debt Service Account (that covers a portion of the next year's interest on debt and debt repayment).

Liabilities represent those external claims on the assets of the project, in this case the outstanding debt and the accumulated taxes that have been deferred. The tax deferrals are due to the accelerated depreciation allowed in the tax code. When calculating the taxes payable in a given year, the accelerated depreciation means that there are higher expenses and so less net income in the early years, with a consequent lower tax bill. However, the income statement for financial calculations use the regular, straight-line depreciation so taxes would have been higher. The difference between what was paid and what would have been paid with straight-line depreciation represents the deferred taxes.

Table 3. Example Income Statement for Large PV project (K$)

	2015	2016	2017	2018	2019
Revenues					
Electricity Sales	0	0	21,693	22,127	22,570
Renewable Energy Credits	0	0	3,927	4,005	4,085
Total	0	0	25,620	26,132	26,655
Expenses					
- Fuel Costs	0	0	0	0	0
- O&M Costs	0	0	3,847	3,924	4,002
- Depreciation	0	0	9,956	9,956	9,956
- Depreciation of AFUDC	0	0	188	188	188
- Interest	0	0	9,438	8,809	8,179
Total Expenses	0	0	23,428	22,876	22,325
Pre-Tax Income	0	0	2,192	3,256	4,330
- Property Taxes	0	0	2,015	1,946	1,876
- State/Local Taxes	0	0	943	962	981
- CO2 Emission Cost	0	0	0	0	0
- Fed Income Taxes Payable	0	0	-14,816	-25,245	-13,311
- Deferred Income Taxes			15,027	25,846	14,305
- Less Tax credits	0	0	-82,163	0	0
Net Income	0	0	81,185	-253	477
Less: Dividend Payout	0	0	96,174	25,555	14,745
Add to Retained Earnings	0	0	-14,989	-25,808	-14,267

Table 4. Sample Balance Sheet for Large PV project (K$)

	2015	2016	2017	2018	2019
Assets:					
CWIP	29,340	298,681	0	0	0
Gross Plant & Equip	0	0	298,681	298,681	298,681
- Accumulated Depreciation	0	0	-9,956	-19,912	-29,868
AFUDC	454	5,626	5,439	5,251	5,064
Working Capital	0	481	490	500	510
Debt Service Acct	2,586	9,962	9,648	9,333	9,018
Total	32,380	314,751	304,302	293,854	283,405
Liabilities:					
Debt	15,124	157,297	146,810	136,324	125,837
Deferred Taxes	0	0	15,027	40,872	55,178
Total	15,124	157,297	161,837	177,196	181,015
Equity:					
Stock Outstanding	17,256	157,454	157,454	157,454	157,454
Retained Earnings	0	0	-14,989	-40,797	-55,064
Total	17,256	157,454	142,465	116,657	102,390
Total Liability + Equity	32,380	314,751	304,302	293,854	283,405

The amount of debt will decrease over the input life of the debt (e.g., 15 years) and be zero for the latter years. The deferred taxes will climb during the early years and then decline to zero in the last year of the project.

Equity represents the remaining investment by equity holders in the project. As stock is issued during construction, this amount will increase. Rather than buy back stock, the tool assumes that excess funds are paid out as dividends during times of excess cash. In some situations, there may be times when revenues from sales do not cover cash expenses, such as when debt is being repaid based on the straight-line schedule, and deferred taxes are also being paid. In these cases, additional stock must be issued and no dividends paid.

2.10.3 Sources/Uses of Funds

The last table shows the sources and uses of funds for each year. Table 5 shows a representative statement for the construction and first three years of a project. It is organized somewhat differently from the cash flows described in Table 2 because it begins with the net income as the first source of funds. Since the net income includes some non-cash items (depreciation and deferred taxes), these are added back into the amount to show the cash from operations. Debt and stock issued is also added to calculate the net sources of cash. Uses include the payment of dividends, increases in assets, and debt retirement. As with the balance sheet, the two categories must equal each other.

Table 5. Sample Sources and Uses of Funds Statement for Large PV

	2015	2016	2017	2018	2019
Sources:					
Net Income	0	0	81,185	-253	477
+ Depreciation of P&E	0	0	9,956	9,956	9,956
+ Depreciation of AFUDC	0	0	188	188	188
+ Deferred Taxes	0	0	15,027	25,846	14,305
Cash from Operations	0	0	106,355	35,737	24,926
Debt Issued	15,124	142,173	0	0	0
Stock Issued	17,256	140,198	0	0	0
Net Sources	32,380	282,371	106,355	35,737	24,926
Uses:					
Dividends	0	0	96,174	25,555	14,745
Increase in Gross Plant	29,340	269,341	0	0	0
Increase in AFUDC	454	5,173	0	0	0
Increase in Working Capital	0	481	10	10	10
Increase in Debt Service Acct	2,586	7,376	-315	-315	-315
Debt Retirement	0	0	10,486	10,486	10,486
Net Uses	32,380	282,371	106,355	35,737	24,926

2.11 DATA FOR STORAGE AND DASHBOARD

At the bottom of the FINModule is a section with a restatement of the inputs and key outputs (summarized cash-flow values, fixed prices) for each state. The outputs are used in the Dashboard, and both the inputs and outputs are copied to the StoredOutputs worksheet so that reference or sensitivity cases can be stored, either for comparison on the Dashboard or to be reloaded to be able to regenerate case results. Up to twenty cases can be stored and loaded using the macros on the Dashboard.

3. REGIONAL DATA INPUTS

State-level inputs are for those variables that have different values among the states, so that the individual differences can be incorporated into the calculation. There are two worksheets that maintain these inputs. The StateIncent worksheet is a collection of incentives that are applicable to renewable energy projects based largely on the DSIRE database funded by DOE and maintained by the North Carolina Clean Energy Technology Center (NC State 2015). The second worksheet (StateInputs) aggregates the multiple incentives into applicable values for each state based on the technology and sector, and stores tax rates and power prices within each state, as well as technology- and state-specific data such as capital cost factors and capacity factors (CFs).

3.1 STATE INCENTIVES FROM DSIRE

The DSIRE database (NC Clean Energy Technology Center, 2015) is an online search tool that lists the hundreds of incentives available in the different states for renewable energy and energy efficiency. An ORNL researcher has combed the database to find applicable incentive programs and has recorded key parameters that can be used by PFMT concerning state level ITC and PTC incentives, tax abatements, state REC prices, applicable technologies, sectors, size, and expiration dates. For each incentive recorded, the webpage address and date the data were entered into the site is recorded to allow confirmation of the entry.

Because each entry may only apply to certain projects in the state, a calculation is made as to whether it applies to the project being calculated. If so, the appropriate incentive parameters are calculated and passed to the StateInputs worksheet. On that sheet, all of the records in the Incentives sheet are scanned since there can be multiple entries for the project within each state. These get consolidated to a single summary row for the project for each state.

3.2 OTHER STATE-LEVEL INPUTS

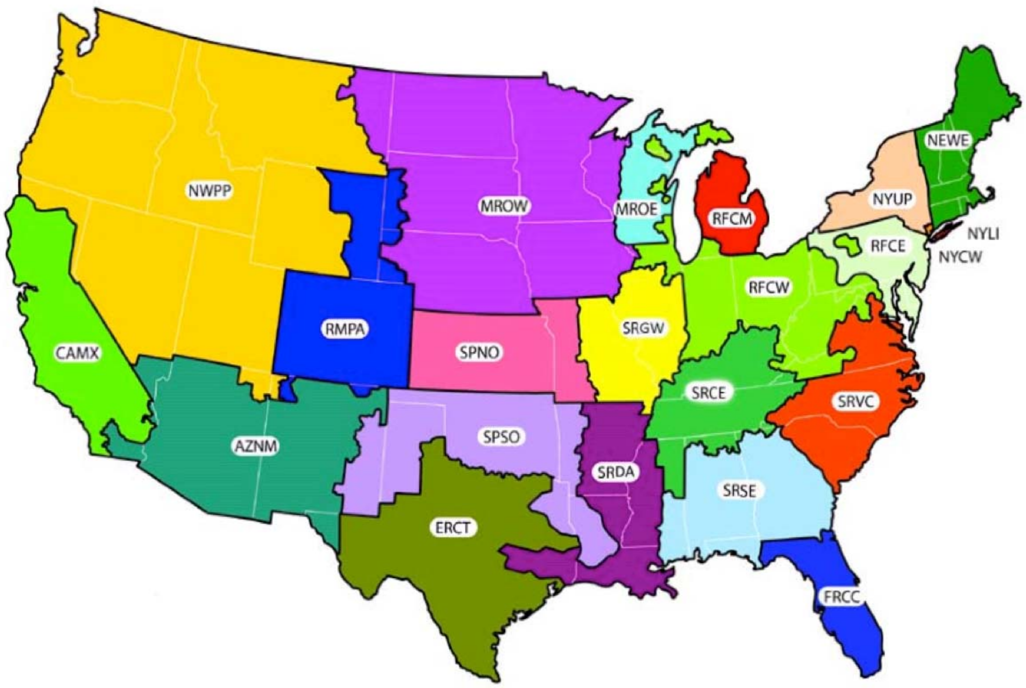
Multiple state-level tax rates can be modeled in PFMT. A property tax can be set that uses either the net book value or gross book value. The rates currently in the model are based on data from Table 35 of *50-State Property Tax Comparison Study* from the Lincoln Institute of Land Policy and Minnesota Taxpayers Association (Lincoln 2011). These data are for rural industrial property taxes in 2010 from representative towns in each state for property values over $25 million, and so they are only approximate for all projects.

The tool also has a variable for taxes on labor inputs, energy inputs, and material inputs. The last one is also used in the model to calculate a sales tax on power sales. Currently, the tool has the labor and energy amounts equal to zero while the material tax is based on 2015 sales tax values reported by Tax-Rates.org (Tax-Rates.org 2015). State average corporate income tax rates are also taken from this site. The site reports a range of values for some states; in these case, the higher of the values is used as the input.

State-level electricity wholesale or marginal prices are also input. These were found for each of the major electrical regions (Figure 4) by downloading the Federal Energy Regulatory Commission (FERC) Form-714 data for all of the balancing area authorities (FERC 2015). Each year, all balancing authorities must submit their “Annual Electric Balancing Authority Area and Planning Area Report.” These electronic data, among other information, give the “system lambda” for each hour of the previous year. The system lambda is defined as:

> For balancing authority areas where demand following is primarily performed by thermal generating units, the system lambda is derived from the economic dispatch function associated

with automatic generation control performed at the balancing authority area's controlling utility or pool control center. Excluding transmission losses, the fuel cost ($/hr) for a set of on-line and loaded thermal generating units (steam and gas turbines) is minimum when each unit is loaded and operating at the same incremental fuel cost ($/MWh) with the sum of the unit loadings (MW) equal to the system demand plus the net of interchange with other balancing authority areas. This single incremental cost of energy is the system lambda. (FERC 2015)



1.	ERCT	TRE All	12.	SRDA	SERC Delta
2.	FRCC	FRCC All	13.	SRGW	SERC Gateway
3.	MROE	MRO East	14.	SRSE	SERC Southeastern
4.	MROW	MRO West	15.	SRCE	SERC Central
5.	NEWE	NPCC New England	16.	SRVC	SERC VACAR
6.	NYCW	NPCC NYC/Westchester	17.	SPNO	SPP North
7.	NYLI	NPCC Long Island	18.	SPSO	SPP South
8.	NYUP	NPCC Upstate NY	19.	AZNM	WECC Southwest
9.	RFCE	RFC East	20.	CAMX	WECC California
10.	RFCM	RFC Michigan	21.	NWPP	WECC Northwest
11.	RFCW	RFC West	22.	RMPA	WECC Rockies

Figure 4. Electricity Market Model Regions. *Source EIA.*

The average cost for the year is found by simply taking the average of all 8,760 hourly values. Not all authorities submitted prices. The database presents the identification (ID) code for within the Energy Information Administration (EIA) datasets. Cross referencing to the datasets allows one to establish the EIA region to which each authority belongs. The list of prices by authority, and associated North American Electric Reliability Corporation region, are shown in Table 6.

Table 6. Balancing Authority Average System Lambda for 2014 and Applicable Region

EIA ID	Utility	Average System Lambda 2014	Region
5723	ERCOT	36.90	ERCT
18445	City of Tallahassee	26.93	FRCC
6452	Florida Power & Light Company	28.44	FRCC
9617	JEA	32.48	FRCC
18454	Tampa Electric Company	33.49	FRCC
14610	Florida Municipal Power Pool	34.45	FRCC
6909	Gainesville Regional Utilities	35.03	FRCC
6455	Progress Energy (Florida Power Corp.)	35.86	FRCC
21554	Seminole Electric Cooperative, Inc.	38.67	FRCC
56669	MISO	37.77	MORE, MROW, RFCM, RFCW, SRDA, SRGW
13434	ISO New England Inc.	63.32	NEWE
13501	New York Independent System Operator, Inc.	46.94	NYCW, NYLI, NYUP
14725	PJM Interconnection LLC	48.21	RFCE, RFCW, SRVC
189	PowerSouth Energy Cooperative (Alabama Electric Cooperative, Inc.)	33.19	SRSE
11249	Louisville Gas & Electric and Kentucky Utilities	27.64	SRCE
18642	Tennessee Valley Authority	31.39	SRCE
3046	Progress Energy (Carolina Power & Light Company)	44.49	SRCE
5416	Duke Energy Carolinas, LLC	36.47	SRVC
17543	South Carolina Public Service Authority	43.54	SRVC
17690	Southwest Power Pool (SPP)	32.41	SPNO, SPSO
803	Arizona Public Service Company	27.80	AZNM
9216	Imperial Irrigation District	32.75	AZNM
18195	Southern Company	37.40	AZNM
5701	El Paso Electric Company	40.20	AZNM
16572	Salt River Project	41.64	AZNM
24211	Tucson Electric Power Company	42.54	AZNM
13407	Nevada Power Company	63.19	AZNM
11208	Los Angeles Department of Water and Power	34.30	CAMX
19281	Turlock Irrigation District	44.86	CAMX
15473	Public Service Company of New Mexico	41.66	NWPP
17166	Sierra Pacific Resources	48.36	NWPP
15466	Public Service Company of Colorado	26.94	RMPA
599	Anchorage Municipal Light & Power	31.86	AK
3522	Chugach Electric Association, Inc.	53.28	AK
19547	Hawaiian Electric Company, Inc.	161.83	HI

Not all authorities submitted system lambdas, but enough did that all regions are covered, some with just a single authority, some with multiple ones. Some authorities, such as SPP and MISO, cover multiple regions. For simplicity, regional prices were simply the average of the lambdas of all authorities in the region. There are additional sources of data for authorities within open markets (e.g., California ISO), but those data were not included at this time.

Regional prices were assigned to individual states by calculating the proportion of demand provided by each region within a state and applying the costs from Table 6 to that proportion, then determining an average. The proportions were found by using the 2014 retail sales as listed both by region (from EIA's Annual Energy Outlook 2015) and by state (from EIA's Annual Electricity Report). Four matrices with regions along the top and states in the rows are created. Matrix 1is a sparse matrix with the fractions of regions applied to each state, as shown in Table 7. The sum across each row for each state totals 1.0.

Table 7. Matrix of calculated proportions of regional sales in each state

	ERCT	FRCC	MROE	MROW	NEWE	NYCW	NYLI	NYUP	RFCE	RFCM	RFCW	SRDA	SRGW	SRSE	SRCE	SRVC	SPNO	SPSO	AZNM	CAMX	NWPP	RMPA	AK	HI
AK																							1.00	
AL														0.52	0.48									
AR												0.53						0.47						
AZ																			0.75		0.25			
CA																			0.03	0.97	0.00			
CO																						1.00		
CT					1.00																			
DC									1.00															
DE									1.00															
FL		0.96												0.04										
GA														1.00	0.00									
HI																								1.00
IA				1.00																				
ID																					1.00			
IL											0.69		0.31											
IN											1.00													
KS																	1.00							
KY											0.00				1.00									
LA												0.46						0.54						
MA					1.00																			
MD									0.98		0.02													
ME					1.00																			
MI			0.08							0.91	0.00													
MN				1.00																				
MO													0.71				0.29							
MS												0.14		0.77	0.09		0.00							
MT				0.15																	0.85			
NC																1.00								
ND				1.00																				
NE				1.00																				
NH					1.00																			
NJ									1.00															
NM																		0.20	0.80		0.00	0.00		
NV																			1.00		0.00			
NY						0.38	0.14	0.47																
OH											1.00													
OK																		1.00						
OR																					1.00			
PA									0.70		0.30													
RI					1.00																			
SC																1.00								
SD				0.90																		0.10		
TN															1.00									
TX	0.82											0.16						0.00	0.02					
UT																					1.00			
VA											0.25					0.75								
VT					1.00																			
WA																					1.00			
WI			0.21	0.14							0.65													
WV											1.00													
WY																					0.52	0.48		

These fractions were derived by creating three additional tables. Matrix 2 multiplies each state's demands for 2014 (from the Electric Power Annual) by the fractions in the first matrix to get a matrix of the sales by state and region. These are summed at the bottom of each column to get the total sales assigned to each region, based on the fractions. Matrix 3 then divides the sales by this sum of the column to create the fraction of demand in that region from each state. These should sum to 1.0 for each column. Lastly, the third matrix's fractions are multiplied by the annual sales by region (from the Annual Energy Outlook) to create an alternate estimate of sales in each region by state.

A calculation is performed to find the sum of the square of the difference between each cell in Matrix 2 and Matrix 4. The cell values in Matrix 1 (Table 7) are manipulated using Excel's Solver function to minimize this value thereby creating the "best fit" for the regional proportions for each state. Lastly, the average system lambdas for each region are multiplied by the values in Matrix 1 to calculate the average marginal cost for each state. These are copied to the input table in the StateInputs worksheet.

3.3 TECHNOLOGY-SPECIFIC FACTORS

3.3.1 Capacity Factors

The technology-specific CFs for each state and technology are also listed in StateInputs. The CF for solar PV is found by using data from the AEO2015. Values for each region by month and hour of the day are listed in the input file solarin.txt from the Annual Energy Outlook 2015. These factors were converted to annual values for each electricity market region by multiplying by the number of hours per month, summing, and dividing by 8,760. Applying these CFs by the fractions in Table 7 and then summing each row gives the average CF for each state.

The onshore wind CF was determined using data from NREL and AWS TruPower that was used in the 2010-2015 Eastern Interconnection Transmissions Study (EIPC 2013). It provides six data sets that list the potential wind resource (capacity and generation amounts) for each state at 80- and 100-m tower heights and with CFs greater than 30%, 35%, and 40%. The reference (NREL and TruPower 2011) is a publicly available display of the data for a CF ≥30% and hub height of 80 m. As expected, there is less resource available at higher CFs, and some states have no resources at the higher CFs. Higher turbine heights provided higher CFs. Since the PFMT is only considering a single representative project, a state does not need a large resource base to have a potential project built. However, if resources are limited at high CFs, then lower CF sites are more likely to be used. We set a minimum level of 1,000 MW of available resource from any of these combinations of hub heights and CF to select the appropriate CF. If the amount of resource was below that amount, then the next lower height and/or minimum CF level was selected. For example, Table 8 shows the resource and average CF for different tower heights and minimum CF. The highest CF occurs for the 80-m height with >40% CF, but there is only 667 MW of potential resource in the state. Therefore, the next highest CF, 43%, is used in PFMT. Some states did not have sufficient resources available in any of the categories, and therefore they had the CF set at 1% (to avoid any division errors elsewhere in the tool.)

Table 8. Potential Onshore Wind Resource and Capacity Factor for New York. *Source: NREL*

	80M, >40%CF	80M, >35%CF	80M, >30%CF	100M, >40CF	100M, >35%CF	100M, >30%CF
Potential Capacity (MW)	667	4,805	25,781	3,205	20,418	57,639
Capacity Factor	44%	38%	33%	43%	38%	34%

Offshore wind CFs were found from the EIPC study inputs, namely Exhibit 11 of Appendix A of the assumptions document. (CRA 2010) It provides capacity factors for regions and states with significant offshore wind potential. The geothermal CFs will differ by state for those states that have current capacity, implying that future plants could be added at the same capacity factor. Gas combined cycle, gas combustion turbine, nuclear, and biomass CFs are based on the AEO2015 assumptions. The same values are used for every state since these are not presumed to vary.

3.3.2 Capital Costs Adjustments

In 2010, EIA commissioned R.W. Beck Inc. to create a reference data source for a number of generating technologies (EIA 2010) to be used in the National Energy Modeling System (NEMS). Among other parameters, R.W. Beck Inc. created tables of the construction cost variations by location for each technology. Although much of their data are relatively dated, these factors are assumed not to have changed significantly in the intervening years.

Table 9. Capital Cost Location Percent Variation (*EIA 2010)*

	Large PV	Small PV	Onshore Wind	Offshore Wind	Biomass	Geo-thermal	Gas CC	Gas CT
AK	27.5%	26.0%	39.0%	7.8%	14.3%	21.1%	34.5%	44.6%
AL	-7.5%	-7.5%	-4.5%	0.0%	-6.7%	0.0%	-9.3%	-4.1%
AR	-6.6%	-6.5%	-3.6%	0.0%	-6.0%	0.0%	-8.1%	-2.9%
AZ	-5.7%	-5.7%	-3.1%	0.0%	0.0%	-3.7%	1.7%	-2.3%
CA	10.4%	10.0%	13.2%	4.3%	7.6%	6.0%	23.8%	18.3%
CO	-3.2%	-3.4%	2.0%	0.0%	-12.9%	-3.4%	1.3%	2.3%
CT	6.5%	6.2%	7.2%	5.2%	11.3%	0.0%	26.5%	23.1%
DC	3.8%	3.5%	8.4%	1.9%	14.8%	0.0%	32.1%	36.4%
DE	3.9%	3.7%	5.0%	2.9%	9.4%	0.0%	25.0%	22.9%
FL	-6.0%	-5.9%	-3.8%	0.0%	-5.2%	0.0%	-7.9%	-3.7%
GA	-8.5%	-8.4%	-5.2%	-8.1%	-7.5%	0.0%	-7.7%	-0.8%
HI	43.4%	40.5%	30.1%	13.8%	28.1%	27.2%	47.9%	71.5%
IA	-0.5%	-0.7%	3.5%	0.0%	-3.2%	0.0%	-2.0%	0.6%
ID	-1.7%	-2.0%	3.2%	0.0%	-4.5%	-3.3%	-4.6%	-1.9%
IL	16.9%	16.5%	15.2%	14.7%	12.5%	0.0%	15.1%	11.0%
IN	-1.7%	-1.7%	-0.2%	-1.8%	-0.4%	0.0%	0.0%	2.1%
KS	-3.7%	-3.9%	1.7%	0.0%	-6.0%	0.0%	-4.9%	-0.9%
KY	-6.1%	-6.0%	-3.6%	0.0%	-5.2%	0.0%	-5.9%	-3.2%
LA	-10.2%	-10.1%	-6.5%	0.0%	-8.8%	0.0%	-5.9%	3.3%
MA	13.3%	13.0%	11.6%	11.6%	17.0%	0.0%	37.1%	33.1%
MD	-2.1%	-2.3%	1.4%	-2.8%	-0.6%	0.0%	18.8%	19.1%
ME	-2.5%	-2.8%	6.2%	-3.8%	-4.0%	0.0%	-4.0%	0.1%
MI	-0.6%	-0.6%	0.7%	-0.6%	-0.6%	0.0%	1.5%	2.8%
MN	8.2%	7.9%	9.6%	6.5%	4.1%	0.0%	6.3%	5.6%
MO	2.0%	1.9%	2.3%	0.0%	1.2%	0.0%	2.9%	3.4%
MS	-7.0%	-6.9%	-4.2%	0.0%	-6.2%	0.0%	-8.7%	-3.7%
MT	-0.6%	-0.9%	4.5%	0.0%	0.0%	0.0%	-2.1%	1.3%
NC	-8.6%	-8.5%	-4.9%	-8.3%	-7.4%	0.0%	-8.2%	-4.1%
ND	-3.4%	-3.6%	2.2%	0.0%	-6.0%	0.0%	-5.4%	-1.6%
NE	-0.6%	-0.8%	3.6%	0.0%	-3.4%	0.0%	-1.8%	1.0%
NH	0.3%	0.0%	5.4%	0.0%	-2.8%	0.0%	6.3%	-0.7%
NJ	14.2%	14.0%	12.4%	13.3%	11.7%	0.0%	22.2%	21.0%
NM	-1.2%	-1.5%	3.8%	0.0%	0.0%	-2.4%	-3.0%	3.2%
NV	7.9%	7.6%	9.4%	0.0%	0.0%	3.1%	5.1%	4.1%
NY	15.5%	15.1%	14.1%	13.6%	13.1%	0.0%	40.6%	36.4%
OH	-4.8%	-4.8%	-2.8%	0.0%	-2.5%	0.0%	-2.7%	0.5%
OK	-3.7%	-3.9%	1.7%	0.0%	-6.0%	0.0%	-4.9%	-0.9%
OR	5.9%	5.5%	8.9%	4.9%	3.0%	1.9%	12.7%	4.6%
PA	2.5%	2.5%	2.3%	0.0%	1.9%	0.0%	11.3%	8.6%
RI	2.8%	2.7%	2.4%	2.4%	2.0%	0.0%	21.1%	16.4%
SC	-11.4%	-11.3%	-6.8%	-11.1%	-10.1%	0.0%	-12.9%	-5.9%
SD	-5.4%	-5.5%	0.9%	0.0%	-7.7%	0.0%	-7.4%	-2.8%
TN	-9.3%	-9.2%	-5.6%	0.0%	-7.9%	0.0%	-9.1%	-5.1%
TX	-9.3%	-9.2%	-5.9%	-8.7%	-7.8%	0.0%	-9.4%	-5.8%
UT	-1.8%	-2.1%	4.0%	0.0%	0.0%	-3.1%	-3.9%	-0.1%
VA	-4.9%	-4.9%	-1.1%	-4.7%	-1.0%	0.0%	4.3%	4.4%
VT	-3.2%	-3.4%	3.2%	0.0%	-5.7%	0.0%	-1.0%	4.9%
WA	2.8%	2.6%	5.1%	2.2%	1.2%	0.9%	2.0%	2.9%
WI	0.9%	0.8%	1.2%	0.6%	1.9%	0.0%	2.3%	3.1%
WV	-1.4%	-1.4%	0.0%	0.0%	-1.7%	0.0%	0.3%	2.3%
WY	-2.2%	-2.5%	4.3%	0.0%	0.0%	-3.3%	-1.2%	4.9%

4. TECHNOLOGY INPUTS

4.1 TECHNOLOGIES SELECTED

The model can evaluate multiple types of technologies. Currently eight technology options have been identified as shown in Table 10. Below each technology name are listed the current values used for the input variables within the model.

