September 26, 2012

Energy Storage Computational Tool (ESCT) v1.2 Overview

Developed under DOE Contract DE-FE0004001 Task 430.05

The Energy Storage Computational Tool (ESCT) identifies and monetizes the costs and benefits of energy storage (ES) systems deployed in utility applications.

Characteristics of ESCT v1.2		Advantages
Primary Purpose	The ESCT is primarily designed to identify, quantify, and monetize the costs and benefits of an operational ES project. So, many of the inputs represent measured data.	• Straightforward to use • Lends itself to quality control • Provides a consistent and credible method for identification and calculation of benefits • Ensures consistency of results across projects • Well suited for long term analysis
Secondary Purpose	The ESCT can also help the user evaluate the potential costs and benefits of a proposed or hypothetical project. It could also help to optimize the size, type, and location of the ES system.	
Perspective	The ESCT is designed to account for all benefits including those that accrue to the asset owner, ratepayer/consumer, and societal stakeholders.	
Data Inputs	Measured data is used where available and estimated data is used for additional benefits that are difficult to measure or quantify.	
Platform	The ESCT is entirely self-contained in Microsoft Excel and can be saved, edited, and updated.	

The tool identifies potential benefits and estimates the monetized value for an ES project based on the project details and application specified by the user.

Project Details

Where is the asset located?

Location

Is the asset in a regulated market?

Regulatory Structure

Who will own the ES device?

Owner

What ES technology will be used?

Technology

How will the asset be used?

Application(s)

Example: Frequency Regulation

Why is that good?

Benefits

Ancillary Service Revenue

What is that worth?

Monetary Value

$1.5 MM/year

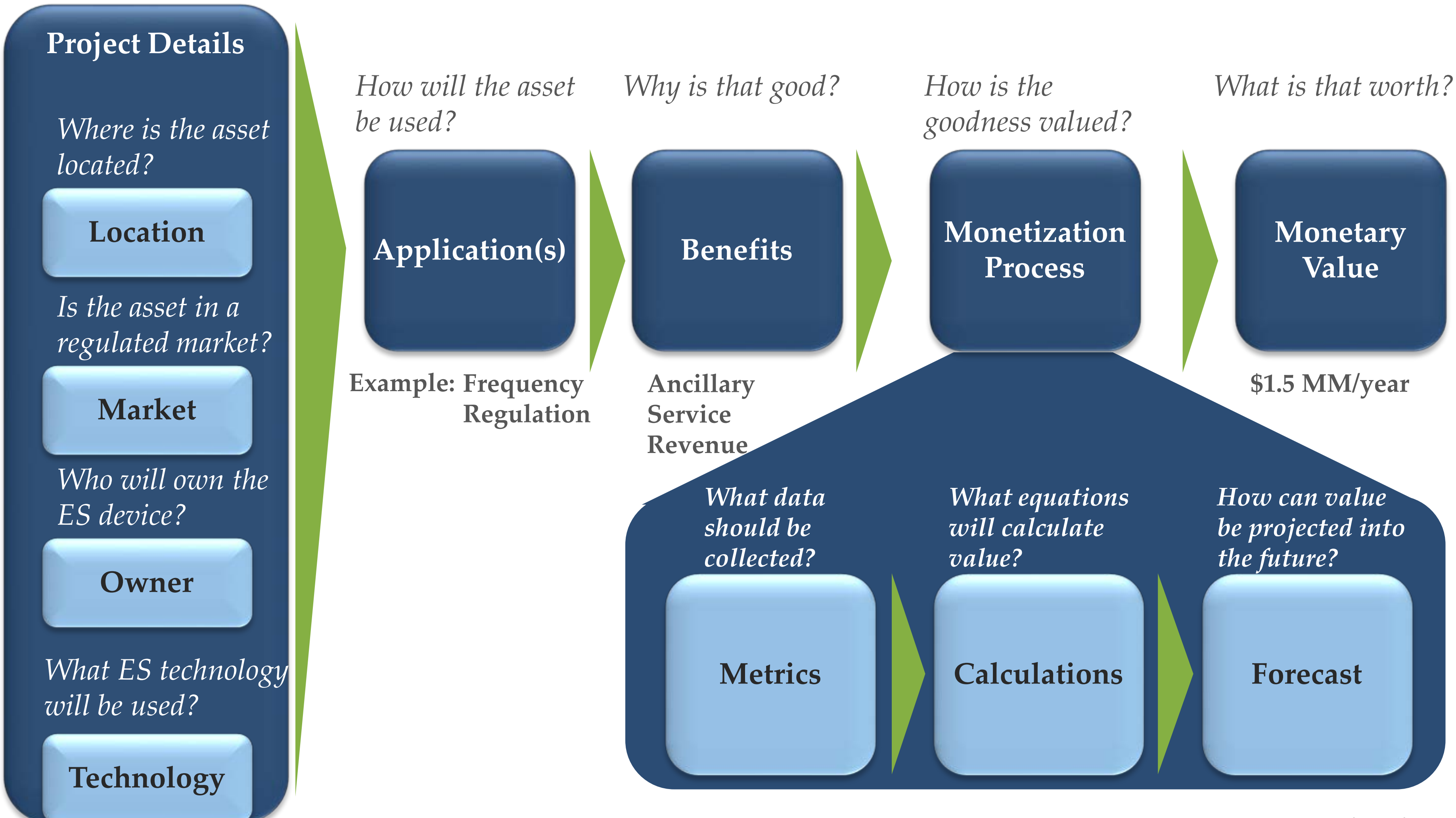
Achievable benefits may vary depending on the location of the ES on the grid, the regulatory structure, the owner, and the type of technology selected.