Table 10. Technology Inputs

Tech Options	Large PV	Small PV	Onshore Wind	Offshore Wind	Biomass	Geotherm al	Gas CC	Gas CT
Technology	Solar	Solar	Wind	Wind	Biomass	Geotherma l	Gas	Gas
Capacity, MW	150	7	100	400	150	50	400	210
Sector	Commer-cial	Commer-cial	Commer-cial	Commer-cial	Commer cial	Commercia l	Commer-cial	Commer-cial
Prod Tax Credit, $/MWh	0	0	23	23	11	23	0	0
Fed Investment Tax Credit	30%	30%	0%	30%	0%	10%	0%	0%
ITC Applicable Capital	90%	90%	90%	90%	90%	90%	90%	90%
Tax Depreciation Life	5	5	5	5	5	5	20	15
Capital Cost, $/kW	2000	2200	2016	6267	3726	2493	1036	683
Operating Life, years	30	30	30	30	30	30	30	30
Book Depreciation Life	30	30	30	30	30	30	30	30
Var. O&M Cost, $/MWh	0.00	0.00	0.00	0.00	5.36	0.00	3.33	10.56
Fix O&M Cost, $/kW	25.13	25.13	40.26	75.32	107.52	114.93	15.64	7.17
O&M - Labor %	50%	50%	50%	50%	50%	50%	50%	50%
O&M - Matl %	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Cost, $/mmBTU	0.00	0.00	0.00	0.00	3.00	0.00	3.00	3.00
Thermal Efficiency, %	36%	36%	36%	36%	25%	36%	54%	40%
CO2 Emissions, T/MWh	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.45
Years to Construct	2	1	3	4	4	4	3	2
Year before Operation								
-7	0%	0%	0%	0%	0%	0%	0%	0%
-6	0%	0%	0%	0%	0%	0%	0%	0%
-5	0%	0%	0%	0%	0%	0%	0%	0%
-4	0%	0%	0%	5%	15%	15%	0%	0%
-3	0%	0%	5%	10%	30%	15%	25%	0%
-2	10%	0%	10%	30%	40%	35%	50%	65%
-1	90%	100%	85%	55%	15%	35%	25%	35%

The data values can come from a variety of sources. There are a number of similar studies that publish data such as this, though occasionally it may be in a slightly different format. For example, dollar values may be some earlier year's basis rather than 2015 purchasing power, or thermal efficiency may be given as a heat rate value. Table 11 describes each of the parameters in more detail and provides references for the values.

Table 11. Description and sources of technology data

Variable	Description	Source
Tech Name	Label used for selecting the technology	
Technology	Type of Technology – used for evaluating applicability of state incentives	
Capacity, MW	Capacity of project – used for evaluating applicability of state incentives and total costs	
Sector	Residential, Commercial or Industrial – used for evaluating applicability of state incentives	
Prod Tax Credit, $/MWh	Prod Tax Credit, $/MWh – National production tax credit in 2015$	Assumptions to AEO2015 (Energy Information Administration, 2015)
Fed Investment Tax Credit	National credit, applies to certain renewables	Assumptions to the AEO2015 (Energy Information Administration, 2015) and the NREL Annual Technology Basis (Blair, et al. 2015) (ITC may lower to 10% after 2016.)
ITC Applicable Capital	Represents percentage of total capital cost that qualifies for the ITC. Does not include supporting structures and common equipment	
Tax Depreciation Life	Modified Accelerated Cost Recovery System (MACRS) life for calculating expensing of facility for tax calculations, based on IRS rules	Assumptions to AEO2015 (Energy Information Administration, 2015) IRS Publication 946
Capital Cost, $/kW	National average capital cost applied to facility, adjusted by state	Assumptions to AEO2015 (Energy Information Administration, 2015) except solar based on extrapolation of LBNL 2011-2014 costs (Bolinger & Seel, 2015)(Barbose 2015) and 10% increase for small utility PV
Operating Life, years	Operating Life, years	Assumptions to AEO2015 (Energy Information Administration, 2015)
Book Depreciation Life	Book Depreciation Life	Assumptions to AEO2015 (Energy Information Administration, 2015)
Var. O&M Cost, $/MWh	Var. O&M Cost, $/MWh	Assumptions to AEO2015 (Energy Information Administration, 2015)
Fix O&M Cost, $/kW	Fix O&M Cost, $/kW	Assumptions to AEO2015 (Energy Information Administration, 2015)
O&M - Labor %	O&M - Labor %	Arbitrary split of 50%
O&M - Matl %	O&M - Matl %	Arbitrary split of 50%
Fuel Cost, $/mmBTU	Fuel Cost, $/mmBTU	NREL ATB (Blair, et al. 2015)
Thermal Efficiency, %	Thermal Efficiency, %	Assumptions to AEO2015 (Energy Information Administration, 2015)
CO_2 Emissions, T/MWh	CO_2 Emissions, T/MWh	Calc from efficiency and conversion 53.07 KgCO_2/mmBTU for gas (EIA 2016)
Years to Construct	Years to Construct	Assumptions to AEO2015 (Energy Information Administration, 2015)

The capital costs used are largely based on inputs from the EIA AEO2015 inputs. The geothermal costs are reflective of expansion of current plants rather than greenfield sites, so only current states are applicable for projects. Future PFMT analyses could utilize greenfield sites and expand into newer states, but these plants are two to four times more expensive, according to the NREL *Annual Technology Baseline* (NREL 2015). Because solar PV costs are changing rapidly, its capital costs are based on the cost reduction rate between 2011 and 2014 as reported in LBNL's reports (Bolinger & Seel, 2015) (Barbose 2015) extrapolated to 2017.

5. PFMT USING TABLEAU SOFTWARE

The PFMT tool using Tableau software currently provides two types of solutions. The first solution requires the installation of the Tableau Desktop 9 standalone software and R on the same machine and then accessing the PFMT tableau workbook (PFMT_Vxx.twbx) file. The second solution is by providing access to the tool as a pre-computed scenario workbook on Tableau server. A user needs to have an account to be able to log in to the server via any web browser to access PFMT. Below is the description of these two solutions, also highlighting their pros and cons.

5.1 TABLEAU DESKTOP SOLUTION

The section below first describes how to install Tableau Desktop 9 and R on a Windows/Mac machine and then describes the R integration process with Tableau to perform the calculations. Finally, all the input parameters, calculated outputs, and the dashboards created are discussed in detail.

5.1.1 Tableau Desktop 9 Installation

When you purchase Tableau, you will receive a welcome email that explains what you need to do to download and install the software. Use the included user name and password to log into the Customer Portal so you can download the software and your product key. Follow the instructions below to download and install your products.
Step 1: Sign in to the Tableau Customer Portal using your email address and the password provided by Tableau.
Step 2: Click the My Keys link.
Step 3: In the Products Key column, copy the product key for the Tableau product you want to install.
Step 4: Under Product Downloads, click the link to the product you want to download.
Step 5: On Windows computers, you will be prompted to save or run Tableau Desktop.exe. On a Mac, TableauDesktop.dmg is copied to your Download folder.
Step 6: On Windows, when the download finishes, double-click the installer file to begin the installation. Follow the on-screen instructions to install the product.

On a Mac, you will be prompted to drag the Tableau Desktop icon to your Applications folder:

Step 7: When you are done installing Tableau, you will need to activate and register the product. Click Activate the product.
Step 8: Click the text box and press Ctrl + V (Cmd-V on a Mac) to paste your product key. You can also right-click (control-click on a Mac) in the text box and select Paste. When finished, click Activate.

Important: If you are upgrading versions and have paid your maintenance since the last time you completed off-line activation, contact Tableau Customer Service first. If you are working offline, refer to the Offline Activation Help article for information on how to activate Tableau.

Step 9: Click the Register button to continue with the registration process.
Step 10: Register the product by typing your name, company, email address, and any other necessary information. Then click the Register button.
Step 11: When registration is successful, click Continue to start using the product.

5.1.2 R Setup for Tableau Desktop

This section explains how to set up the R statistical package on the same Windows machine as the Tableau Desktop installation.

1. In a web browser, go to www.r-project.org.
2. Find where you select a CRAN Mirror. Click the link and select a site that is reasonably close to where you are located. This just means you will download the R installer from somewhere relatively close.
3. After selecting the CRAN mirror site, click the link to download the R installer for Windows. Save the download file to your local hard drive.
4. You are done with the browser portion.
5. Double-click on the saved R installer to install the software. Accept all defaults.
6. You will end up with an R icon on your desktop. Double-click to start the control screen.
7. In the menu bar, select "Packages" -> "Set CRAN mirror". Select a site near your location.
8. In the menu bar, select "Packages" -> "Install package(s)..." Select "Rserve" from the list.
9. Click OK to install Rserve.
10. Before each use in Tableau, do the following (there is a way to automate this):
    a) Run R by clicking on the R desktop icon.
    b) In the command window, enter library(Rserve) and press the Enter key.
    NOTE: Command is CASE SENSITIVE!
    c) In the command window, enter Rserve() and press the Enter key.
    NOTE: Command is CASE SENSITIVE!
    d) Run Tableau Desktop.
    e) Click Help -> Settings and Performance -> Manage R Connection.
    f) Key in localhost for the Server name and 6311 for the Port.
    NOTE: You might have to use 127.0.0.1 for Server name.
    g) Click the "Test Connection" button to test the connection.
    NOTE: These four steps are a one-time process.

5.1.3 Inputs and Key Outputs

The Tableau desktop version of PFMT first connects to the PFMT Excel version file “Tableau Inputs” worksheet and “TableauStateInputs” worksheet to extract all the input data values. All the other inputs (technology inputs, FINModule worksheet inputs) need to be entered as parameters within the Tableau dashboard displayed as text boxes, dropdown lists, radio buttons, etc. The key outputs of this tool are generated using financial calculations within a Tableau-R interface environment, and the final deliverable is a set of interactive dashboards that allow the user to intuitively explore the impacts of different federal and state policies on the financial costs of power projects (including different technologies such as solar, wind, gas, biomass, etc.) across all the 50 states of United States. The input-parameters dashboard displays all the finance, technology and dashboard inputs that can be varied by the user (Figure 5).

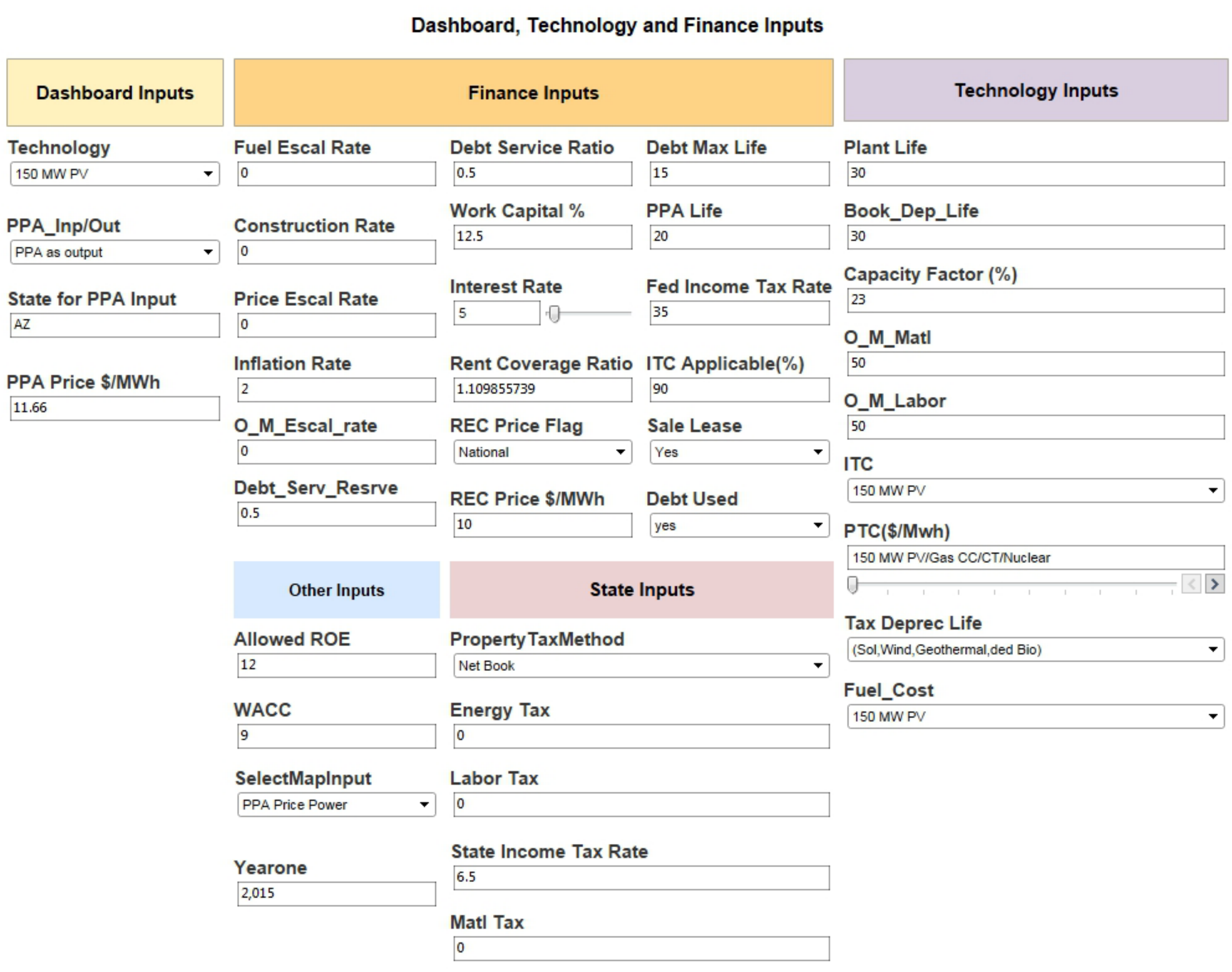


Figure 5. Input Parameters Dashboard.

Table 12 below is a comprehensive list of parameters that can be modified within the Financial model through the “Parameters” sheet or the “Parameters Dashboard” sheet (where the inputs are categorized as Financial, Technology, and State inputs similar in the Excel version).

Table 12. Tableau Input Parameters

Numerical Parameters		Categorical Parameters
Book_Dep_Life	Interest Rate	Scenario Selection
Allowed ROE	Labor Tax	State
CO_2 Cost	Matl Tax	Debt Used
CO_2 rate	O_M_Cost_MW	Technology
Capacity Factor (%)	O_M_Cost_Mwh	
Capacity_MW	O_M_Escal_rate	
Capital Energy	O_M_Labor	
Capital Labor	O_M_Matl	
Capital Land	LEP Price $/MWh	
Capital Material	PTC($/Mwh)	
Capital Cost	Plant Life	
Construction Rate	Price Escal Rate	
Debt Max Life	Project Lifetime	
Debt Service Ratio	PropertyTaxMethod	
Debt_Serv_Resrve	REC Price $/MWh	
Energy Tax	SelectMapInput	
Fed Income Tax Rate	Start Year	
Fuel Escal Rate	State Income Tax Rate	
Fuel_Cost	State Policy(ON/OFF)	
ITC	Tax Deprec Life	
Inflation Rate	WACC	
Yearone	Work Capital %	
LEP Life	Sale Lease	

5.1.4 R Integration

The best way to understand how the R integration works is to think of Tableau as the front end for displaying results obtained from a set of complex calculations that are run using R. The flowchart below (Figure 6) gives a high-level overview of how this coupling works.

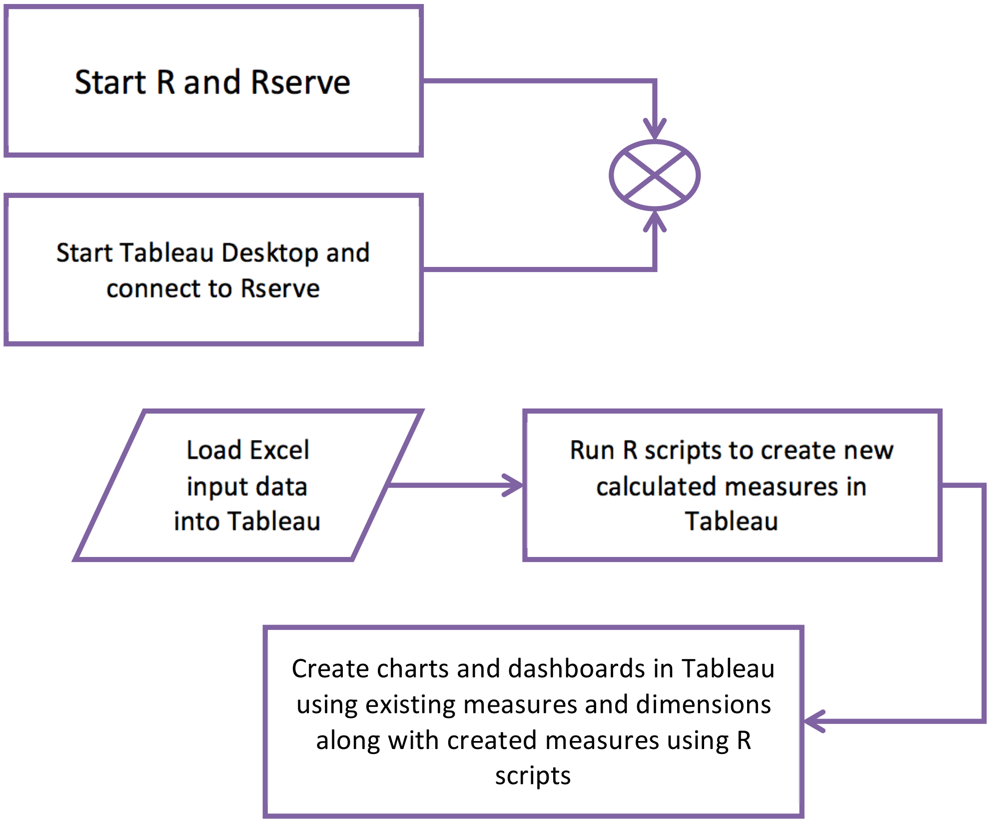


Figure 6. Flowchart describing Tableau and R coupling.

All the financial calculations that are generated as calculated fields run within the "SCRIPT_REAL" in-built Tableau function which essentially hands off the computations to an Rserver. All the input arguments required for each of these calculations are appended at the end of this "SCRIPT_REAL" function, and these values are consumed by the R variables at the beginning of the R code as shown in the sample below. For this example, there are five input parameters: [Plant Life], SUM ([Capital Cost],[Capacity_MW],[Start Year],[WACC]). These parameters are being sent to R along with the code.

```
SCRIPT_REAL (
  "PlantLife <- max(c(.arg1))
 Capacity_Factor <- max(c(.arg2))
 Capacity_MW <- max(c(.arg3))
 Start_Year <- max(c(.arg4))
 WACC <- max(c(.arg5))/100
 Production_Mwh <- numeric(0)

year <-
c(2015,2016,2017,2018,2019,2020,2021,2022,2023,2024,2025,2026,2027,2028,2029,2030,2031,2032,2033,2034,2035,2036,2037,2038,2039,2040,2041,2042,2043,2044,2045,2046 ,2047,2048,2049,2050)

for (i in 1:36 ) {

 if (year[i]>=Start_Year && year[i]< (Start_Year+PlantLife)) {Production <- Capacity_MW*8760*Capacity_Factor
 } else {Production <- 0}

 Production_Mwh <- c(Production_Mwh,Production)
}

npv <- function(i, cf, t=seq(along=cf)) {sum(cf/(1+i)^(t))}
```

npv_prod <- npv(WACC,Production_Mwh)(1+WACC)*

npv_prod",**[Plant Life],SUM([Capital Cost],Capacity_MW],[Start Year],[WACC])**

Any of the calculated fields can be accessed from the Measures panel by right clicking on a field name and selecting the "Edit" option (Figure 7).

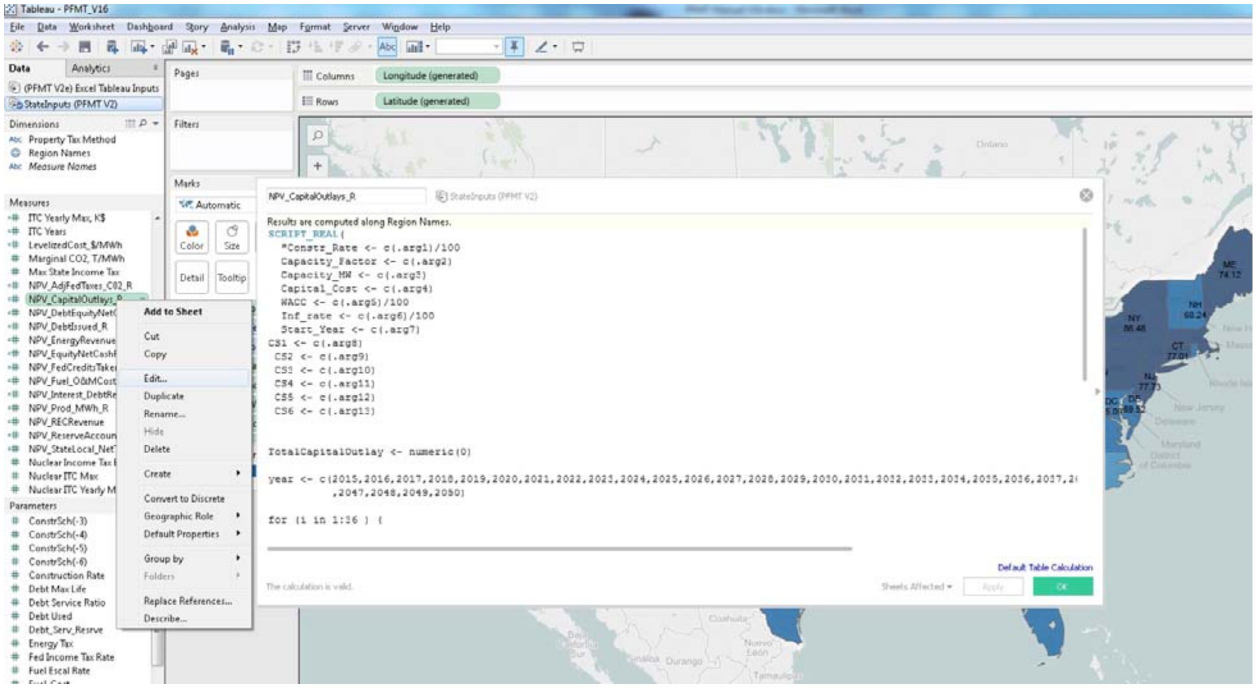


Figure 7. Accessing calculated fields and their underlying R codes.

5.1.5 Dashboard Outputs

The following measures (Table 13) are calculated and displayed as a table within the "Dashboard Outputs" sheet. Each of these calculations comprise individual R scripts with about 50 parameter input values, and they generate a single output value for each state. Since these calculations are being run across the entire nation, the Table Calculations option must be set to compute "using Cell" because this option sets the addressing to the individual cells in the imported data table from Excel. All fields become partitioning fields.

Table 13. R Script Names for Dashboard Outputs

Display Names	Measure Names
Estimated LEP	LEP in R
Return on Equity	Return_On_Equity_R
Return on (D+E)/IRR	IRR_DebtEquity_R
Return for Lessor	Return_On_Lessor_R
Return for Lessee	Return_On_Lessee_R

5.1.6 Net Cash Flow Calculations

Revenue, Capital Costs, Operating Costs, Debt Costs and Net Taxes are calculated separately as R measures within "SCRIPT_REAL" built--n Tableau function. These measures are used to create a

Tableau sheet named “**NetCashFlowInteractive**”. This visualization graph can be filtered using the “Region Names”. Hence, multiple cash flow diagrams for several states can be visualized simultaneously for comparison purposes.

Note: Each of these R measures was independently tested within the R environment (with input parameters hard-coded) and was then tested within the Tableau Desktop by varying input parameters on the front end interface to match the Excel version of the PFMT model output.

5.1.7 Net Present Value (NPV) Calculations

The following measures are calculated and displayed as a table within the “NPV Outputs” sheet (Table 14). Each of these calculations comprises individual R scripts, and each calculation takes approximately 50 parameter input values and generates a single output value for each state. Since these calculations are run across the entire nation, the Table Calculations are set to compute “using Cell” option as this sets the addressing to the individual cells in the imported data table from Excel. All fields become partitioning fields.

Table 14. R Script Names for NPV Outputs

Display Names	Measure Names
Adj Fed Taxes	NPV_AdjFedTaxes_C02
Capital Outlays	NPV_CapitalOutlays
Net Cash Flow(D+E)	NPV_DebtEquityNetCashFlow
Debt Issued	NPV_DebtIssued
Energy Revenue	NPV_EnergyRevenue
Net Cash Flow(Equity)	NPV_EquityNetCashFlow
Fed ITC+PTC	NPV_FedCreditsTaken
Fuel + O&M Costs	NPV_Fuel_O&MCosts
Interest + Debt Repaid	NPV_Interest_DebtRepaid
REC Revenue	NPV_RECRevenue
Reserve Account	NPV_ReserveAccount
State/Local NetTax	NPV_StateLocal_NetTax.R

Note: Each of these R measures was independently tested within the R environment (with input parameters hard-coded) and was then tested within the Tableau Desktop by varying inputs parameters on the front end interface to match the excel version of the PFMT model output.

5.1.8 Tableau Desktop Workbook Features

- The tableau desktop solution enables the accessibility to the PFMT Tableau workbooks using installation of the standalone Tableau Desktop license. The workbooks accessed through the desktop are fully interactive and will need to connect to a local R server so that the financial calculations are performed on the fly.
- The workbooks that are currently accessible from the Tableau Desktop are not pre-computed. Hence, the visualizations of the model results in response to user-inputs take a while (about 5 to 6 seconds) to update since the software is directly interfacing with the R environment to perform the computations instantaneously.
- This workbook version exposes the complete capability of the tool, and hence it is ideal for financial analysts and domain experts (e.g., EPSA analysts) who are cognizant about the various financial, policy, and technology parameters existing in the model and who can study their impacts on the energy project financial viability in a systematic fashion.

5.1.9 Tableau Desktop Dashboard Design

Each dashboard view is connected to one or more worksheets that it represents. Therefore, when the user makes changes to the worksheet, the dashboard is automatically updated. Conversely, changes the user makes to the dashboard affect the worksheet. Therefore, the user can edit the original view by jumping to a selected worksheet from a dashboard.

Below is the list of Tableau sheets created within Tableau Desktop which can be combined in any desired fashion to create dashboards:

- LEP Output Map
- NetCashFlowInteractive
- Dashboard Outputs
- NPV Outputs
- StateData-DSIRE Database
- National Summary
- TreeMap

5.1.10 Tableau Dashboards Created Within Tableau Desktop

Tableau dashboards created within Tableau Desktop differ from those created within the pre-computed workbooks with some additional parameters added to allow for more flexibility in configuration. Because there are about 35 parameters that are configurable, analysts can add them dynamically into the dashboard by accessing Analysis → Parameters from the menu.

Figure 8 displays the Estimated LEP for the desired ROE level on a map and Net Cash Flows for the selected states on the map also allowing simultaneous display of multiple cash flow charts. All the input parameters which the user can vary (Allowed ROE, Technology, WACC, REC Price Flag, REC Price, SelectMapInput, PTC, ITC for all technologies, etc.) are displayed on the left, and the dashboard's outputs [LEP, IRR(Debt+Equity, Return for Lessor, Lessee, etc.] are displayed on the right.

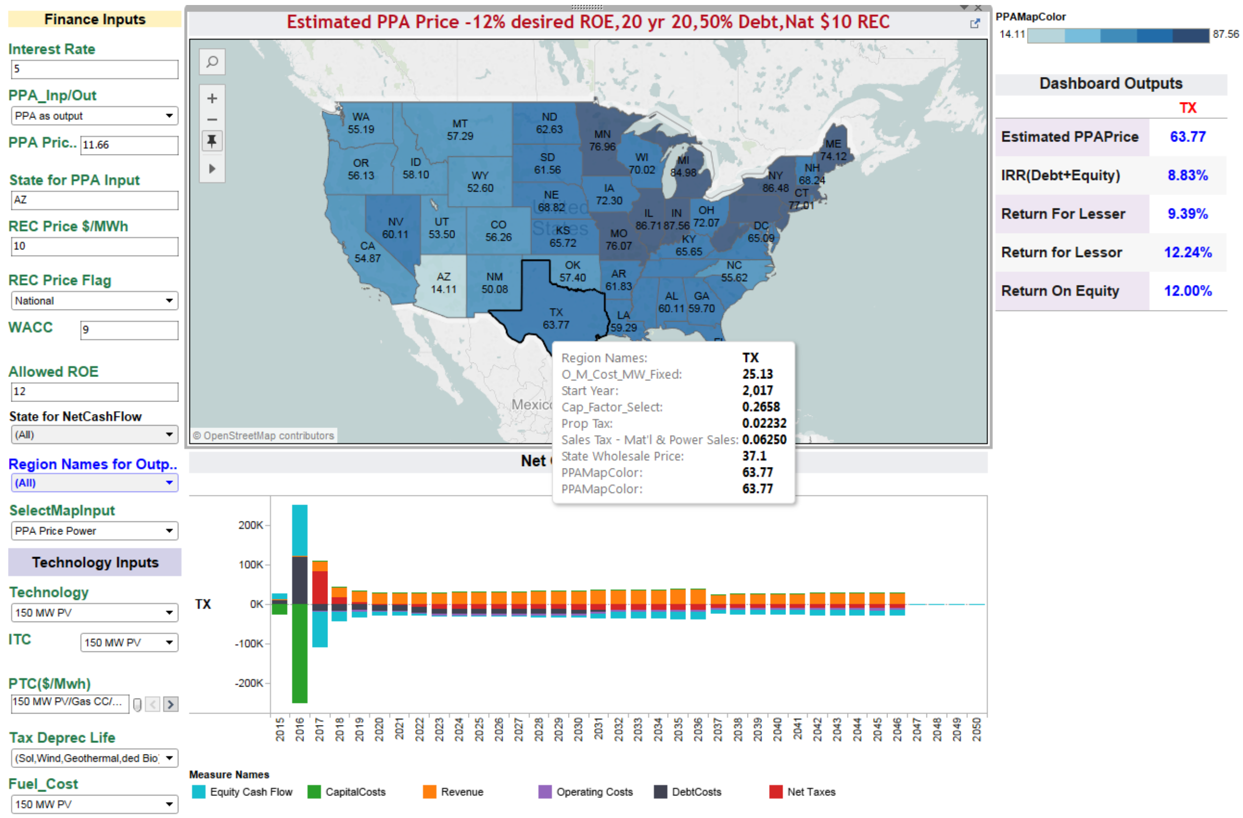


Figure 8. LEP Map Dashboard for 150 MW PV Technology with Tableau Desktop.

Figure 9 displays the Net Cash Flow diagram of selected states for a selected Technology allowing simultaneous display of multiple cash flow charts. All the input parameters, which the user can vary (Allowed ROE, Technology, WACC, Fed Income Tax Rate, REC Price Flag, REC Price, SelectMapInput, PTC, ITC for all technologies, etc.), are displayed on the left, and the dashboard outputs (LEP, IRR-Debt+Equity, Return for Lessor, Lessee, etc.) are displayed on the right.

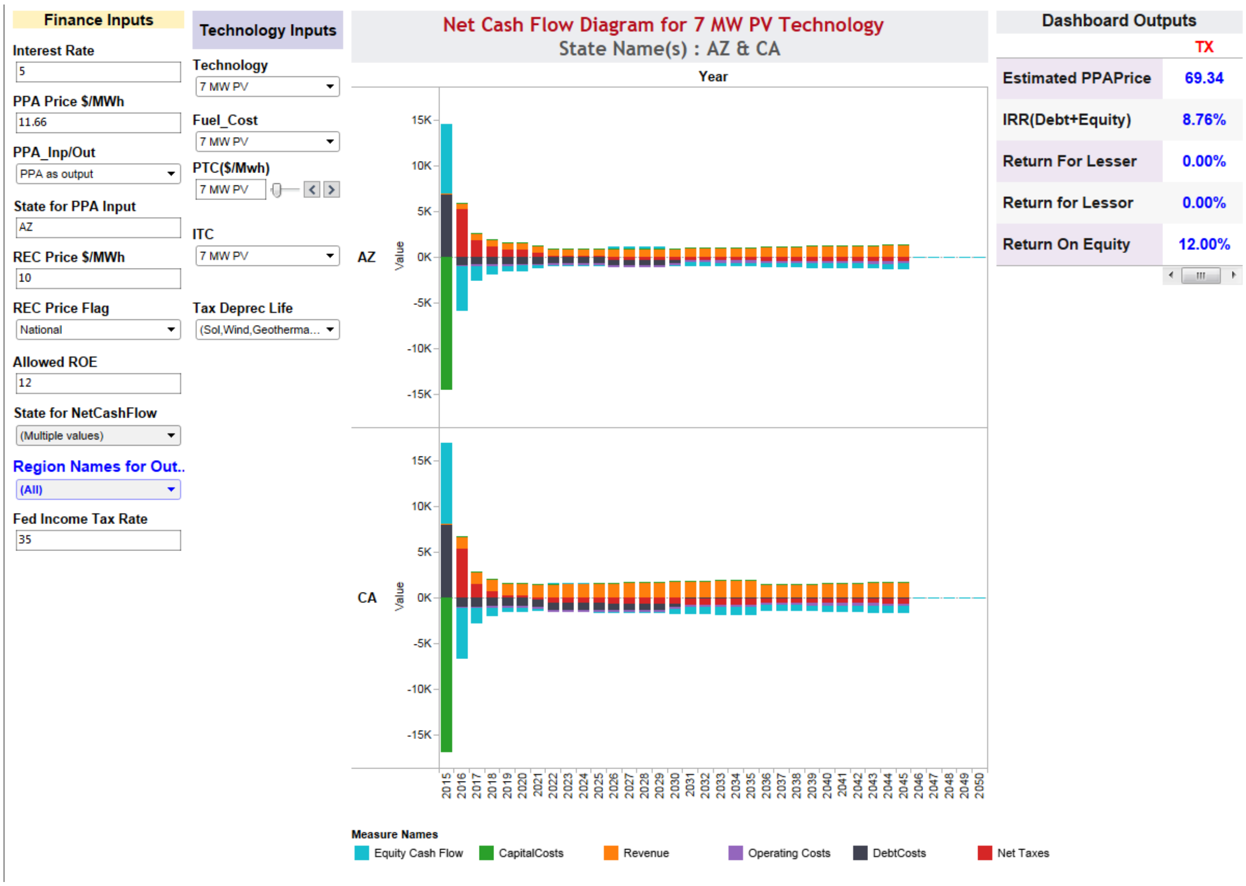


Figure 9. Net Cash Flow Dashboard for 7 MW PV Technology within Tableau Desktop.

Figure 10 shows the LEP Map dashboard view for Small PV technology with 12% desired ROE and 5% interest rate as inputs.

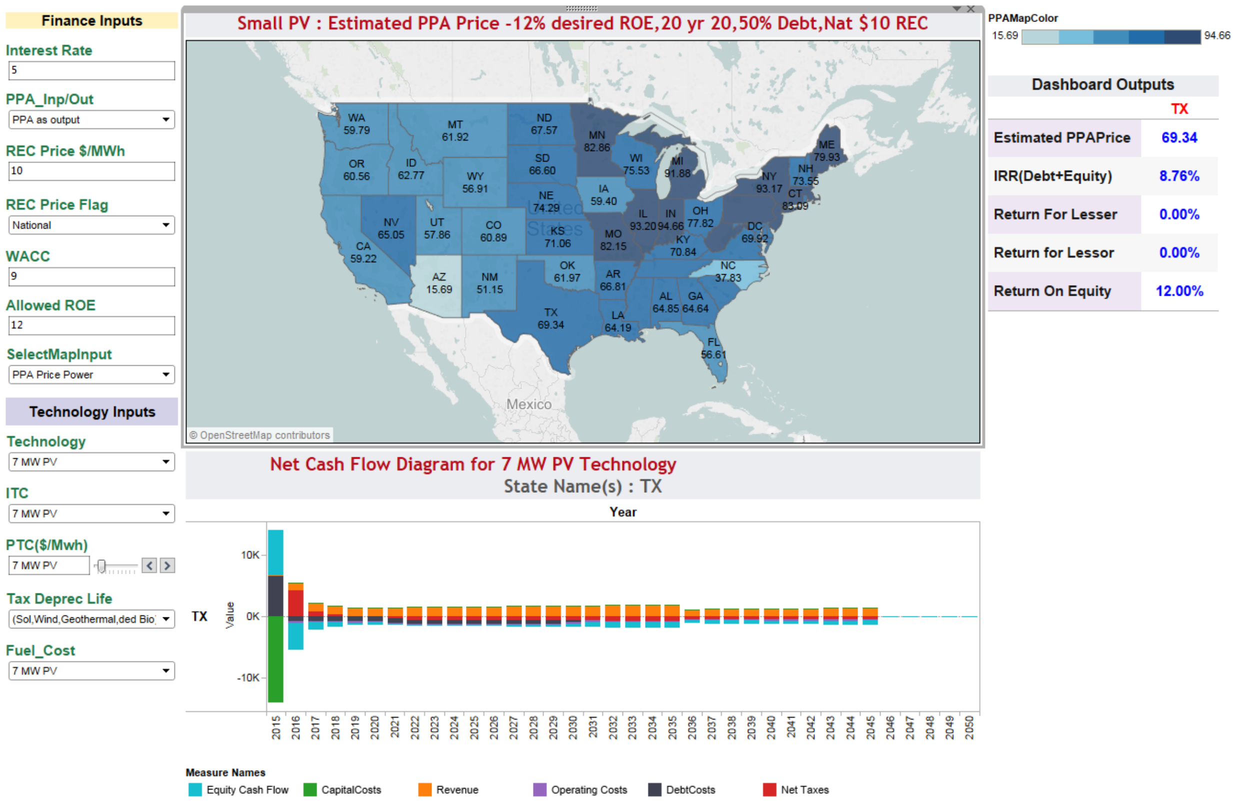


Figure 10. LEP Map Dashboard for 7 MW PV Technology within Tableau Desktop.

Figure 11 displays a scatterplot of the calculated LEP versus the state's input wholesale price for all the 50 states.

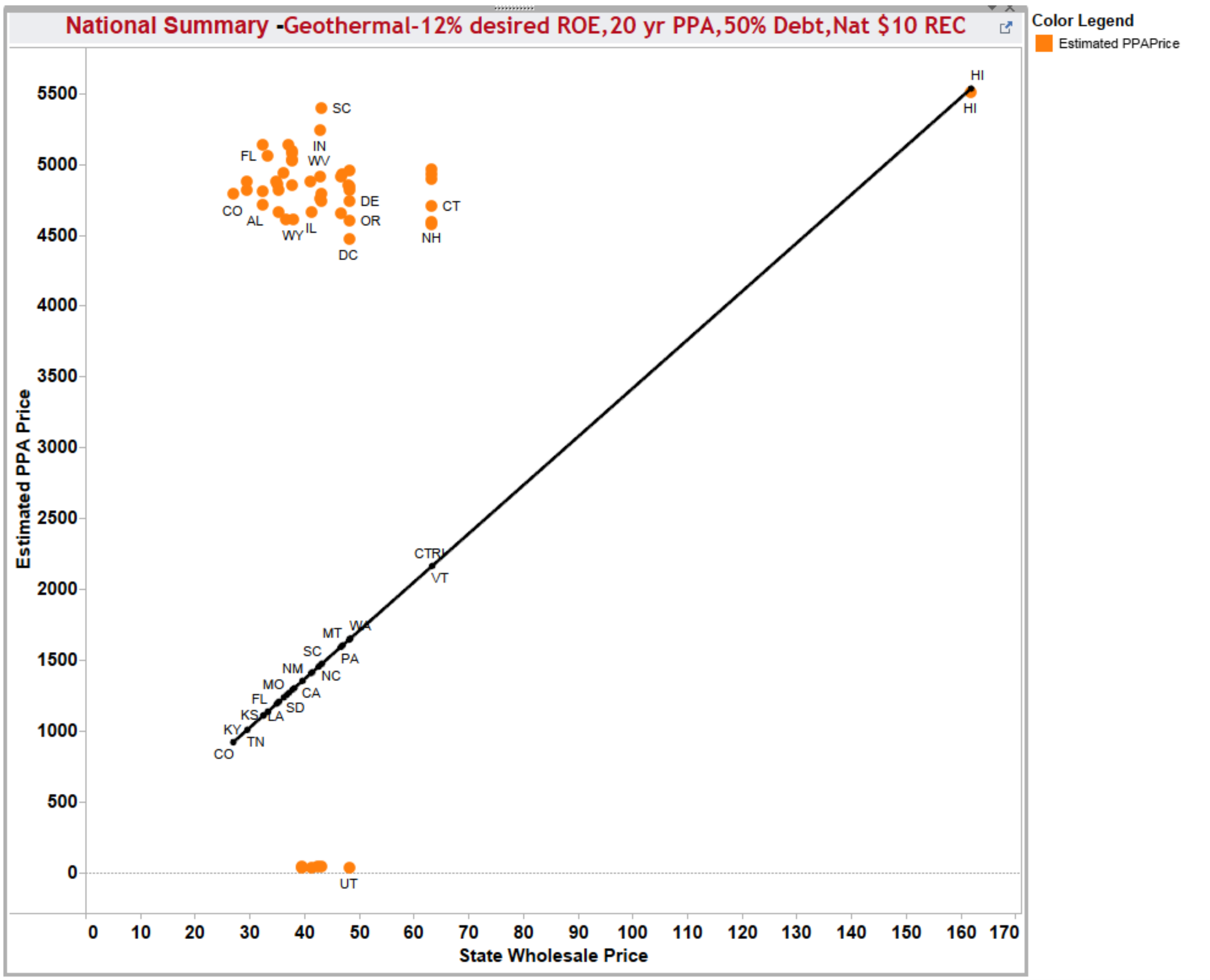


Figure 11. National Summary Dashboard for Geothermal Technology within Tableau Desktop.

Figure 12 displays two maps indicating the relationship between the state exemptions and the calculated LEP versus the state's input wholesale price for all the 50 states.

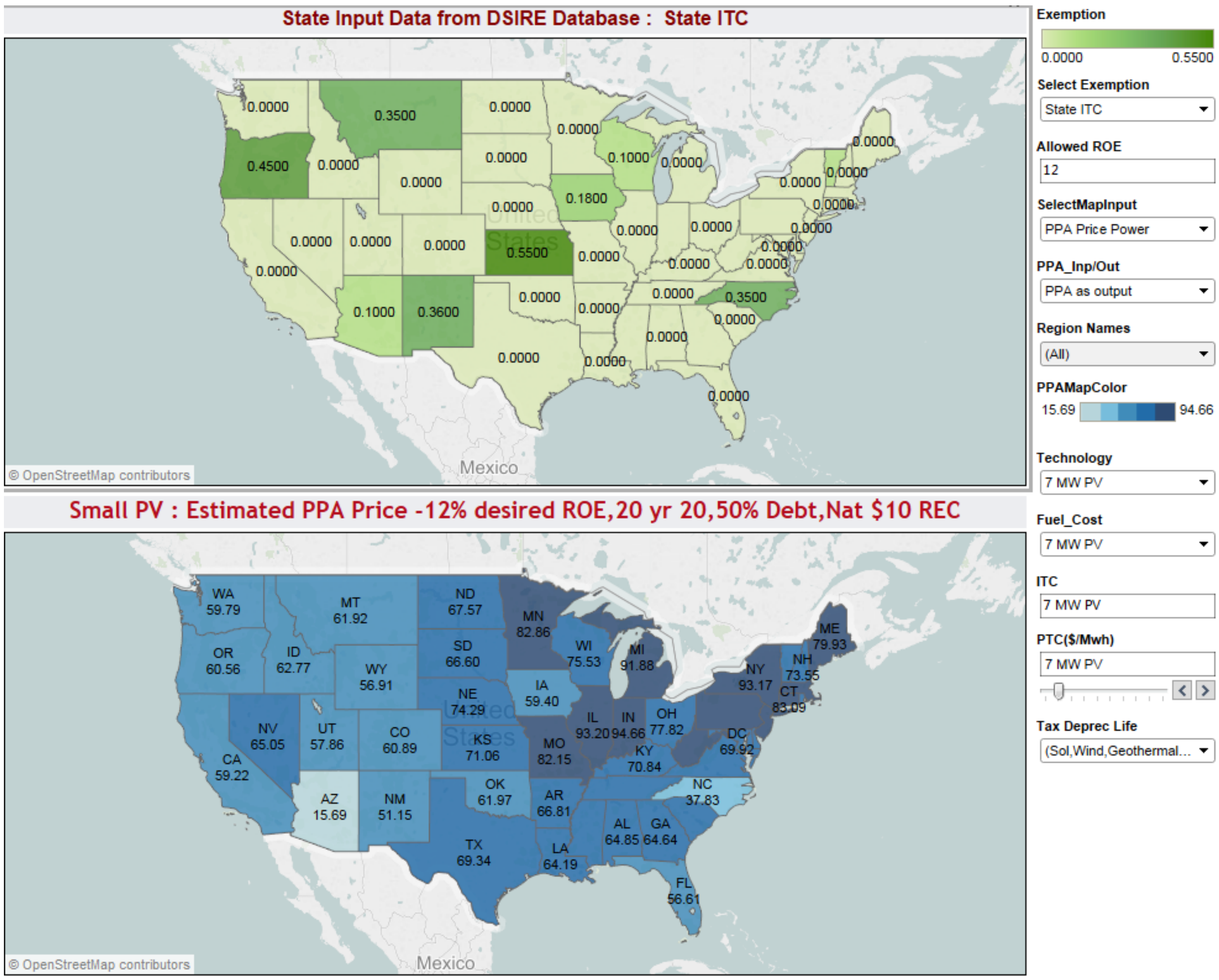


Figure 12. StateData-DSIRE+ LEP Map Dashboard within Tableau Desktop.

5.2 TABLEAU SERVER SOLUTION

5.2.1 Tableau Server 9 Installation

Tableau Server (version 9.0.5 9000.15.0820.1222 64-bit) is currently installed on an ORNL Windows server machine. This production environment is a virtual machine that has two processors with four physical cores each. This is an externally facing virtual machine running Windows server 2012, which is accessible from any web browser (e.g., Internet Explorer, Firefox) using user credentials.

5.2.2 Tableau Server Workbook Features

- The Tableau Server enables the accessibility to the PFMT Tableau workbooks using internet and any web browser from any location. The workbooks accessed through the server are fully interactive and require no additional software installations for the PFMT operation. Hence, the server allows broader usage and is not just restricted to the DOE_EPSA analysts.

- The workbooks that are currently accessible from the Tableau server are pre-computed scenarios. Hence, the visualization of the results of the model in response to user inputs is extremely fast since we are not directly interfacing with the R environment to do the calculations on the fly, thereby saving the computation time.

- Although this workbook version does not expose the complete capability of the tool, it is ideal for decision makers who are not hardcore financial analysts because it facilitates identification of key insights and enables easy understanding of the results with a fairly simple and intuitive user interface.

5.2.3 Tableau Server Workbook Scenario Details

For the Map Dashboard, the following scenarios were computed:

1) Four Technologies – 150 MW, Onshore Wind, GasCC, and Gas CT
2) Interest Rate – 5% and 7 %
3) Allowed ROE – 8% and 12%
4) Fed Income Tax Rate – 0% and 35%
5) ITC – 0, 10, 20, 30% (Only for 150 MW Technology with Fed IT = 35% fixed, Allowed ROE = 8% fixed, PTC = 0 fixed, InterestRate = 5% fixed)
6) PTC – 0 and 22 (Only for Onshore Wind Technology but all combinations of ROE, Fed IT, and Interest Rate)

For the NetCashFlow Dashboard, the following scenarios were computed:

Interest Rate – 5% fixed.

1) Four Technologies – 150 MW, Onshore Wind, GasCC, and Gas CT
2) Allowed ROE – 8% and 12%
3) Fed Income Tax Rate – 0% and 35%
4) ITC – 0, 10, 20, 30% (Only for 150 MW Technology with Fed IT = 35% fixed)
5) PTC – 0 and 22 (Only for Onshore Wind Technology but all combinations of ROE and Fed IT)

For Geothermal, Biomass, Offshore Wind, Building PV, two scenarios for each were computed based on the default technology inputs from PFMT_V2j.xlsm version (With interest rate 5% fixed, Fed Income tax rate 35% fixed, and ROE 8% and 12%).

5.3 TABLEAU STORY POINTS FOR ILLUSTRATION

Story Points is a way to create a narrative with data. You can tell a story with data, just as you can tell a story with pictures. For illustration purposes, two story points were created (Figure 13 and Figure 14) within the workbook (Tab color Red) showing PTC sensitivity analysis for onshore wind and sensitivity analysis of ITC for large PV technology.

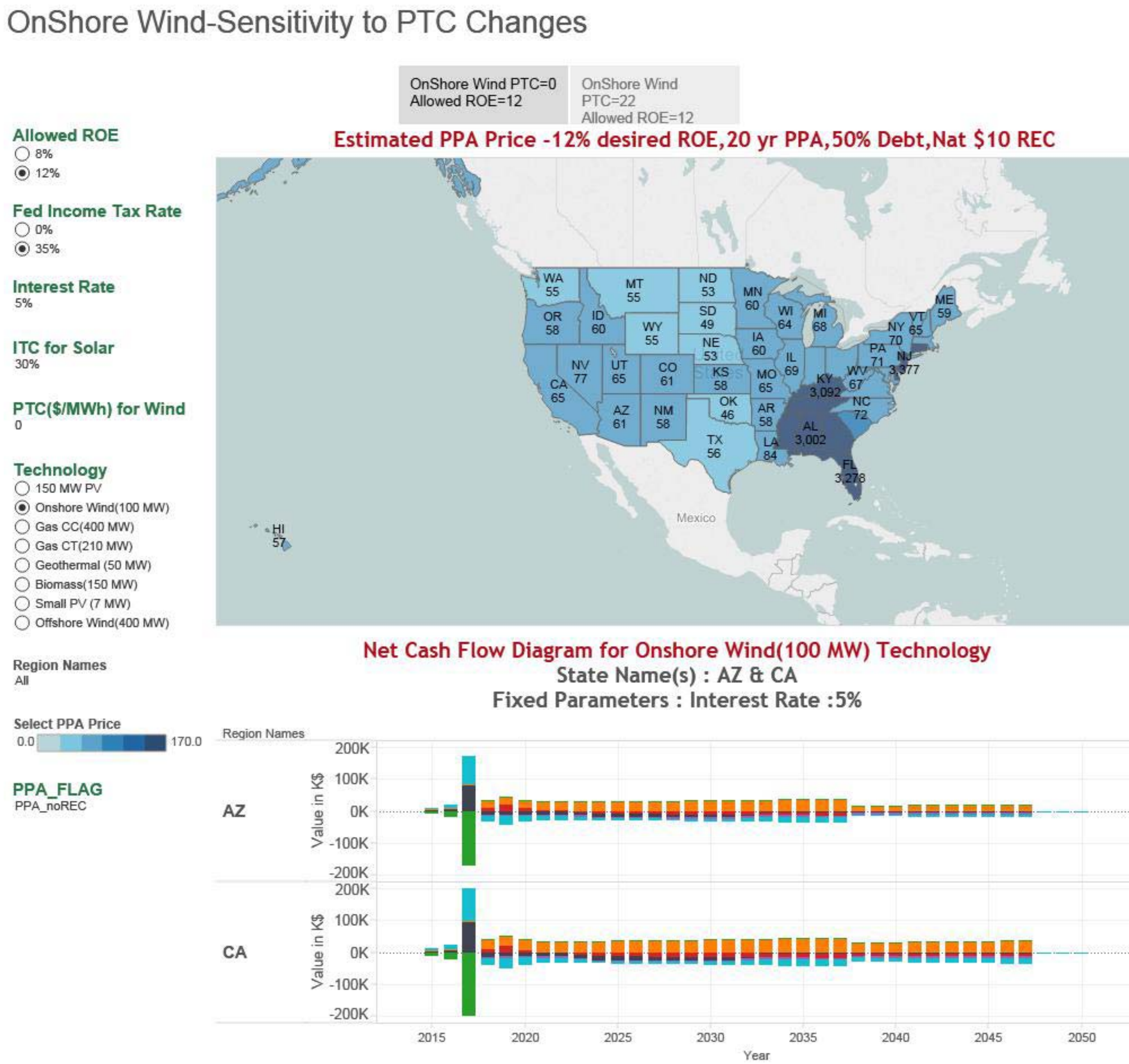


Figure 13. Story Points Describing Sensitivity to PTC Changes for Onshore Wind Technology.

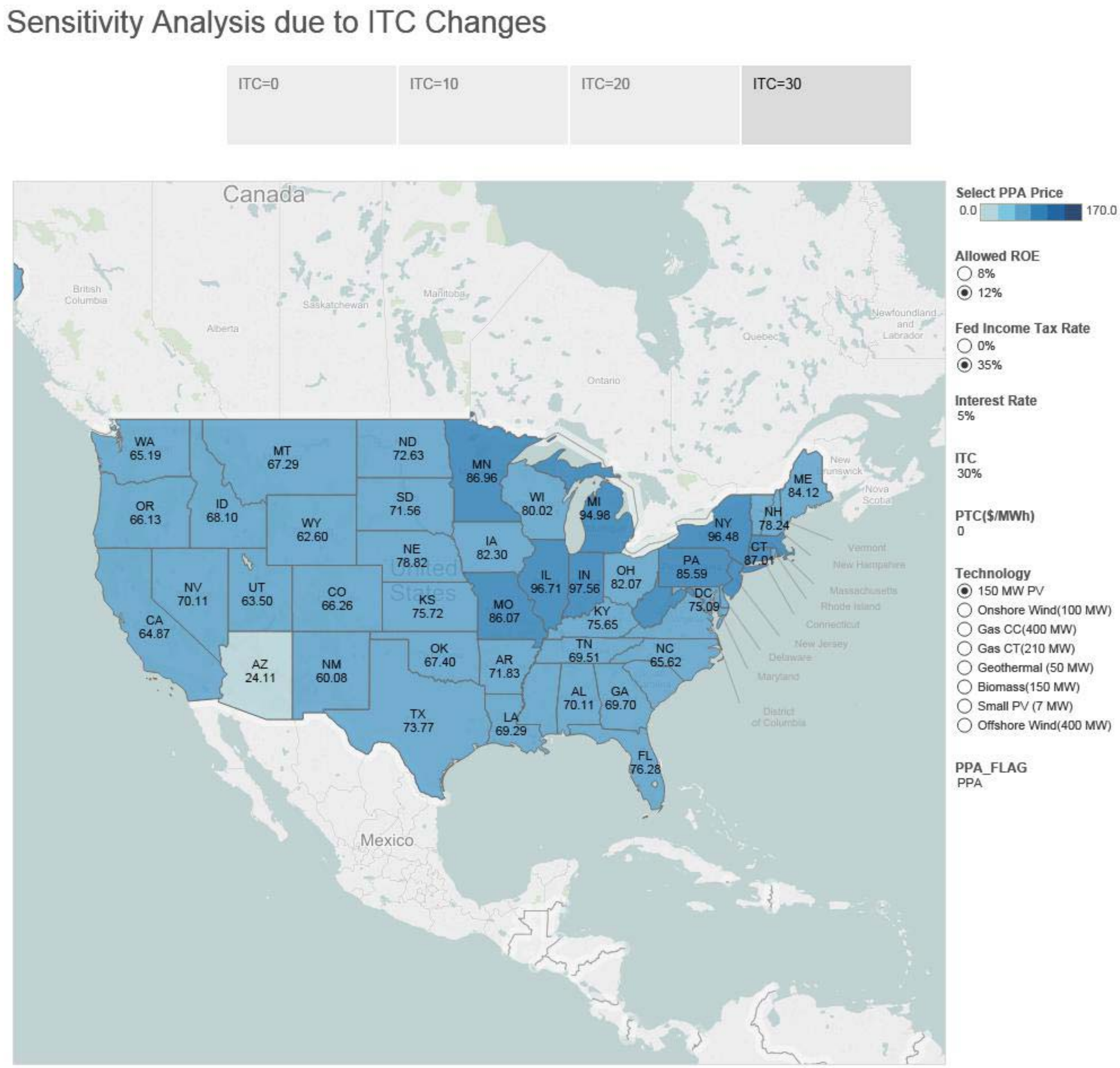


Figure 14. Story Points Describing Sensitivity to ITC Changes for Large PV Technology.

5.3.1 Tableau Dashboards Published On Tableau Server

Below is the list of worksheets created within the pre-computed workbook that were used to create various dashboards.

- Estimated LEP Output Map
- ITC Selection
- NetCashFlow
- Dashboard Outputs
- Technology-inputs

Figure 15 displays a dashboard consisting of the NetCashFlow and Technology inputs worksheet that allows simultaneous display of multiple cash flow charts for the selected states within the Region Names dropdown menu. All the input parameters, which the user can vary (Allowed ROE, Technology, PTC for Wind, ITC for solar, etc.), are displayed on the left, and the dashboards outputs (LEP, IRR (Debt+Equity) are displayed on the right.

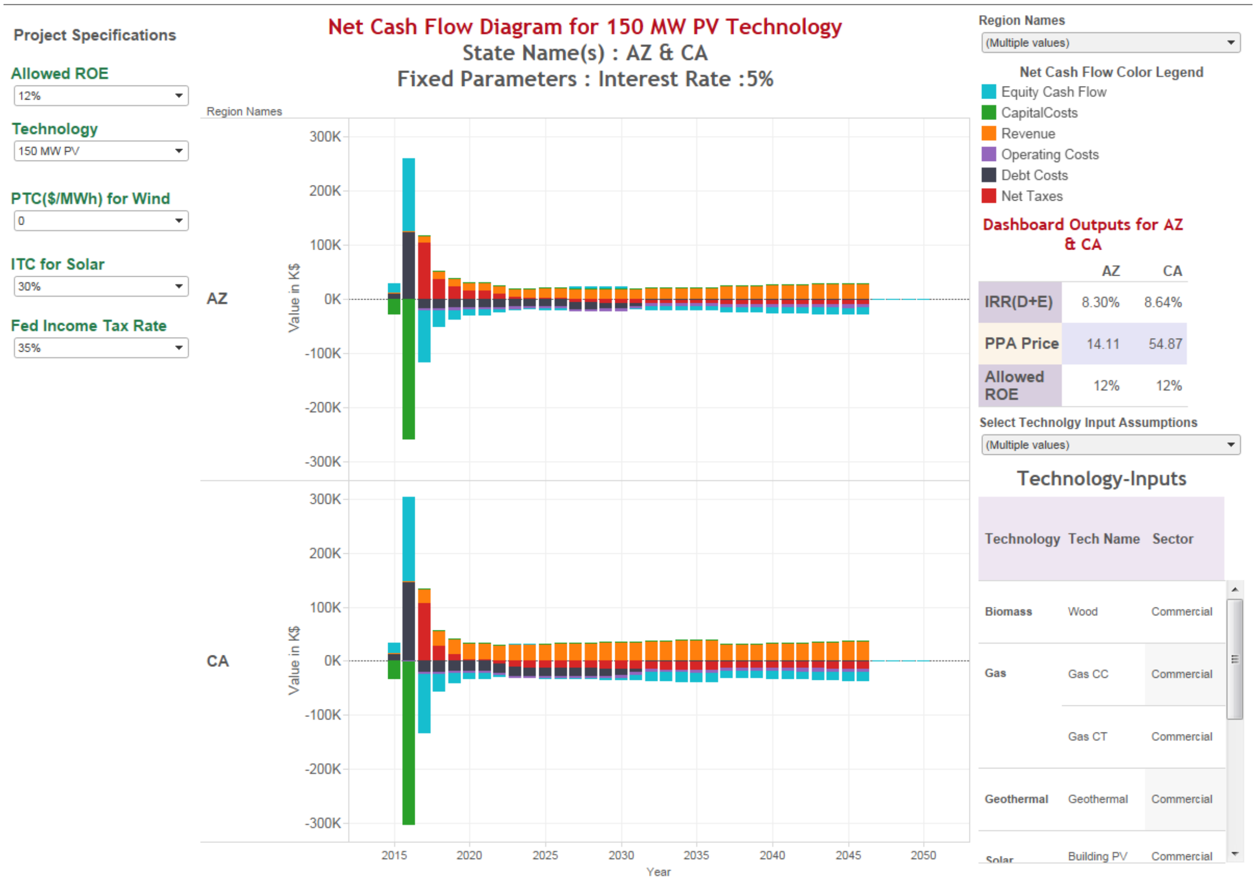


Figure 15. Net Cash Flow Diagram for 150 MW PV Technology.

The Figure 16 dashboard consists of the Estimated LEP Output Map worksheet that provides a national perspective of the LEPs estimated such that the return on equity matches a desired input level. All the input parameters, which the user can vary (Allowed ROE, Technology, PTC for Wind, ITC for solar, etc.), are displayed on the left, and the dashboard's outputs (LEP, IRR (Debt+Equity) are displayed on the right. Various input data sources used for all the technology, financial, and policy inputs can also be accessed within the same dashboard.

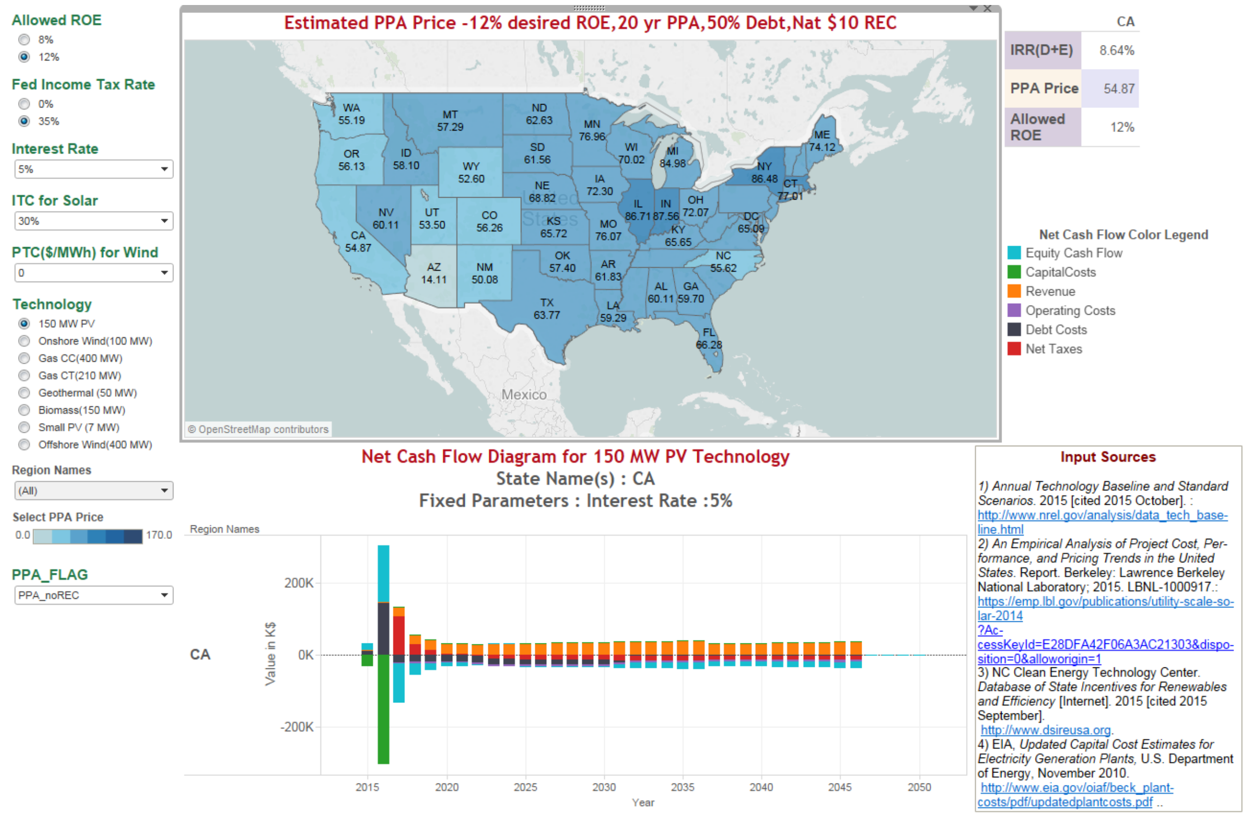


Figure 16. LEP Map Dashboard for 150 MW PV Technology.

The Technology-Inputs dashboard lists the same input data as in the TechnologyInputs worksheet in the Excel version (Table 10), although reformatted for use by Tableau. Figure 17 shows LEP Map dashboard view for Geothermal technology with 12% desired ROE and 5% interest rate as inputs.

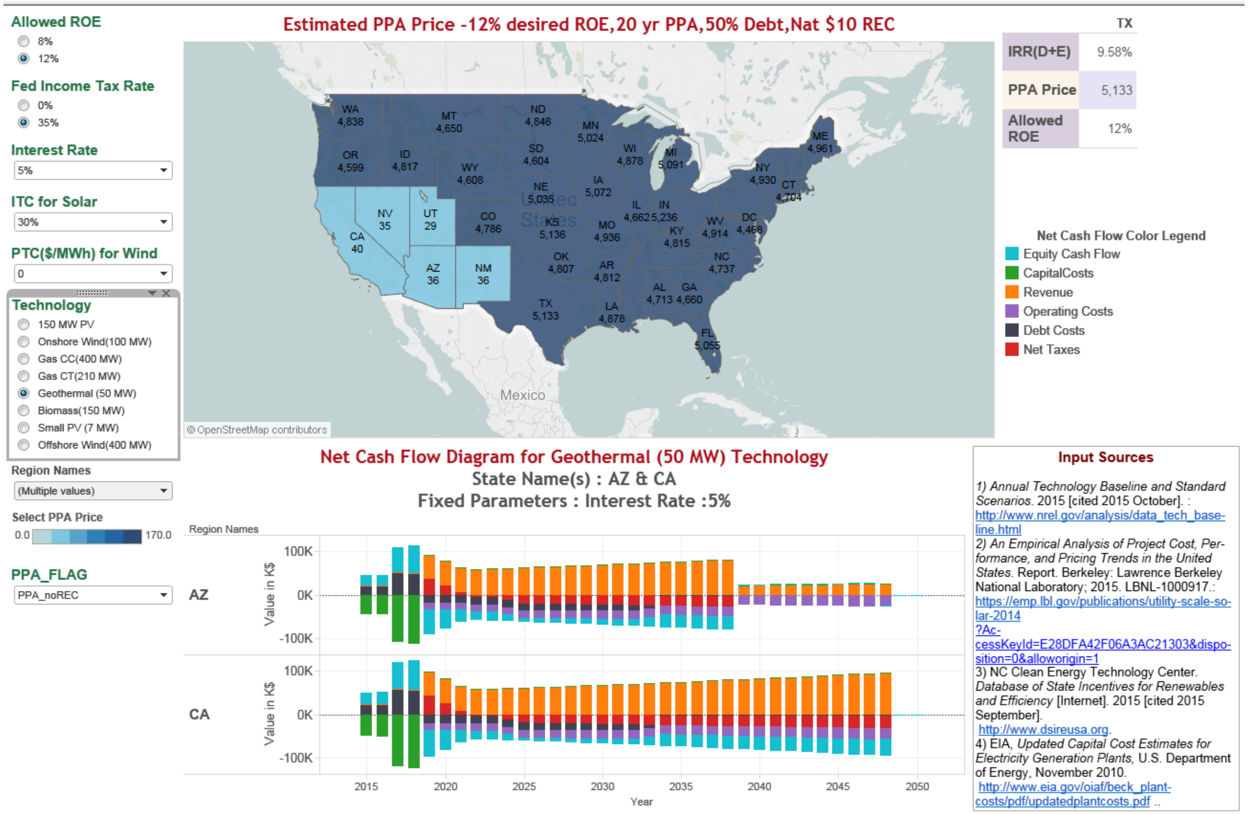


Figure 17. LEP Map Dashboard for Geothermal Technology.

5.4 Multi-Case Sensitivity Analysis Visualization

Analysts may wish to evaluate the impact of changing various key inputs over a range of values on multiple technologies. This is done on the MultiCase worksheet of the Excel model [refer to Section 5.3]. Results are automatically copied into the "Sensitivity Analysis" working after running various scenarios in the MultiCase worksheet.

The "SensitivityAnalysis_Dashboad.xlsx" workbook is an input file to the Tableau pre-computed workbook, namely "PrecomputedDashboards_Vxx.twbx".

NOTE: Whenever we generate new scenarios, the result values need to be appended into the "SensitivityAnalysis of the Excel model, and the data source needs to be refreshed within the "PrecomputedDashboards_Vxx.twbx" workbook.

5.4.1 ITC Sensitivity Analysis

Four tableau worksheets (ITCMap1, ITCMap2, ITCMap3, ITCMap4) were created to map the LEP-System prices on two United States tiled maps for two different ITC values (0 and 30%) using an ordinal color scale. The D6-ITCMaps Dashboard combines all four worksheets to allow comparison of the LEP-System Prices across four technologies (Figure 18). Each worksheet allows selection of one of the eight technologies that are currently being modelled. Therefore, the D6-ITCMaps Dashboard allows selection of four different technologies using TechInput 1, TechInput 2, TechInput 3 and TechInput 4 dropdown menus. Details of some of the Tableau variables are given below:

LEP_System

```
IF [LEP_System]<=-50 THEN "<=-50"
ELSEIF [LEP_System]>-50 AND [LEP_System]<=-10 THEN  ">-50 and <=-10"
ELSEIF [LEP_System]>-10 AND [LEP_System]<=10 THEN  ">-10 and <=10"
ELSEIF [LEP_System]>10 AND [LEP_System]<=50 THEN  ">10 and <=50"
ELSEIF [LEP_System]>50 AND [LEP_System]<=90 THEN  ">50 and <=90"
ELSEIF [LEP_System]>90 AND [LEP_System] <=100 THEN  ">90 and <=1000"
ELSE "NA"
END
```

System Price

```
CASE [Technology Selection 1] WHEN 0 THEN [Large PV System Price]
WHEN 1 THEN [Onshore Wind System Price]
WHEN 2 THEN [Gas CC System Price]
WHEN 3 THEN [Gas CT System Price]
WHEN 4 THEN [Geothermal System Price]
WHEN 5 THEN [Biomass System Price]
WHEN 6 THEN [Small PV System Price]
WHEN 7 THEN [Offshore Wind System Price]
END
```

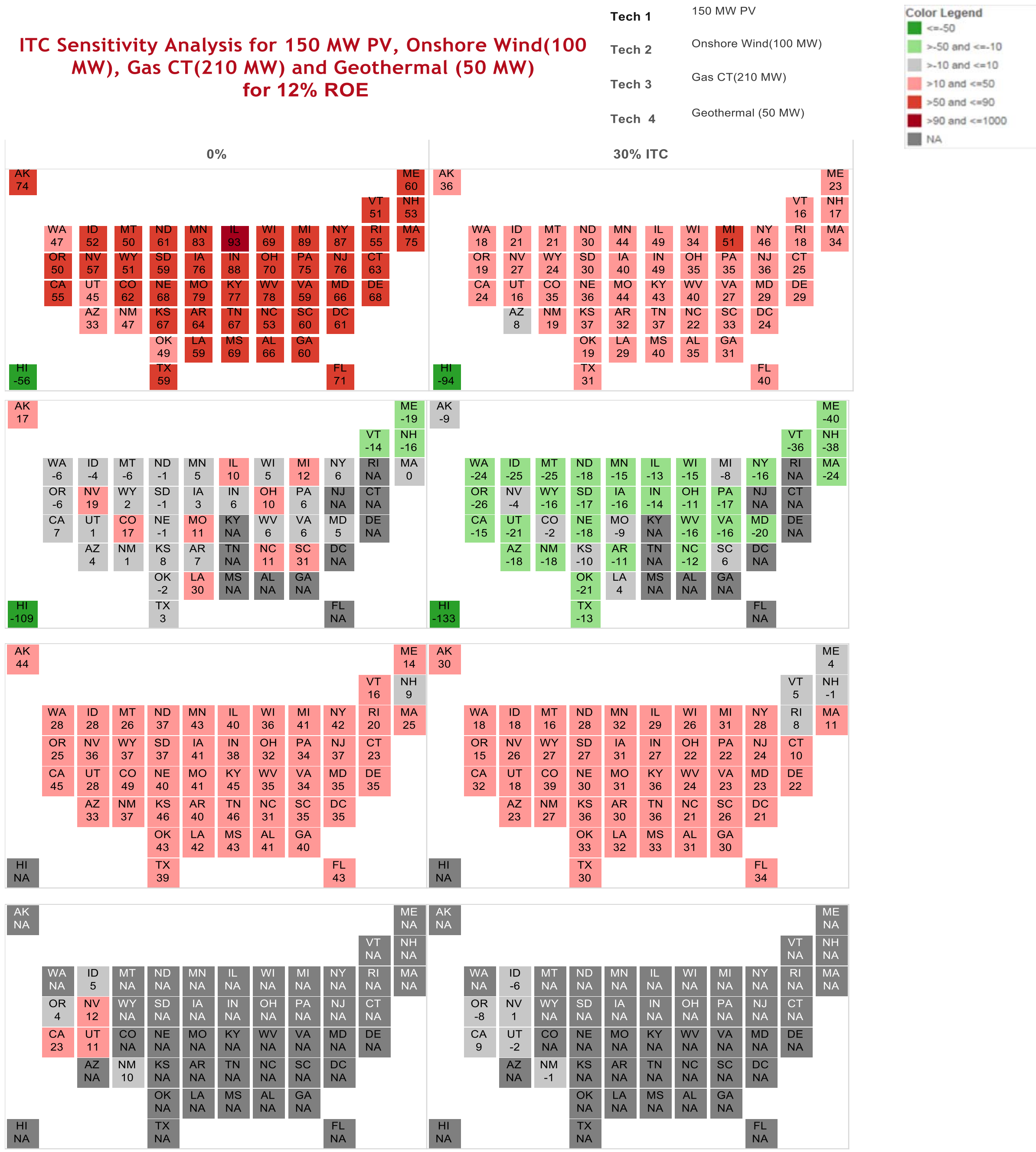


Figure 18. Tiled maps of LEP-System prices for LargePV,Onshore Wind,Gas CC and Geothermal Technology for 2 different ITC Values(0 and 30%).

5.4.2 PTC Sensitivity Analysis

Four Tableau worksheets (PTCMap1, PTCMap2, PTCMap3, PTCMap4) were created to map the LEP-System prices on two United States tiled maps for two different PTC values (0 and 22 $/MWh) using an ordinal color scale. The PTC worksheet of the SensitivityAnalysis_Dashboard.xlsx acts as the data source for this worksheet. The D7-PTCMaps dashboard combines all the four worksheets to allow comparison of the LEP-System Prices across four technologies (Figure 19). Each worksheet allows selection of one of the eight technologies that are currently being modelled. Therefore, the D6-ITCMaps Dashboard allows selection of four different technologies using TechInput 1, TechInput 2, TechInput 3 and TechInput 4 dropdown menus. Details of some of the Tableau variables are given below:

LEP_System

```
IF [LEP_System]<=-50 THEN "<=-50"
ELSEIF [LEP_System]>-50 AND [LEP_System]<=-10 THEN  ">-50 and <=-10"
ELSEIF [LEP_System]>-10 AND [LEP_System]<=10 THEN  ">-10 and <=10"
ELSEIF [LEP_System]>10 AND [LEP_System]<=50 THEN  ">10 and <=50"
ELSEIF [LEP_System]>50 AND [LEP_System]<=90 THEN  ">50 and <=90"
ELSEIF [LEP_System]>90 AND [LEP_System] <=100 THEN  ">90 and <=1000"
ELSE "NA"
END
```

NOTE: Row and space are the attributes used to create the tiled map view with “square” option chosen in the Mark view of the Tableau frontend.

5.4.3 Accelerated Depreciation Sensitivity Analysis

Four tableau worksheets (TaxDepLife-Map1, TaxDepLife-Map2, TaxDepLife-Map3, TaxDepLife-Map4) were created to map the LEP-System prices on two United States tiled maps for two different TaxDepLife values (5 and 30 years) using an ordinal color scale. The TaxDepLife worksheet of SensitivityAnalysis_Dashboard.xlsx acts as the data source for this worksheet. The D8-TaxDepLifeMap dashboard combines all four worksheets to allow comparison of the LEP-System Prices across four technologies simultaneously (Figure 20). Each worksheet allows selection of one of the eight technologies that are currently being modelled. Therefore, the D6-ITCMaps Dashboard allows selection of four different technologies using Technology Selection 1/2/3/4 dropdown menus. Details of some of the Tableau variables are given below:

LEP_System

```
IF [LEP_System]<=-50 THEN "<=-50"
ELSEIF [LEP_System]>-50 AND [LEP_System]<=-10 THEN  ">-50 and <=-10"
ELSEIF [LEP_System]>-10 AND [LEP_System]<=10 THEN  ">-10 and <=10"
ELSEIF [LEP_System]>10 AND [LEP_System]<=50 THEN  ">10 and <=50"
ELSEIF [LEP_System]>50 AND [LEP_System]<=90 THEN  ">50 and <=90"
ELSEIF [LEP_System]>90 AND [LEP_System] <=100 THEN  ">90 and <=1000"
ELSE "NA"
END
```

NOTE: Row and space are the attributes used to create the tiled map view with “square” option chosen in the Mark view of Tableau frontend.

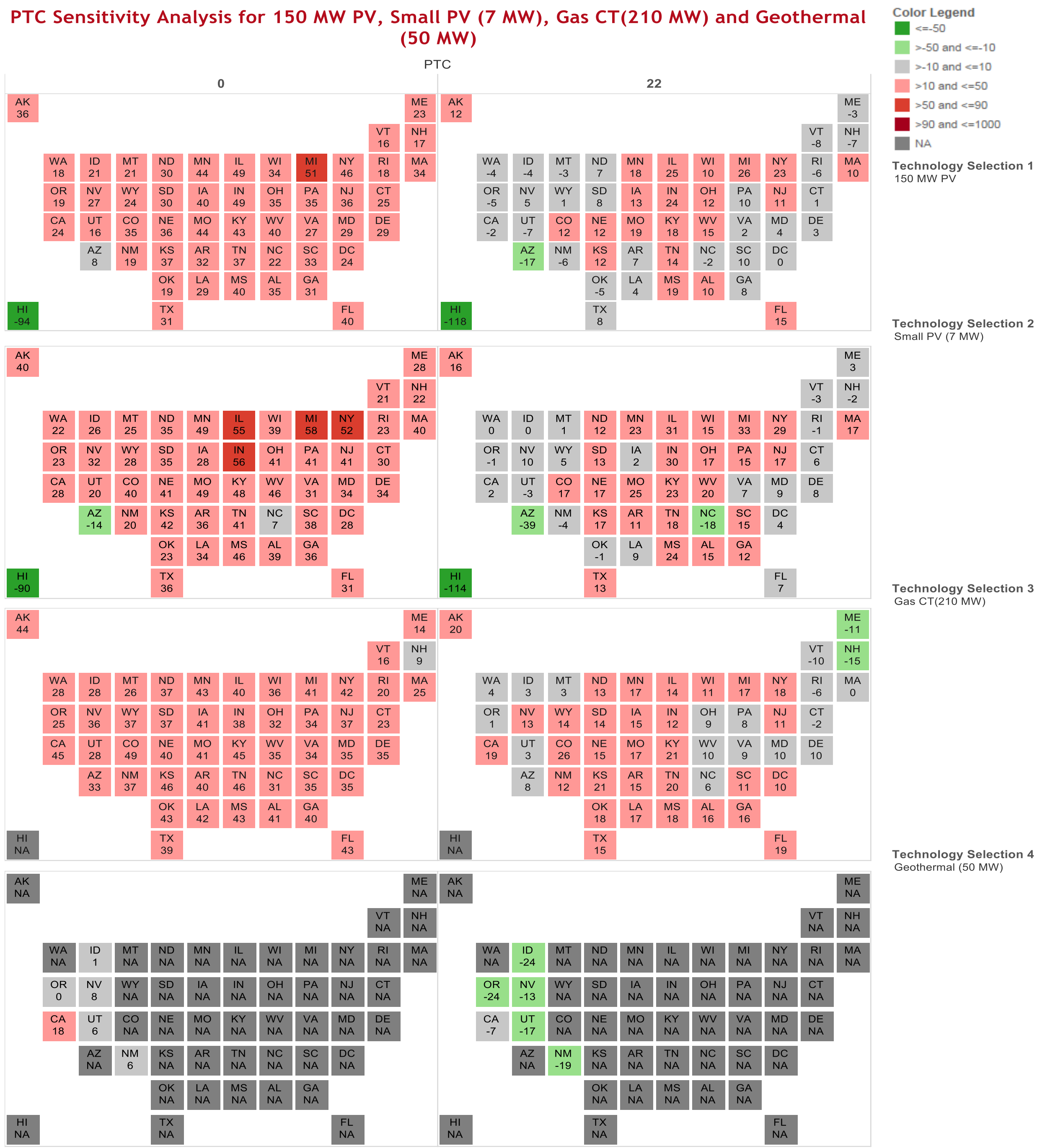


Figure 19. Tiled maps of LEP-System prices for Large PV, Onshore Wind, Gas CC, and Geothermal Technology for two different ITC Values (0 and 30%).

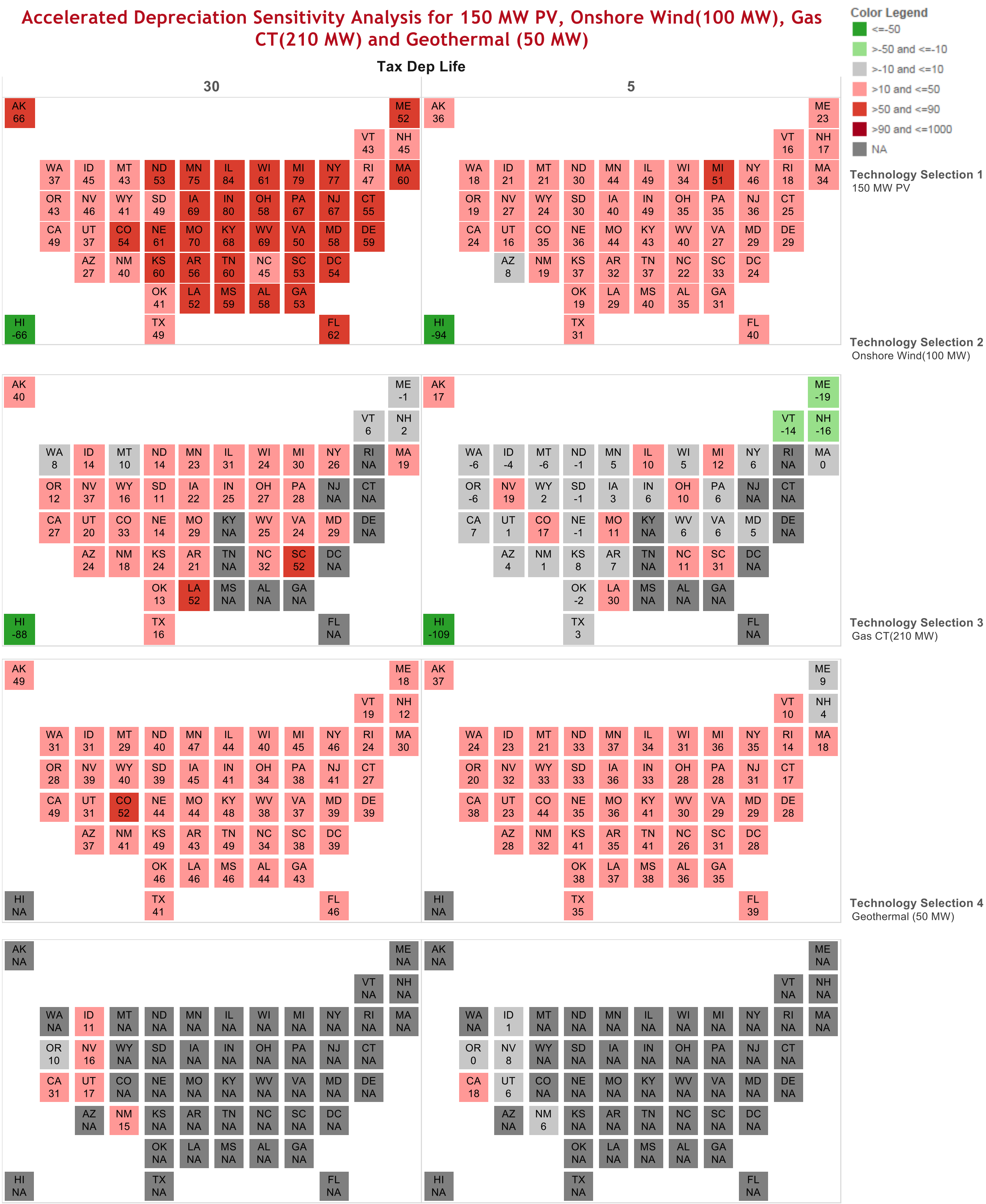


Figure 20. Figure shows eight tiled maps of LEP-System prices for Large PV, Onshore Wind, Gas CT, and Geothermal Technology for two different TaxDepLife Values (5 and 30 years).

5.4.4 Current Incentives Map

To be able to understand the impact of various tax policies and incentives on the economic viability of a new energy project, we first need a reference map to compare against. Using the Reference Cases worksheet of the SensitivityAnalysis_Dashboard.xlsx file, we created a Current Incentives map dashboard by generating eight images using the worksheet and combining them in the “CurrentIncentives-D9” dashboard sheet of the Tableau workbook (Figure 21).

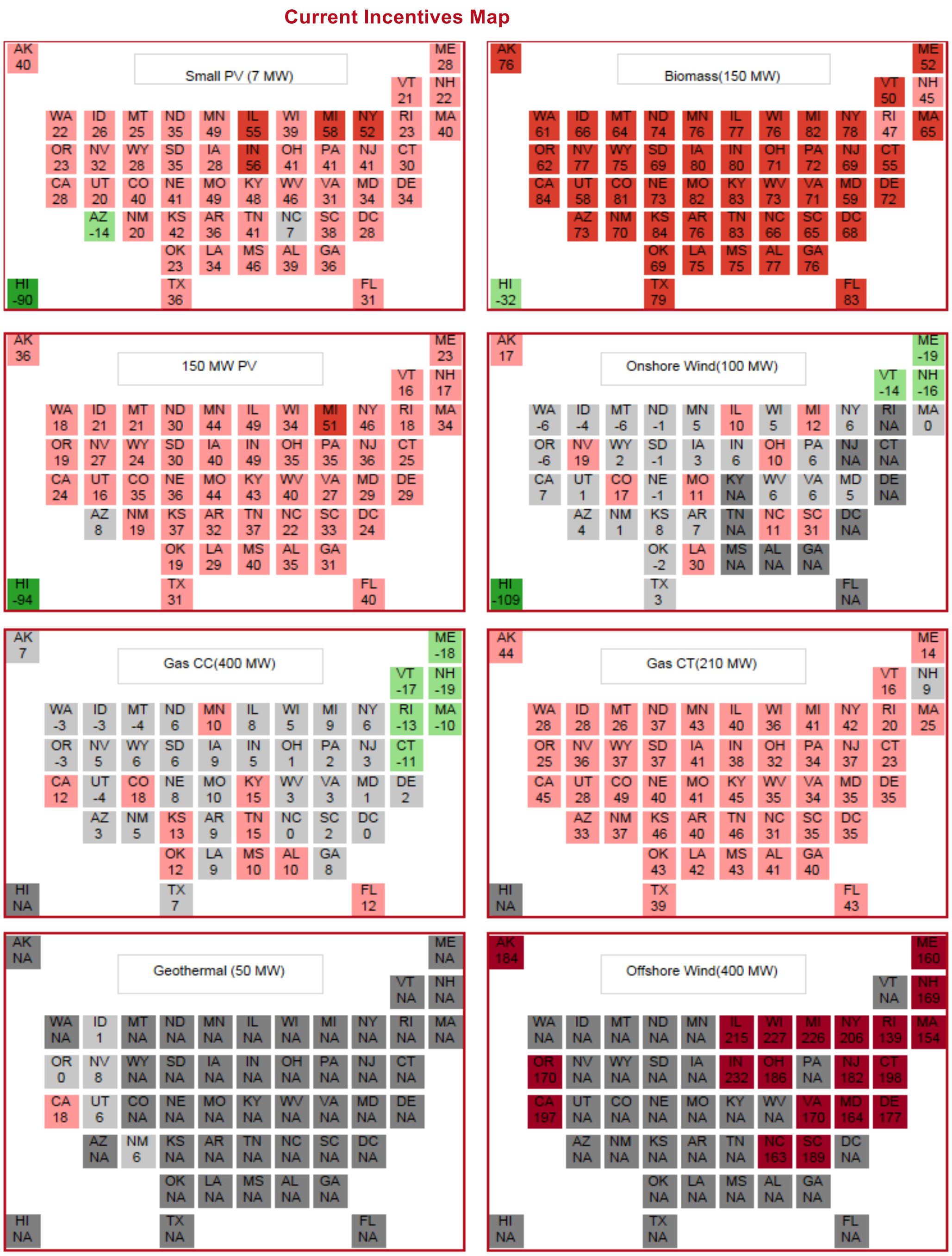


Figure 21. Eight tiled maps of LEP-System prices for Large PV, Onshore Wind, Gas CT, and Geothermal Technology with current valid incentives for ITC and PTC.

5.4.5 NoIncentives Map

To be able to understand the impact of current various tax policies and incentives on the economic viability of a new energy project, we also need a reference map with no incentives. Using the Refcases_Noincentives worksheet of the SensitivityAnalysis_Dashboard.xlsx file, we created a Noincentives map dashboard by generating eight images using the worksheet and combining them in the "NoIncentives-D9" dashboard sheet of the Tableau workbook (Figure 22).

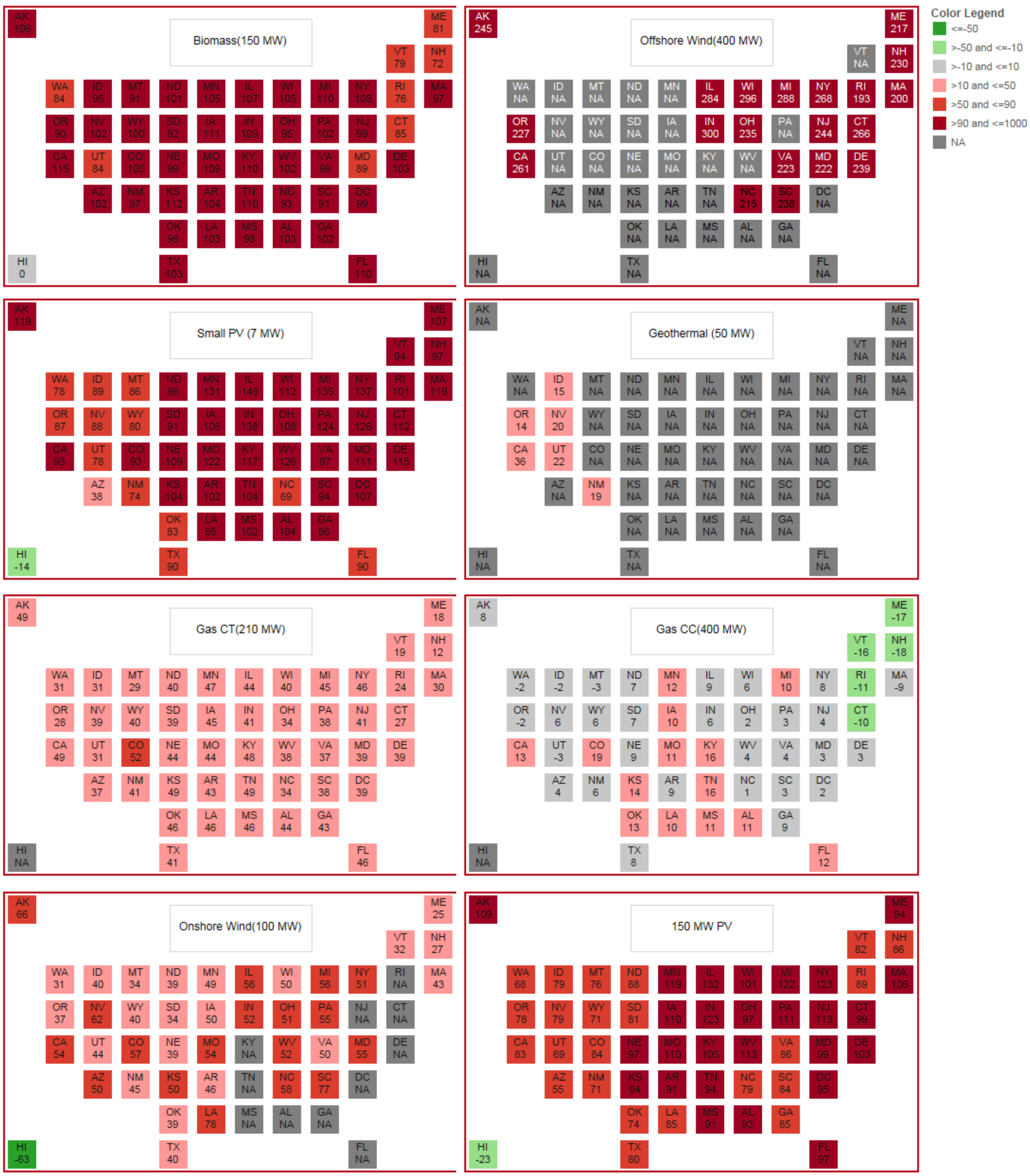


Figure 22. Eight tiled maps of LEP-System prices for Large PV, Onshore Wind, Gas CT, and Geothermal Technology with no incentives for ITC and PTC.

5.4.6 Box Plots for ITC Sensitivity Analysis

Two tableau worksheets named Box Plots-ITC SA and Box Plots-ITC SA2 were created to plot the LEP prices for all the states for four different ITC values as box plots. The ITC-SA-D5 Dashboard combines the two worksheets to allow comparison of the LEP prices between two technologies. Each worksheet allows selection of one of the eight technologies that are currently being modelled. Therefore, the ITC-SA-D5 Dashboard allows selection of two different technologies using Technology Selection 1 and 2 drop down menus. These plots (Figure 23) mainly help to identify outliers by displaying the upper and lower whiskers, quartiles, median values, etc. and the relationship between the ITC and LEP prices.

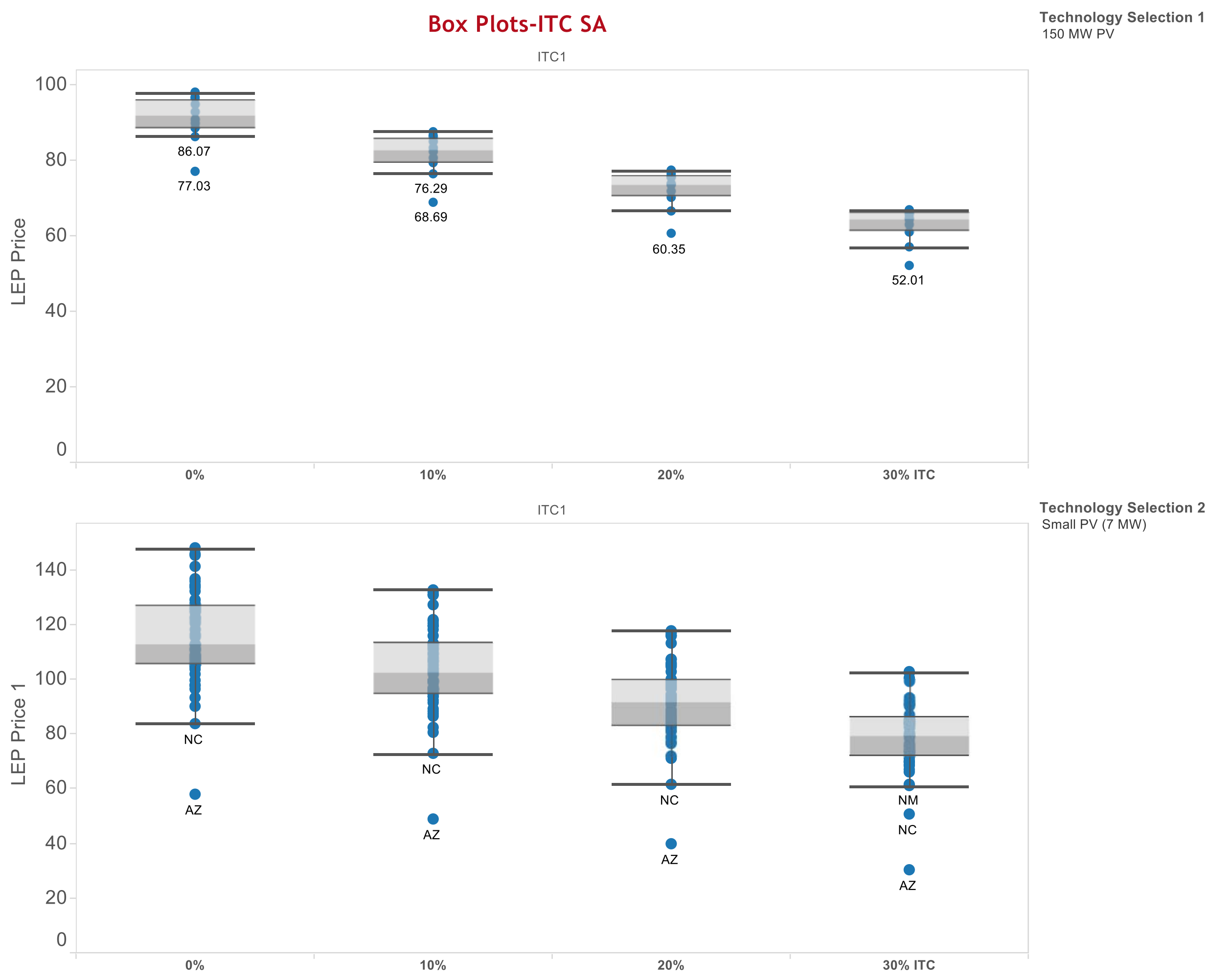


Figure 23. Box plots of LEP prices for Large PV and Small PV Technology for various values of ITC.

5.4.7 Line Charts for ITC Sensitivity Analysis

Two tableau worksheets (ITC-SA-LineCharts and ITC-SA-LineCharts1) were created to plot the LEP prices and System prices for all the states for four different ITC values as line charts. The ITC-SA-D1 Dashboard combines the two worksheets to allow comparison of the LEP prices between two technologies. Each worksheet allows selection of one of the eight technologies that are currently being modelled. Therefore, the ITC-SA-D5 Dashboard allows selection of two different technologies using

Technology Selection 1 and 2 drop down menus. These plots (Figure 24) mainly help to identify the relationship between the ITC and LEP prices. A new parameter (BottomN) has been defined that allows filtering only the top N states with the least LEP prices.

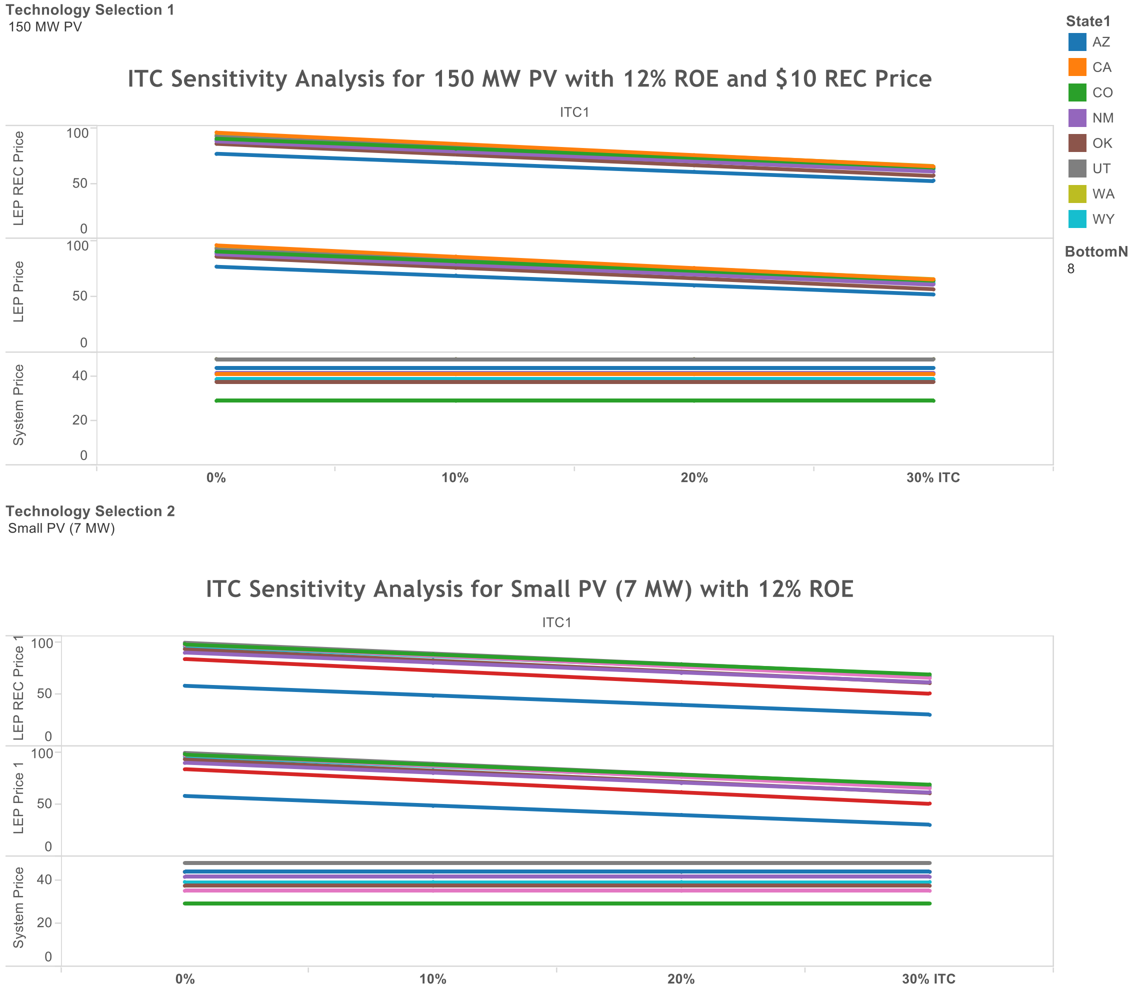


Figure 24. Line of LEP prices and System prices for Large PV and Small PV Technology for various values of ITC.

Similarly, the ITC-SA-D2 Dashboard displays the ROE and ROE D+E values for all states. Therefore, the ITC-SA-D2 Dashboard allows selection of one of different technologies using Technology Selection 1 drop down menus. These plots (Figure 25) mainly help identify the relationship between the ITC and ROE D+E prices. Color represents different states.

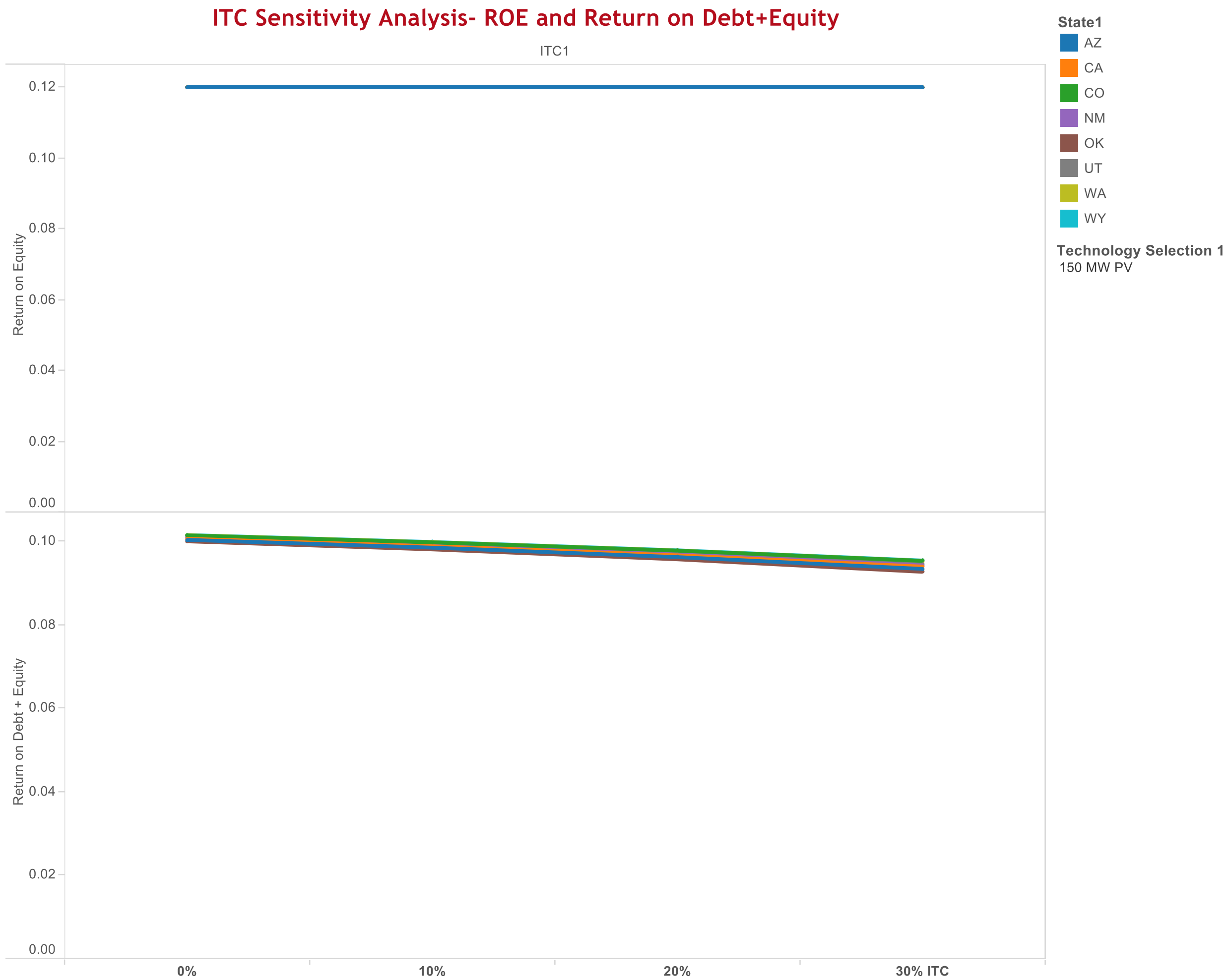


Figure 25. ROE prices and ROE D+E prices for LargePV and Small PV Technology for various values of ITC.

5.4.8 NPV Charts for ITC Sensitivity Analysis

The ITC-SA-D4 Dashboard displays REC Revenue, Energy Revenue, Fed Tax Credits, Debt Issued, Fed Incom + CO_2 Taxes, State/Local Net Tax, Fuel+O&M Cost, Capital Outlays, Int+Debt Repaid and Net Equity values for selected states (Figure 26). The ITC-SA-D2 Dashboard allows selection of one of different technologies using the Technology Selection 1 dropdown menu. Color distinguishes the different attributes displayed as a stacked bar chart. ITC has four values in this dashboard: 0%, 10%, 20%, and 30% ITC.

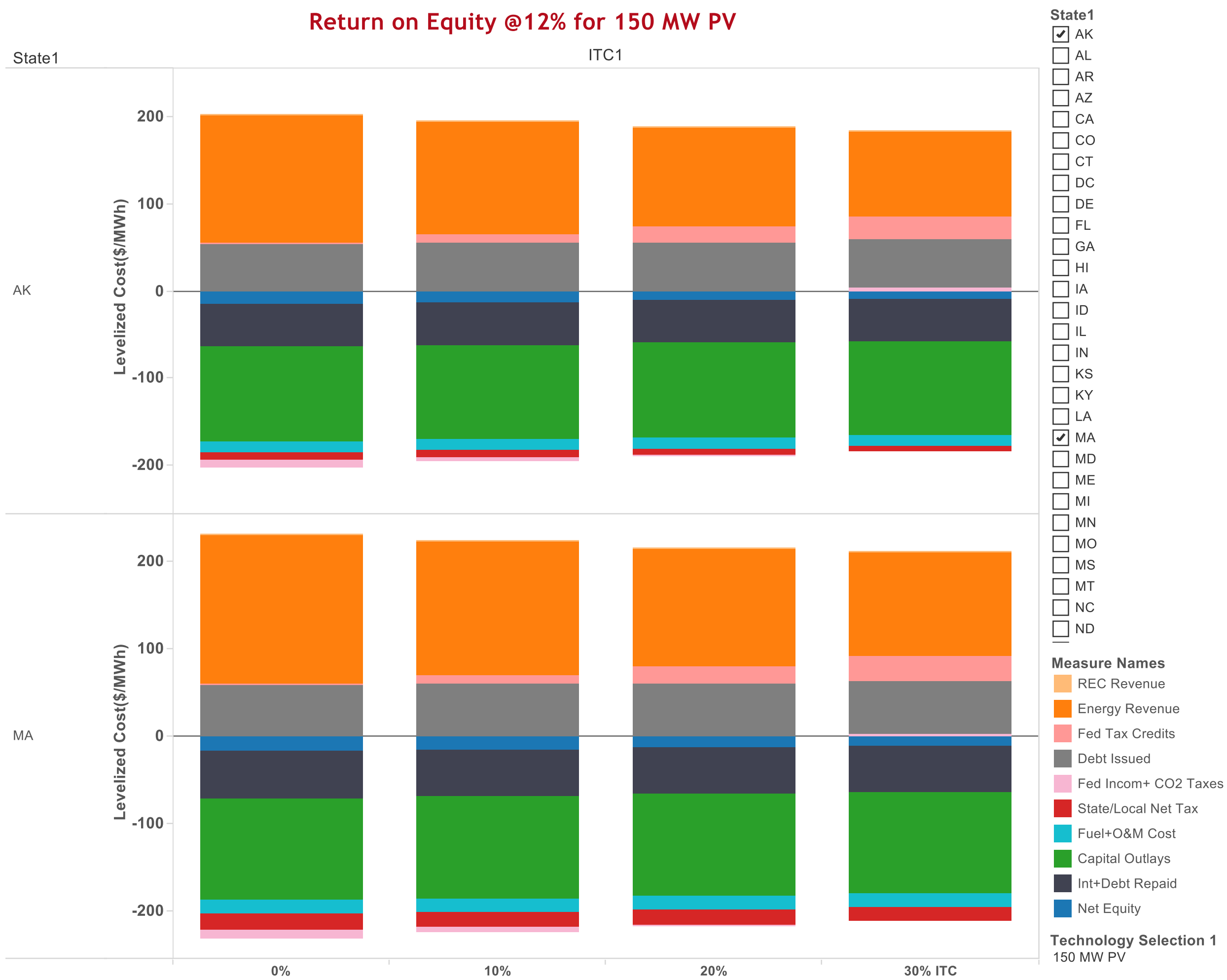


Figure 26. NPV Dashboard for Large PV Technology displaying values for different ITC inputs.

5.4.9 Net Cash Flow Charts for ITC Sensitivity Analysis

The ITC-SA-D3 Dashboard displays Net Taxes, Operating Costs, Revenue, Net Debt, Capital Costs and Net Equity values for selected states (Figure 27). The ITC-SA-D3 Dashboard allows selection of different technologies using the Technology Selection 1 drop down menu. Color distinguishes the different attributes displayed as a stacked bar chart. ITC has four values displayed in this dashboard: 0%, 10%, 20%, and 30% ITC.

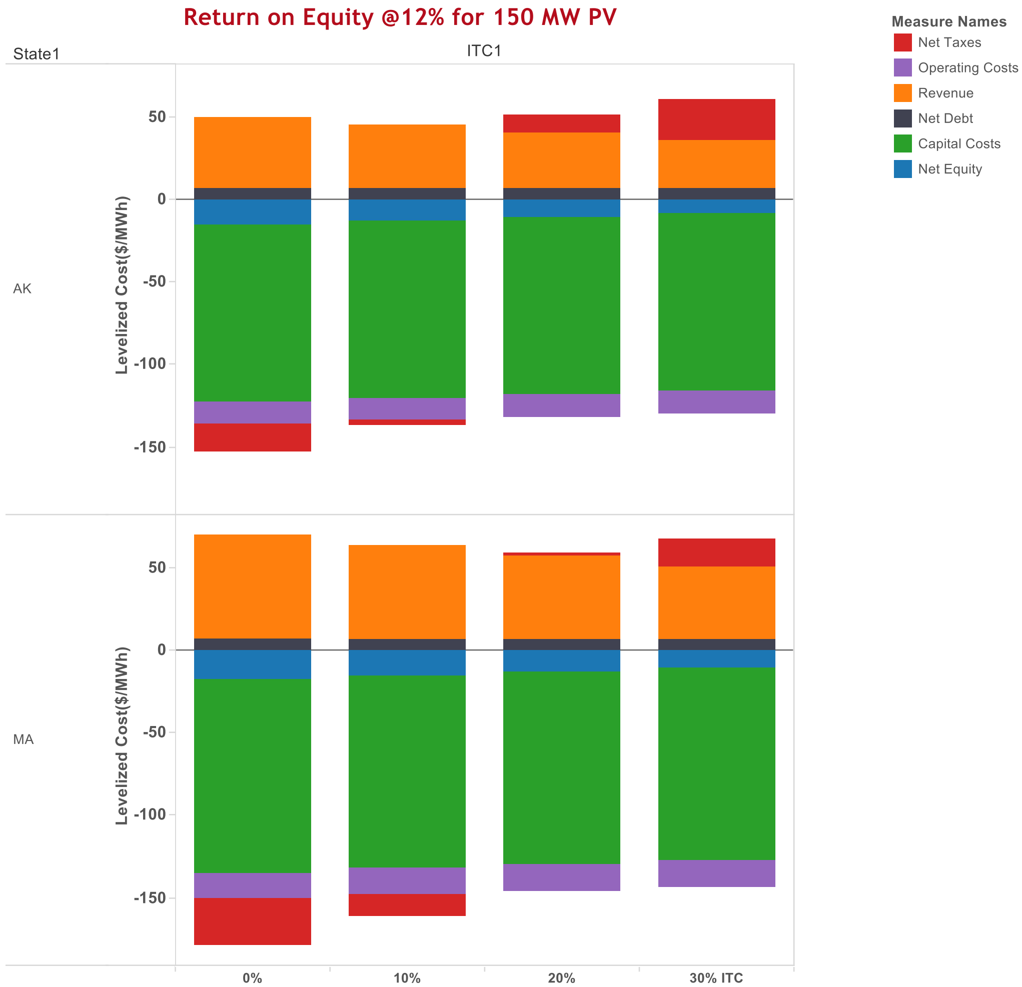


Figure 27. NetCashFlow Dashboard for Large PV Technology displaying values for different ITC inputs.

6. PFMT OPERATIONS

6.1 EXCEL DASHBOARD

In the Excel workbook, the first worksheet (Dashboard) provides the location for key inputs to be set (name, description, technology); the solution objective to run (Return on Equity, Return on Debt + Equity, CO_2-adjusted System Price, Fixed Price, Stored Case); and key output results. The outputs include a table of the levelized cost of the different cost components. A map shows the state-by-state values for different parameters, and other charts show the cash flow and calculated versus system prices.

6.1.1 Input settings

The Case Name can be anything and appears in the title of the map on the page. The Case Description can be longer to reference distinguishing features of this run. The Technology selection is limited to those listed in the TechnologyInputs worksheet, and the State listed is used to identify state showing in the net cash flow chart, as well as within FINModule.

The energy price can be adjusted for each state to meet a variety of objective functions. The inputs to define the objective are listed in Table 15. A desired Return on Equity or Return on Debt + Equity can be entered. The Return on Debt + Equity includes both equity cash flows and debt-related cash flows and can be thought of as the return on capital or pre-tax weighted average cost of capital (WACC). Alternatively, the prices from one of the cases stored earlier can be applied to understand the impact of changing a policy but leaving the prices unchanged. The third parameter lets the user specify which case to use. Alternatively, the user can specify a single price in the fourth parameter that all states use for their energy price. A user can also specify that the CO_2 adjusted System Price be used for all years. The fifth parameter is where the user specifies which of the five objectives should be used in the calculation by use of a drop-down list of choices.

Table 15. Dashboard Objectives Inputs

	Desired	Actual
Return on Debt + Equity	9.00%	**9.41%**
Return on Equity	12.00%	**12.00%**
Stored Case to Use for Price	2	
Fixed Price to Use	$60.00	
Objective to Solve For	ROE	**Return on Equity**

6.1.2 Results Table

Two tables are included that disaggregate the project cash flow stream into the net present value using the desired WACC value showed elsewhere on the sheet. The first table disaggregates on specific categories, and the second table shows the same information arranged by the different groups interacting with the project, similar to what is shown in Figure 1. Examples of the two tables are shown in Table 16 and Table 17. The values are shown both in thousands of $ and in $/MWh. The latter is found by dividing the NPV of costs by the NPV of the production from the project.

Table 16. Results using desired return on debt + equity @ 9% for Large PV in New York

Energy Revenue	REC Revenue	Fuel+ O&M Cost	Capital Outlays	Reserves Accounts	Debt Issued	Interest+ Debt Repaid	Fed ITC+PTC	Fed Taxes	State/Local Net Tax	Net to Equity	Net to Debt + Equity
$332,739	$-	$-43,536	$-326,332	$-7,224	$171,785	$-150,184	$81,635	$8,360	$-37,546	$29,696	$8,095
119.96	0.00	-15.70	-117.65	-2.60	61.93	-54.15	29.43	3.01	-13.54	$10.71	$2.92

Table 17. Results by group using desired return on debt + equity @ 9% for Large PV in New York

Ratepayers	Suppliers & Employees	Creditors	Federal Taxpayers	State Taxpayers	Equity Holders
$332,739	$-369,868	$14,377	$89,995	$-37,546	$29,696
119.96	-133.35	5.18	32.45	-13.54	10.71

6.1.3 Charts

A map has been developed that gives state-by-state color changes based on the values for that state. A user can select which values to appear in the map by changing the label in the drop-down menu on cell J12: (LEPR, LEP, LEP−System, LEP Diff, ROE). The LEPR option shows the levelized price for energy during the fixed price life plus any REC price, and the LEP plot shows only the calculated energy price. The LEP−System option subtracts the average system price from this energy only price to reflect the competitiveness of the energy cost from the technology. If a project has a significant REC income, then the energy price will be lower to receive the desired ROE. The LEP Diff option shows the LEP minus the price from a stored case, which is identified in cell K through 12. Lastly, ROE displays the actual return on equity for each state.

An example map is shown in Figure 28. The map displays a color-coded state map with a legend showing the values for major colors in the map. High values at or above the top value in the legend are all given the dark red color. This color then fades to almost white as it approaches the bottom of the second range in the legend. The white range is for a narrow span of colors such as those near the marginal cost for the state. Colors below that range start at very light blue, becoming darker as they approach the value in the last block of the legend. States with very high values (i.e., not widely available in those states), have a grey color.The actual mapped values for each state are listed to the right of the map on the worksheet. If the user desires to change the ranges displayed, he/she can do so in the brown cells in Q70:T94.

Two other charts are also found on the Dashboard. The Project Cash Flow chart is a stacked column graph showing the components of project’s cash flow. In every year, cash flow must balance, so the graph will be symmetrical around the x-axis. During construction, funds are received from debt and equity holders (positive) and spent on construction-related activities or in the buildup of reserve accounts related to debt and upcoming operating costs. (Construction costs dominate in the example.) The LEP versus system price is an x-y plot of the project LEP and the system price. Those states with LEPs above system price would be above the black diagonal line, and those below the line have lower prices.

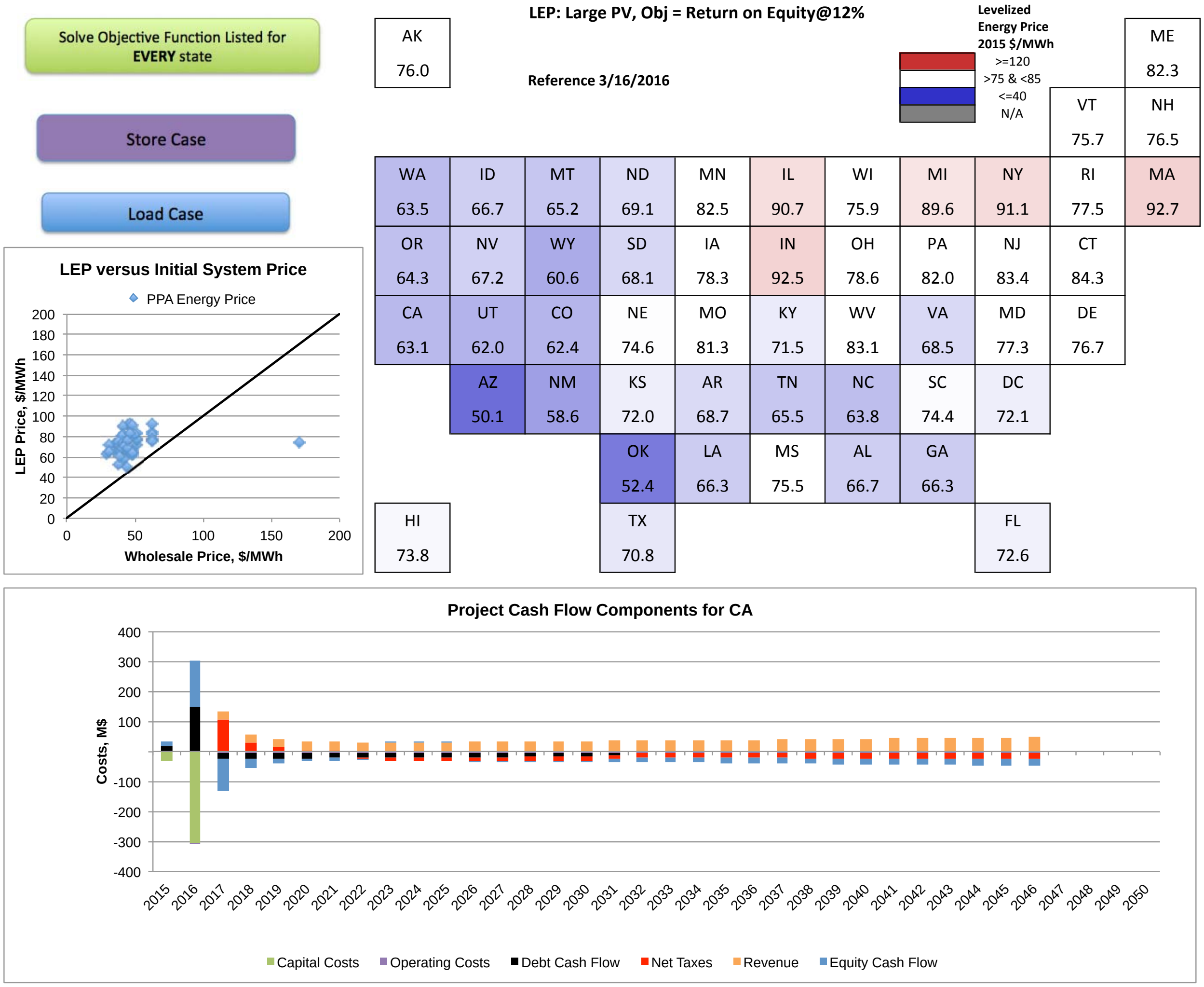


Figure 28. Example map and other charts from Dashboard for Large PV.

6.1.4 Dashboard Operations

There are three macro buttons underneath the objectives inputs table. The largest, green button will calculate the price for every state based on the objective selected, storing the results at the bottom of FINModule. The other two macros allow the user to store the input and key outputs of up to 20 different case runs, and the third button will load a specified case back into the worksheets. The case name and description of each of the 20 cases can be found listed below the charts and buttons. Each technology is stored in a separate column on StoredOutputs, so there can be up to 20 cases for each technology stored. Cases 1 through 10 are used in the MultiCase analysis described in Section 5.2. Case 11 currently stores the Reference cases to allow a user to quickly reload default results back into the model

The user can make any changes to inputs on any sheet and then select the green button to calculate the impact on all of the states. He/she can then examine the values for any state by entering a state code into the input block on the Dashboard. This should update the charts, tables, and FINModule calculations to match the parameters for that state. However, if the user then changes any other inputs, then he or she should press the green button after making the changes because the Dashboard charts only select data from the stored results at the bottom of FINModule, rather than selecting the live data in FINModule (which will not reflect changes otherwise).

As an example, suppose a user wants to change the federal income tax rate and run the cases. To do this, the user would:

1. Go to the FINModule worksheet.

2. Change the Fed. Income Tax Rate in cell G3 from 35% to whatever value is desired.

	A	B	C	D	E	F	G	H	I	J
1	Project Finance Mapping Tool - Financial Module			Dashboard Inputs			FINModule Inputs			FINModule Inputs
2										
3	Gas CT, Obj = ROE@12%, Int. rate=0.06		Technology	Gas CT		Fed. Income Tax Rate	35%		Debt Ratio	50%
4	Reference 3/23/16		State	CO		AMT/Carry Flag	No		Debt Max Life	15
5						AMT Depreciation Life	20		Interest Rate	6%
6			Technology Type	Gas		General inflation rate	2.0%		Debt Serv Resrve (%year)	50%
7			Capacity MW	210		Price Escal rate*	0.0%		Work Cap % of O&M	12.5%
8			Sector	Commercial		Constr Escal rate*	0.0%		Sale/LeaseBack	FALSE
9			Prod Tax Credit, $/Mwh	0		O&M Escal rate*	0.0%		Rent Coverage Ratio	1.15x
10			Fed Investmt Tax Credit	0%		Fuel Escal rate*	0.0%		LEP Life	30
11			ITC Applicable Capital	90%	* Escalation Rates are +/- general inflation				REC Price Flag	National
12			Tax Deprec. Life	15					Natl REC Price, $/MWh	0
13									Carbon Cost, $/T CO2	0

Figure 29. FINModule worksheet input section.

3. Go to the Dashboard worksheet.

4. Make a change to the Case Name (B2) and/or Description (B3) to identify the new case. (Note: In the Case Name, there may be an equation to generate it based on other parameters. The user can use it as-is, modify the equation, or type his or her own case name.)

	A	B	C	D	E
1					EPSA PRC
2	Case Name	Gas CT, Obj = ROE@12%, Int. rate=0.06			
3	Case Descrip	Reference 3/23/16			
4	Technology	Gas CT		Energy Revenue	REC Revenue
5	State (for CF graph	CO		494,396	0
6	Levelized Energy Price, $/MWh		76.09	95.05	0
7	Energy+REC Price, $/MWh		76.09		
8			Desired	Actual	
9	Return on Debt + Equity (WACC)		9.00%	10.40%	
10	Return on Equity		12.00%	12.00%	
11	Stored Case to Use for Price		12		
12	Fixed Energy Price to Use		$ 90.00		LEPR,
13	Objective to Solve For		ROE	ROE@12%	

Figure 30. Dashboard worksheet input section.

5. Select the Technology to be studied in B4.

6. Ensure that other inputs, such as the desired objective in C13, are selected.

7. Press the green button to re-solve the model for all 50 states (plus the District of Columbia).

8. Examine the new map values and colors, LEP versus system prices, and/or cash flow as desired.

9. Change the state in cell Dashboard!B5 to select a state in the cash flow graph and FINModule data.

10. Examine any other data of interest in FINModule.

If the user wishes to change one of the technology-specific variables (as shown in Table 10) then he/she would select the TechnologyInputs sheet instead of FINModule sheet for steps 1 and 2. If the user wished to change a state-specific value, he/she would select either the StateIncent sheet or StateInputs sheet to make the change.

6.2 MULTI-CASE ANALYSIS

Analysts may wish to evaluate the impact of changing various key inputs over a range of values on one or more technologies. This is done on the MultiCase worksheet.

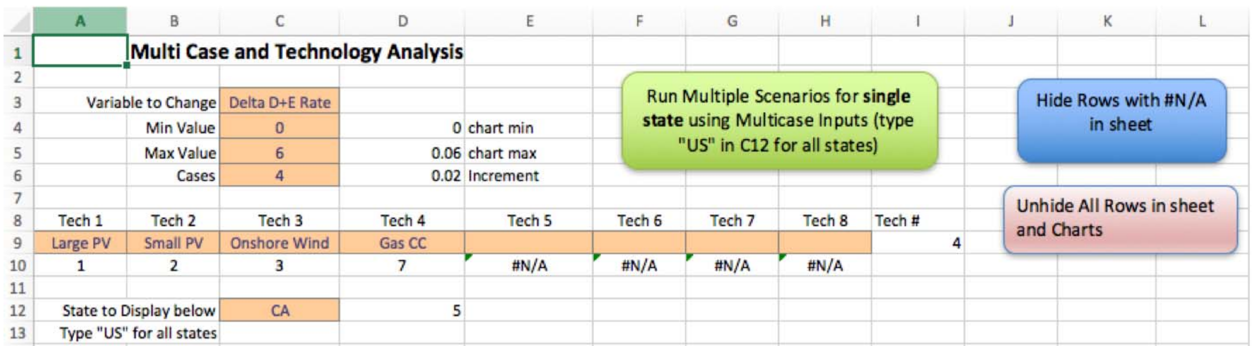


Figure 31. MultiCase worksheet input section.

On the MultiCase sheet, the user can specify in cell C3 which variable he/she wants to vary. The current list includes:

- Investment Tax Credit
- Production Tax Credit
- Income Tax Rate
- Tax Depreciation Life
- CO_2 Cost
- Return on Equity
- Interest Rate
- Return on Equity and Interest Rate
- National REC Price

The user then picks minimum and maximum values and the number of cases to be run (up to 10 per technology) in cells C4:C6. The variable is set at the minimum in the first case. If the numbers of cases (C6) is set at 1, then only the minimum value is run in the analysis. An increment to be added to the variable in each case is calculated in cell D6:

$$Increment = \frac{Max\,Value - Min\,Value}{(Cases - 1)} \qquad \text{Eq. 37}$$

The user can select any combination of the eight technology options to be analyzed. The user lists which options in cells A9:H9. If fewer technologies than eight are to be compared, then the remaining cells should be left blank. If the user wants to fill in the Tableau export files, he or she should have all eight technologies listed in A9:H9 (in any order) and select two cases to be run, one at the minimum and one at the maximum. Furthermore, the user should set the state to be “US” in cell C12. This causes the model to calculate and store the values for all of the states rather than just the one listed.

Three macro buttons are included on the worksheet. The green button, “Run Multiple Scenarios for single state using Multicase inputs (type ‘US’ in C12 for all states)” will run the model for up to 72 cases, once for each case for each technology selected. If ‘US’ is selected, it will run 72 × 51 or 3,672 times). The results for each are stored in the worksheet StoredOutputs in eight major columnar sections (of 234 columns each), one section for each of the technology options and a block of 80 rows for each of the cases, 1 through 10.

Due to the way Excel plots columns charts, the best way to avoid plotting all eight cases per technology (even when fewer were run) is to hide the rows with no data. This is done with the “Hide Rows with #N/A in sheet” macro. If the cases are rerun with more cases per technology, the user should use the last button “Unhide all rows” and then rehide the empty rows to show the new complete set.

A variety of graphs have been set up that show some of the key summary data from the cases. Currently, four graphs display results from up to all eight technology options. The LEP and ROE are shown as lines for each technology. The levelized costs are shown in two different stacked-bar charts. One consolidates all of the cash flow into six categories (Figure 32), and the second chart gives more detail by plotting ten categories by splitting the revenue, taxes, and debt into multiple categories (Figure 33).

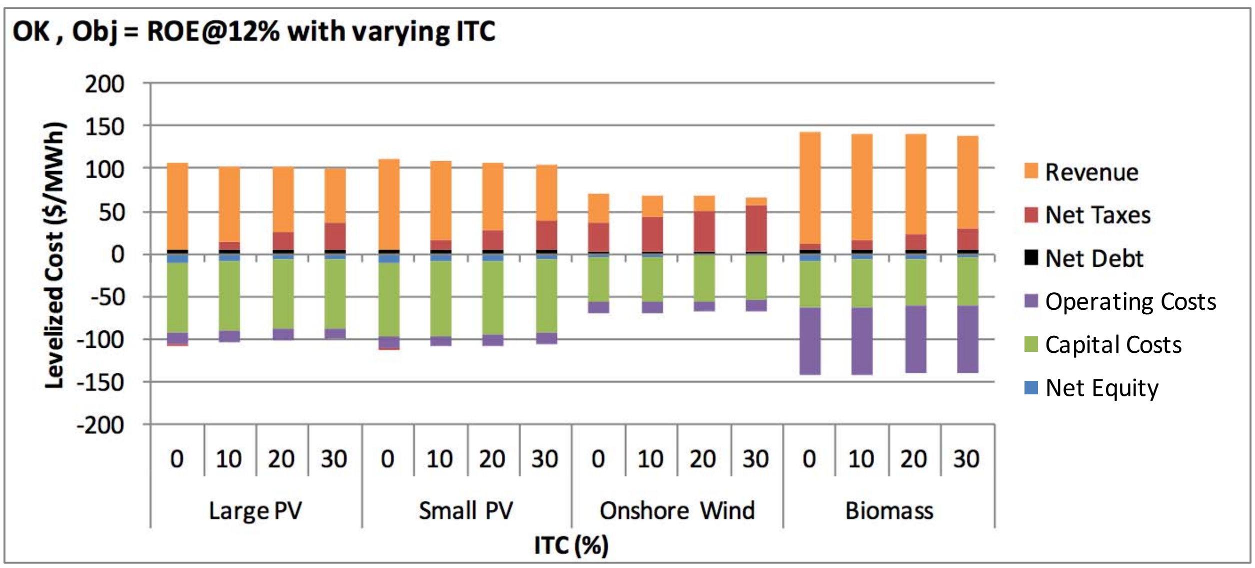


Figure 32. Comparison of ITC effects on levelized costs for four technologies in Oklahoma.

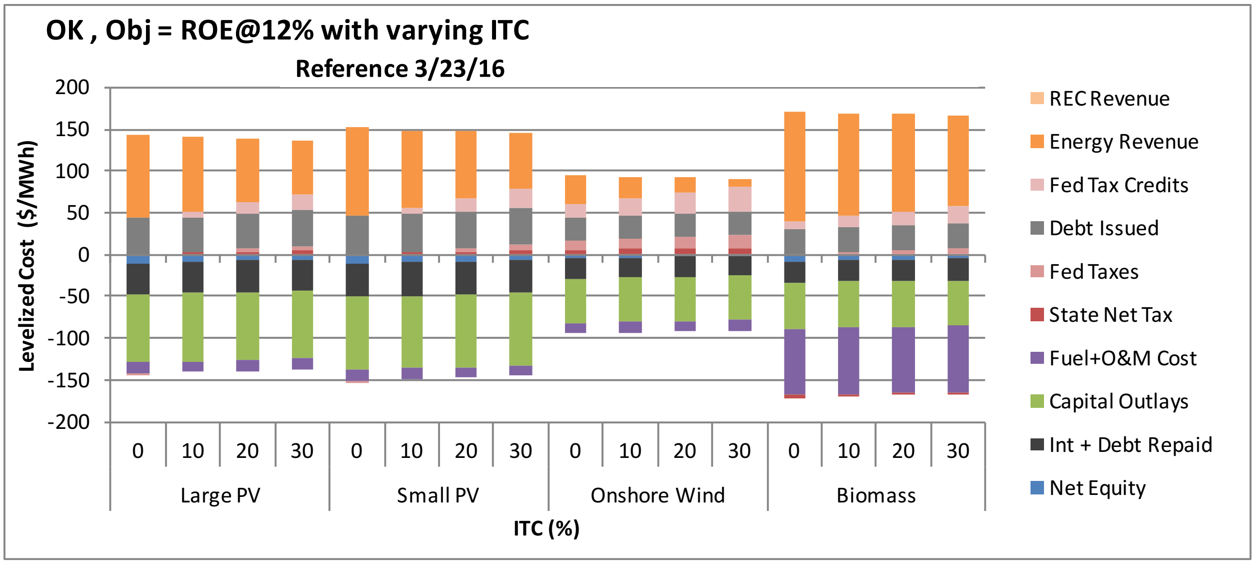


Figure 33. Comparison of ITC effects on levelized costs for four technologies in Oklahoma.

As an example, suppose a user wishes to view the impact of different values for a PTC, such as 0, 11, and 22 $/MWh. He/she would:

1. Select PTC from the drop-down list of Variable to Change (C3). See Figure 31 for a picture of the Multicase input area.
2. Put 0 in cell C4 for the Min Value.
3. Put 22 in cell C5 for the Max Value.
4. Put 3 in cell C6 for the Cases number.
5. Select the name from the drop-down list on cells A9:H9 (or leave blank) for each of the technologies to be analyzed.
6. Check that other variables for the case on Dashboard, FinModule, TechnologyInputs, and/or StateInputs (e.g., description, objective to solve, other financial or technology parameters) are set correctly.
7. On the MultiCase sheet, click on the green macro button. The model will proceed to run the model for each case and technology.
8. To ensure all cases are being graphed, click on the “Unhide All Rows in sheet” and the “Hide Rows with #N/A in sheet” buttons.
9. Select which state to be shown on the graphs in cell C12.

If a user wants to create variations of the graphs that can be modeled by the steady increment of values from minimum to maximum, then the cases can be run one at a time through the single case method on the Dashboard, storing the case in the desired row. (The program automatically stores the technology in its corresponding column.)

As an example, under MACRS, depreciable property has a tax depreciation life over which its cost is recovered over 3, 5, 7, 10, 15, 20, 27.5, or 31.5 years, depending on the type of property, and through use of statutory recovery methods. Meanwhile, the plants are generally modelled to have a 30-year book depreciation schedule. The MACRS method uses a double-declining balance (or 1.5 declining balance depending on the life), and book depreciation is modelled with a straight-line depreciation. An approximation is to use 30 years for the tax life, but to truly model the value of MACRS, one would need to calculate the cost profile if taxes were based on book depreciation. This eliminates all deferred tax calculations. To do this, the user can put the word “Book” as the tax depreciation life. This will set the tax depreciation to the book value for each year within FINModule.

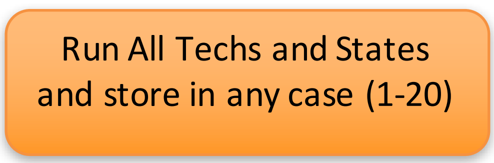
Rather than having to increment to each technology and store the results, a macro has been set up on the Dashboard that runs the model for each of the technologies using all of the input settings in place. It will also ask which case row to store the runs in.

To model this, the user should put the word “Book” in the TechnologyInputs worksheet’s cells B10:I10. The user then selects each technology in turn on the Dashboard, clicks the button to calculate all states, and stores the results in a specific case row, such as row 5. Potentially, the user could:

1. In MultiCase set the min, max, and cases set at 5, 20, and 4, respectively, to run the set of cases with tax life at 5, 10, 15, and 20 years.

2. Set the tax life in TechnologyInputs!B10:I10 to Book.

3. Click the Orange button to the top right in Dashboard (cells R2:T4).



4. It will ask which case row to store the results in. Type 5.

5. Lastly, the user should change the number of cases in MultiCase!c6 to 5 and run the Unhide and Hide macros.

The graphs will show the levelized price calculated and cost components for any state chosen. The software then plots the Book values at 30 years based on the actual book value.

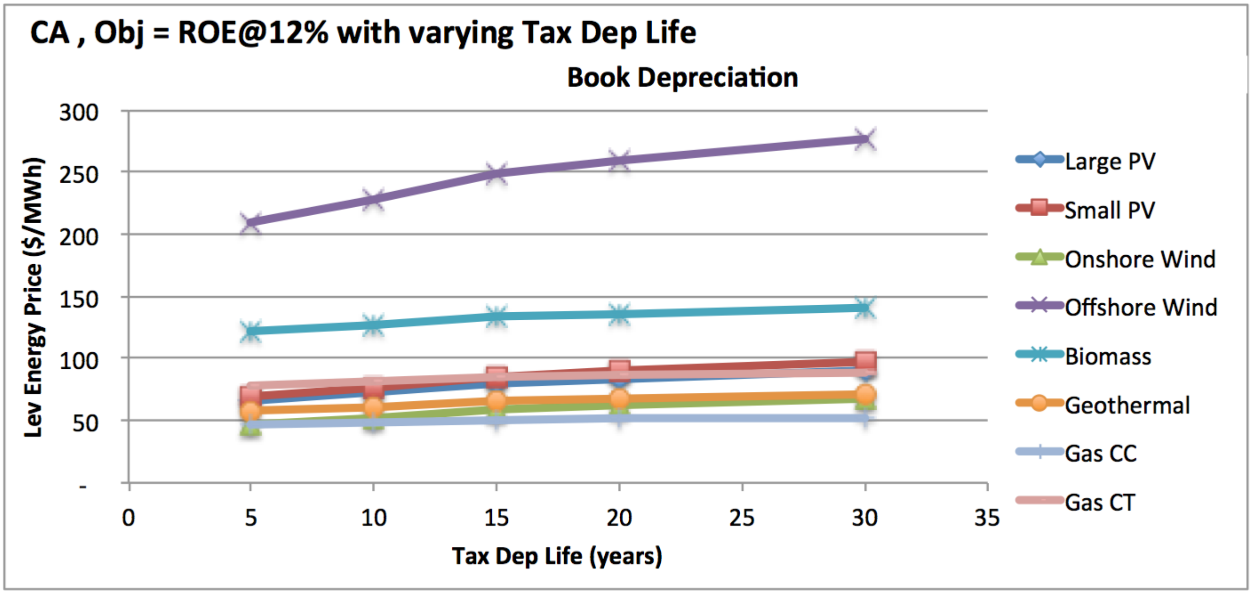


Figure 34. Tax depreciation effects on levelized prices for eight technologies in California.

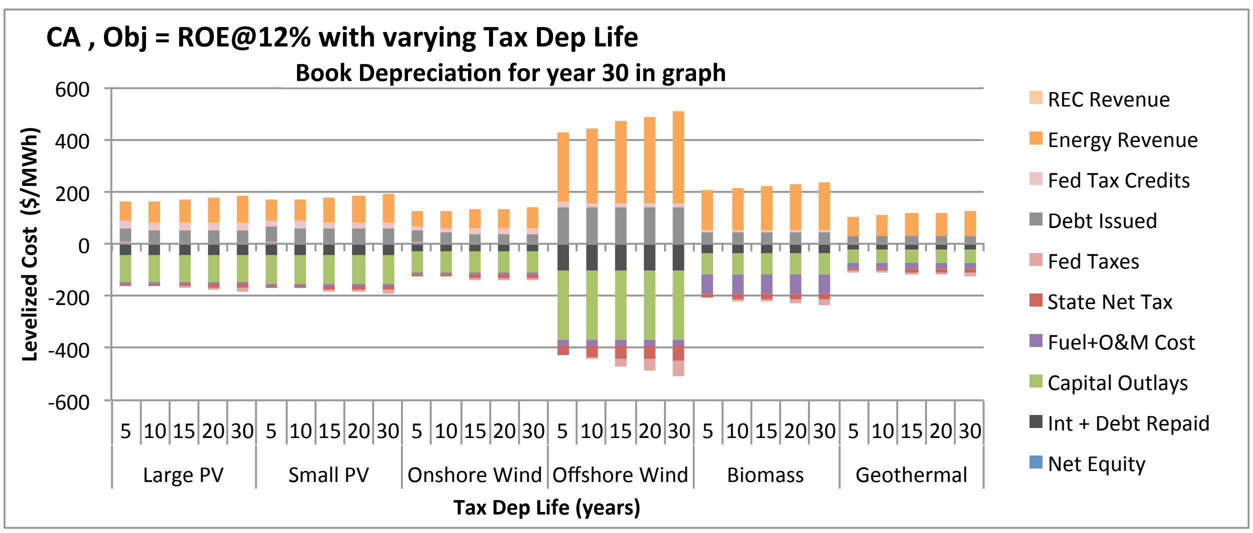


Figure 35. Tax depreciation effects on levelized costs for eight technologies in California.

Afterward, the user can put the original tax depreciation lives into TechnologyInputs!B10:I10 using the reference values in row 43.

6.3 Input Files for Tableau to Ingest New Scenarios

There are three worksheets in PFMT for passing information to Tableau: SensitivityAnalysis, LEP_Dashboard, and NetCashFlow_Dashboard. These collect the results from the first two cases from StoredOutputs and put them into formats useful for Tableau. The worksheets are created by running

MultiCase running two cases, one at the Min value and one at the Max value. The data from these worksheets should be copied into the workbook SensitivityAnalysis_Dashboard.xlsx.

In addition, there is a separate workbook called TableauData.xlsx that creates tables of the Input data for Tableau. This file includes information from the TechnologyInputs, StateIncent, and StateInputs worksheets in the PFMT model and creates two worksheets (TableauStateInputs and TableauInputsFormulas) that can be copied into workbooks for the pre-computed Tableau model described in the next two sections.

6.4 TABLEAU VISUALIZATION OF EXISTING SCENARIOS WITHIN LEP AND NET CASHFLOW DASHBOARDS

The tableau workbook "Precomputed_Dashboards_Vxx.twbx" is the latest version which has been deployed to the Tableau server as well. This workbook can be accessed using either the Tableau desktop or Tableau server, and since the scenarios are precomputed, they need not connect to an R-server.

6.4.1 Input settings for existing scenarios within PPA and NetCashFlow Dashboards

PPA Map dashboard: This dashboard (Figure 36) provides the location for key inputs to be set such as the Technology; Fed Income tax rate (0 or 35%); ITC for solar (0, 10, 20 or 30%); PTC for Wind (0 or 23 $/MWh); PPA Flag (with or without REC); and key output results. Figure 13 shows the inputs pane of the dashboard. The outputs include the Levelized Energy price of the selected state on the map of the United States. The map shows the state-by-state values for different key inputs, and the other widget shows the net cash flow and calculated-versus-system prices.

NetCashFlow dashboard: This dashboard (Figure 37) provides the location for key inputs to be set such as the Technology; Fed Income tax rate (0 or 35%); ITC for solar (0, 10, or 30%); PTC (0, 12, or 23 $/MWh); and key output results. The outputs include net cash flows as stacked bar charts.

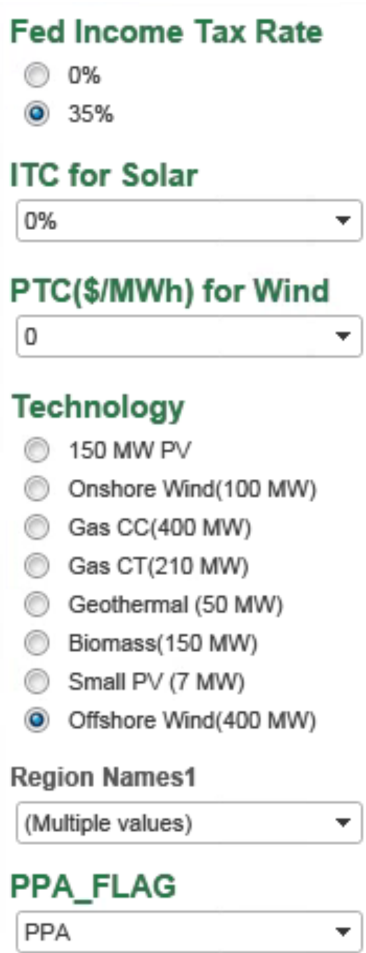


Figure 36. PPA Map dashboard inputs.

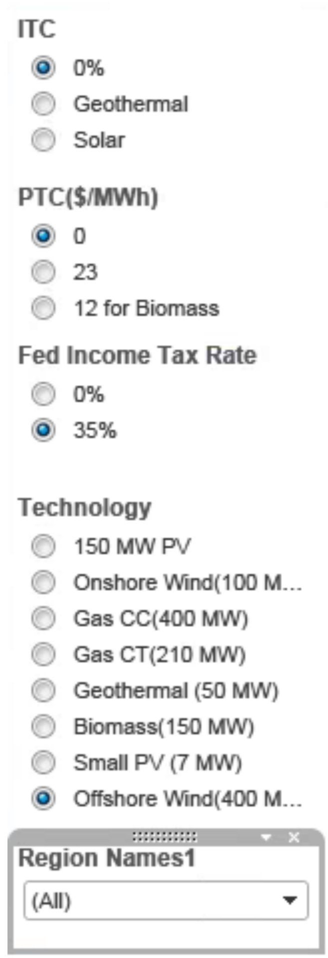


Figure 37. NetCashFlow dashboard inputs.

6.4.2 Output views of existing scenarios

The analyst can interactively visualize the results based on the input selection on the following pre-computed dashboard sheets.

LEP Map dashboard: Figure 38 below shows the output dashboard view along with the input pane. The outputs include the Levelized Energy price of the selected state on the map of the United States. The map shows the LEP prices color coded with shades of blue, and the other widget shows the net cash flows colored with an ordinal color scale. The pre-computed scenarios were computed with some fixed inputs parameters to keep the number of scenarios limited. For example, the ROE was fixed to 12%; LEP life to 20; 50% Debt; and the interest rate was fixed to 6%.

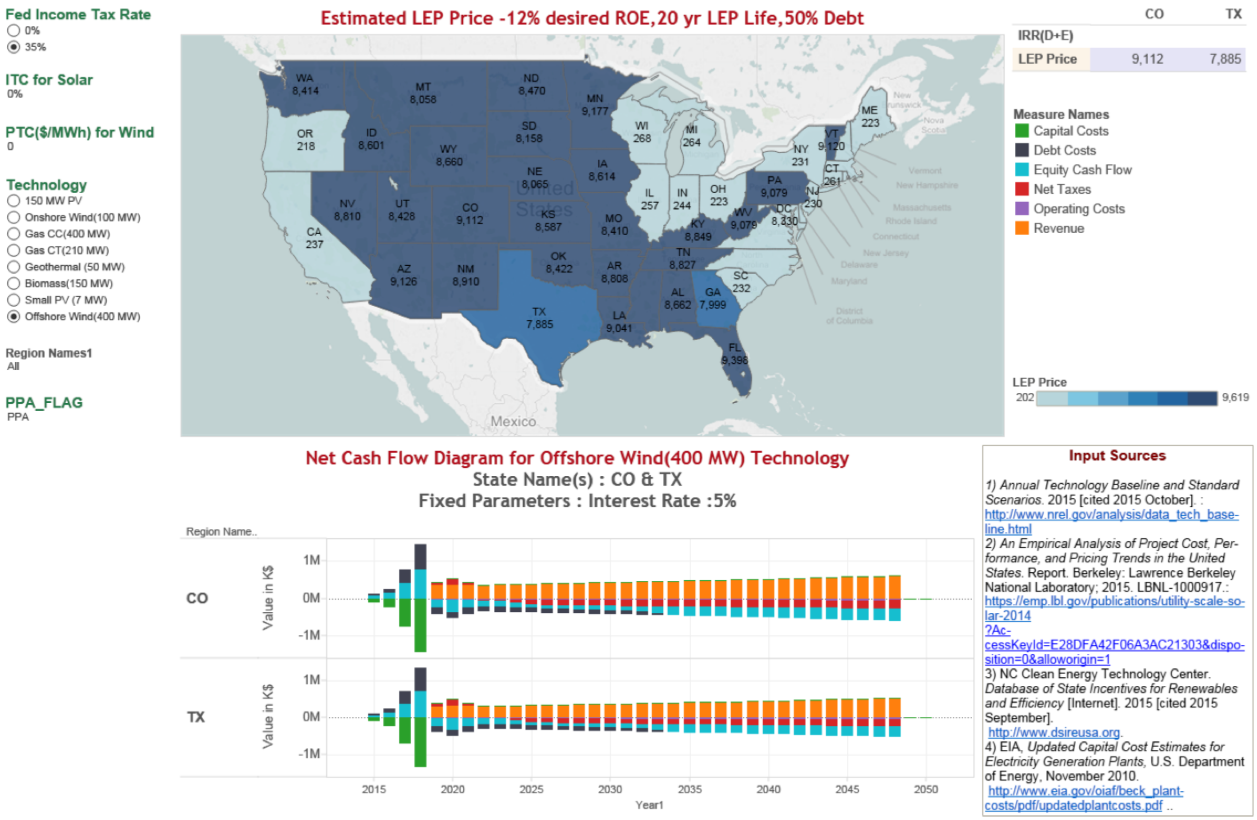


Figure 38. PPA Map dashboard displaying the LEP prices for Offshore Wind Technology.

NetCashFlow dashboard: Figure 39 below shows the output dashboard view along with the input pane. The outputs show the net cash flows colored with an ordinal color scale. The pre-computed scenarios were computed with some fixed inputs parameters to keep the number of scenarios limited. For example, the ROE was fixed to 12%, LEP life to 20, 50% Debt, and the interest rate was fixed to 6%.

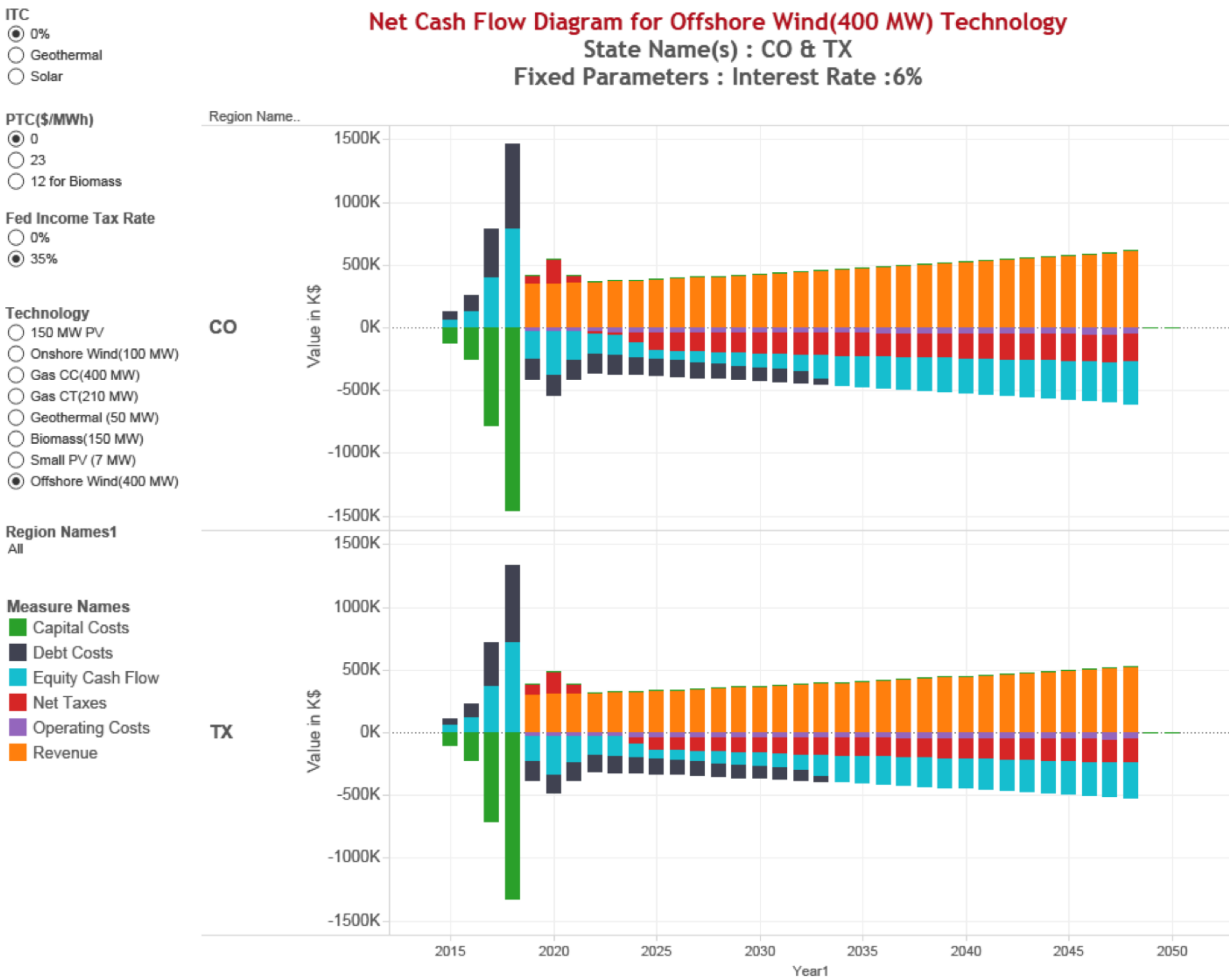


Figure 39. Net Cash Flow dashboard for Offshore Wind Technology.

6.5 Tableau Visualization of New Scenarios within Sensitivity Analysis Dashboards

Once new columns of data for new scenarios are available within a specific worksheet of the Excel file (SensitivityAnalysis_Dashboard.xlsx), we first need to follow the following steps to import the new data into the Tableau workbook file.

1. Select the Tableau worksheet that you need to update with new scenario data. Right click on the highlighted data source in the top left data pane. Select the option Edit Data Source and browse through your computer to get to the location of the Excel file SensitivityAnalysis_Dashboard.xlsx.
2. Select the appropriate sheet of this workbook and extract the data into the Tableau. Note that the import of the data with creation of a new extract takes approximately two minutes.
3. Once the new extract is created, go back to the original Tableau sheet. In the dimensions and measures pane, you will find new values/new scenario data attributes. If the column name is the same as the existing one, but has only updated data, then no new attributes show up, in which case there may be no additional steps to perform.
4. Once new measures are available to visualize, we can create a new calculated field to consolidate the new measures of all the technologies based on the Technology Selection parameter value and

add the new measure to the visualization window. If the measures are not parameter dependent, then they can be added directly on the visualization window.

Examples of newly calculated fields based on the "Technology Selection" parameter value are given below:

Measure Name: LEP Energy Price

```
CASE [Technology Selection 1] WHEN 0 THEN [Large PV LEP Energy Price]
WHEN 1 THEN [Onshore Wind LEP Energy Price]
WHEN 2 THEN [Gas CC LEP Energy Price]
WHEN 3 THEN [Gas CT LEP Energy Price]
WHEN 4 THEN [Geothermal LEP Energy Price]
WHEN 5 THEN [Biomass LEP Energy Price]
WHEN 6 THEN [Small PV LEP Energy Price]
WHEN 7 THEN [Offshore Wind LEP Energy Price]
END
```

Measure Name: LEP_System

```
[LEP Energy Price] – [System Price]
```

Measure Name: LEP_System_Color

```
IF [LEP_System]<=-50 THEN "<=-50"
ELSEIF [LEP_System]>-50 AND [LEP_System]<=-10 THEN  ">-50 and <=-10"
ELSEIF [LEP_System]>-10 AND [LEP_System]<=10 THEN  ">-10 and <=10"
ELSEIF [LEP_System]>10 AND [LEP_System]<=50 THEN  ">10 and <=50"
ELSEIF [LEP_System]>50 AND [LEP_System]<=90 THEN  ">50 and <=90"
ELSEIF [LEP_System]>90 AND [LEP_System]<=100 THEN  ">90 and <=1000"
ELSE "NA"
END
```

For instance, if LEP_System_Color is dropped on the color pane of a U.S. tile map, then the LEP Price-System Price values are displayed on a tile map using an ordinal scale of colors.

6.6 Tableau Visualization of Existing Scenarios within Sensitivity Analysis Dashboards

The Tableau workbook PrecomputedDashboard_Vxx.twbx also provides Sensitivity Analysis dashboards.

This workbook connects to multiple data sources listed below:

1. ITC (SensitivityAnalysis_Dashboard.xlsx)
2. PTC (SensitivityAnalysis_Dashboard.xlsx)
3. Tax Dep Life (SensitivityAnalysis_Dashboard.xlsx)
4. Reference Cases (SensitivityAnalysis_Dashboard.xlsx)
5. RefCases_Noincentives(SensitivityAnalysis_Dashboard.xlsx)

To use the pre-computed sensitivity analysis dashboards, refer to section Multi-Case SENSITIVITY Analysis VISUALIZATION.

6.7 Tableau Visualization of New Scenarios within LEP Dashboard and Net Cash Flow Dashboard for Precomputed Scenario Workbook

The Tableau workbook PrecomputedDashboard_Vxx.twbx provides both Sensitivity Analysis dashboards and pre-computed PPA Map dashboard and the NetCashFlow dashboard.

This workbook connects to multiple data sources listed below:

1. Sheet1 (PPA_Dashboard_Vxx.xlsx),
2. Sheet1(NetCashFlow_Dashboard.xlsx).

6.7.1 PPA Map Dashboard

Once new columns of data for new scenarios are available within a specific worksheet of the Excel file (PPA_Dashboard_Vxx.xlsx), we first need to follow the steps below to import the new data into the Tableau workbook file.

1. Select the Tableau worksheet (Estimated PPA Output Map) that you need to update with new scenario data. Right click on the highlighted data source in the top left data pane. Select the option Edit Data Source and browse through your computer to get to the location of the Excel file PPA_Dashboard_Vxx.xlsx.

2. Select the appropriate sheet of this workbook (Sheet1) and extract the data into the Tableau. Note that the import of the data with creation of a new extract takes approximately two minutes.

3. Once the new extract is created, go back to the original Tableau sheet. In the dimensions and measures pane, you will find new values/new scenario data attributes. If the column name is the same as the existing one but has only updated data, then no new attributes show up, in which case there may be no additional steps to perform.

4. Once new measures are available to visualize, we can create a new calculated field to consolidate the new measures and add the new measure to the visualization window. If the measures are not parameter dependent, then they can be added directly on the visualization window.

   An example of a modified measure to accommodate new interest rate scenario data is given below:

   Original Measure : PPA_GasCC

   ```
   IF ([Fed Income Tax Rate]=0) THEN [LEP Gas CC ROE12 INT6 FedIT0 ITC0 PTC0]
   ELSEIF ([Fed Income Tax Rate]=35) then [LEP Gas CC ROE12 INT6 FedIT35 ITC0 PTC0]
   END WHEN 7 THEN [Offshore Wind LEP Energy Price]
   END
   ```

   Modified Measure : LEP_System

   ```
   IF([Interest Rate] = 6)
   IF ([Fed Income Tax Rate]=0) THEN [LEP Gas CC ROE12 INT6 FedIT0 ITC0 PTC0]
   ELSEIF ([Fed Income Tax Rate]=35) then [LEP Gas CC ROE12 INT6 FedIT35 ITC0 PTC0]
   END WHEN 7 THEN [Offshore Wind LEP Energy Price]
   ```

```
ELSIF([Interest Rate] = 7)
IF ([Fed Income Tax Rate]=0) THEN [LEP Gas CC ROE12 INT7 FedIT0 ITC0 PTC0]
ELSEIF ([Fed Income Tax Rate]=35) then [LEP Gas CC ROE12 INT7 FedIT35 ITC0 PTC0]
END WHEN 7 THEN [Offshore Wind LEP Energy Price]
END
```

6.7.2 Net Cash Flow Dashboard

Once new columns of data for new scenarios are available within a specific worksheet of the Excel file (NetCashFlow_Dashboard.xlsx), we first need to follow the below steps to import the new data into the Tableau workbook file.

1. Select the Tableau worksheet (Estimated PPA Output Map) that you need to update with new scenario data. Right click on the highlighted data source in the top left data pane. Select the option Edit Data Source and browse through your computer to find the location of the Excel file NetCashFlow_Dashboard.xlsx file.

2. Select the appropriate sheet of this workbook (Sheet1) and extract the data into the Tableau. Note that the import of the data with creation of a new extract takes approximately two minutes.

3. Once the new extract is created, return to the original Tableau sheet. In the dimensions and measures pane, you will find new values/new scenario data attributes. If the column name is the same as the existing one but has only updated data, then no new attributes show up, in which case there may be no additional steps to perform.

4. Once new measures are available to visualize, we can create a new calculated field to consolidate the new scenarios and add the new measure to the visualization window. If the measures are not parameter dependent, then they can be added directly on the visualization window.

   Examples of a modified measure to accommodate new allowed ROE scenario data are given below:

   Original Measure : CC_GasCC

```
IF [Allowed ROE]=8 THEN
IF ([Fed Income Tax Rate]=0) THEN [CC GasCC ROE8 Int5 FedIT0 ITC0 PTC0]
ELSEIF ([Fed Income Tax Rate]=35) THEN [CC GasCC ROE8 Int5 FedIT35 ITC0 PTC0]
END
ELSE
IF ([Fed Income Tax Rate]=0) THEN [CC GasCC ROE12 Int5 FedIT0 ITC0 PTC0]
ELSE [CC GasCC ROE12 Int5 FedIT35 ITC0 PTC0]
END
END
```

   Modifed Measure : : CC_GasCC

```
IF [Allowed ROE]=8 THEN
IF ([Fed Income Tax Rate]=0) THEN [CC GasCC ROE8 Int5 FedIT0 ITC0 PTC0]
ELSEIF ([Fed Income Tax Rate]=35) THEN [CC GasCC ROE8 Int5 FedIT35 ITC0 PTC0]
END
```

```
ELSIF [Allowed ROE]=12 THEN
 IF ([Fed Income Tax Rate]=0) THEN [CC GasCC ROE12 Int5 FedIT0 ITC0 PTC0]
ELSE [CC GasCC ROE12 Int5 FedIT35 ITC0 PTC0]
END
ELSE
 IF ([Fed Income Tax Rate]=0) THEN [CC GasCC ROE10 Int5 FedIT0 ITC0 PTC0]
ELSE [CC GasCC ROE10 Int5 FedIT35 ITC0 PTC0]
END
END
```

7. REFERENCES

Blair N, Cory K, Hand M, Parkhill L, Speer B, Stehly T, Feldman D, Lantz E, Augustine C, Turchi C, et al. *Annual Technology Baseline and Standard Scenarios*. 2015 [cited 2015 October]. Available from: http://www.nrel.gov/analysis/data_tech_baseline.html .

Barbose, Galen and Naïm Darghouth, *Tracking the Sun VIII: The Installed Price of Residential and Non-Residential Photovoltaic Systems in the United States*, LBNL-188238, Lawrence Berkeley National Laboratory, August 2015. Available from: https://emp.lbl.gov/sites/all/files/lbnl-188238_1.pdf .

Bolinger M, Seel J. *Utility-Scale Solar 2014: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States*. Report LBNL-1000917. Lawrence Berkeley National Laboratory; 2015. Available from: https://emp.lbl.gov/publications/utility-scale-solar-2014 .

CRA 2013, *Working Draft of MRN-NEEM Modeling Assumptions and Data Sources for EIPC Capacity Expansion Modeling*, Charles Rivers Associates for the Eastern Interconnection Planning Collaborative, December 2010. http://nebula.wsimg.com/2b7b1e7ee96323d67024eae668e9e2c8?AccessKeyId=E28DFA42F06A3AC21303&disposition=0&alloworigin=1

EIA, *Updated Capital Cost Estimates for Electricity Generation Plants*, U.S. Department of Energy, November 2010. Available from: http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf

Energy Information Administration. *Annual Energy Outlook 2015*. DOE/EIA-0383(2015), U.S. Department of Energy, 2015. Available from: http://www.eia.gov/forecasts/aeo/assumptions/

Energy Information Administration. *Assumptions to the Annual Energy Outlook 2015*. DOE/EIA-0554(2015), U.S. Department of Energy, 2015. Available from: http://www.eia.gov/forecasts/aeo/

Energy Information Administration 2015, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2015*, DOE/EIA- (2015), U.S. Department of Energy, June 2015. Available from http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

EIA 2015, *Electricity: Detailed State Data*, [Internet], Release Date: October 21, 2015, Accessed October 22, 2015. Available from: http://www.eia.gov/electricity/data/state/ .

EIA 2016, *Carbon Dioxide Emissions Coefficients* [Internet], Release Date: February 2, 2016, Accessed March 23, 2016. Available from http://www.eia.gov/environment/emissions/co2_vol_mass.cfm .

Federal Energy Regulatory Commission, *Form 714 - Annual Electric Balancing Authority Area and Planning Area Report*, 2015. http://www.ferc.gov/docs-filing/forms/form-714/overview.asp

Hadley, Stanton W., Lawrence J. Hill, and Robert D. Perlack, *Report on the Study of Tax and Rate Treatment of Renewable Energy Projects*, ORNL-6772, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, December 1993. http://www.ornl.gov/~webworks/cpr/v823/rpt/68456.pdf

Internal Revenue Service, 2015, *Publication 946: How To Depreciate Property*, Accessed March 23, 2016, Available from: https://www.irs.gov/pub/irs-pdf/p946.pdf .

Lincoln Institute of Land Policy and Minnesota Taxpayers Association, *50-State Property Tax Comparison Study*, April 2011. Available from: http://www.lincolninst.edu/subcenters/significant-features-property-tax/upload/sources/ContentPages/documents/MTAdoc_NewCover.pdf .

NC Clean Energy Technology Center, 2015, *Database of State Incentives for Renewables and Efficiency* [Internet], cited September 2015. Available from: http://www.dsireusa.org.

NREL, TruPower 2011 (Wind capacity and generation data updated for AL and HI at >30% CF and 80m) Release Date: April 13, 2011. Accessed October 22, 2015. Available from: http://apps2.eere.energy.gov/wind/windexchange/pdfs/wind_maps/wind_potential_80m_30percent.pdf .

NREL 2015, *Annual Technology Baseline*, Release Date: July 16, 2015. Accessed June 23, 2016. Available from: http://www.nrel.gov/analysis/data_tech_baseline.html

Tax-Rates.org, “Sales Tax Rates by State,” [Internet]. Cited October 2015. Available from: http://www.tax-rates.org/taxtables/sales-tax-by-state .

Tax-Rates.org, “Average Corporate Income Tax Rates by State,” [Internet] Cited October 2015. Available from: http://www.tax-rates.org/taxtables/corporate-income-tax-by-state .