Project Details		
Category	**Options**	**Definition**
Location	Generation	This location describes any point between the generator and the transmission lines.
	Transmission	This location describes any point between the beginning of the transmission lines and the step-down distribution substation.
	Distribution	This location describes any place starting downstream of the power transformer at a step-down distribution substation, until the customer meter.
	End-User	This location describes any place on the customer-side of the customer meter.
Regulatory Structure	Regulated	A market in which utilities are vertically integrated, incorporating most elements of electric delivery and service into a single company.
	Deregulated	A market in which vertical integration at utilities has been broken up, allowing for independent power producers and merchant generators.
Owner	Utility	An asset owner that maintains and operates a local transmission and or distribution grid, such as an investor-owned utility, municipal utility, or electricity cooperative.
	Non-Utility Merchant/IPP	An asset owner that can independently deploy generation and ES assets for wholesale market participation or contracts with utilities or end users.
	End-User	An asset owner that is primarily an end-user of electricity.

The ESCT identifies different benefits depending on the application selected.

Applications	Economic										Reliability		Env.	
	Market Revenue			Asset Utilization					Efficiency	Cost	Interruptions		Air	
	Arbitrage Revenue	Capacity Revenue	Ancillary Service Revenue	Optimized Generator Operation	Reduced Congestion Cost	Deferred Generation Capacity Investments	Deferred Transmission Capacity Investments	Deferred Distribution Capacity Investments	Reduced Electricity Losses	Reduced Electricity Cost	Reduced Outages	Improved Power Quality	Reduced CO_2 Emissions	Reduced SO_X, NO_X, and Particulate Emissions
Electric Energy Time Shift	X			X		X	X	X	X	X			X	X
Electric Supply Capacity		X				X								
Load Following			X	X		X							X	X
Area Regulation			X	X		X							X	X
Electric Supply Reserve Capacity			X	X		X							X	X
Voltage Support			X									X		
Transmission Support							X				X			
Transmission Congestion Support					X		X							
T&D Upgrade Deferral				X		X	X	X	X				X	X
Time of Use Energy Cost Management				X		X	X	X	X	X			X	X
Demand Charge Management				X		X	X	X	X	X			X	X
Electric Service Reliability											X			
Electric Service Power Quality												X		
Renewables Energy Time Shift	X			X		X	X	X	X	X			X	X
Renewables Capacity Firming		X				X							X	X
Wind Generation – Short		X				X							X	X
Wind Generation – Long	X			X		X	X	X	X	X			X	X

The user enters data collected during operation of the ES system in order to monetize the benefits and conduct a cost/benefit analysis over time.



ESCT modules reflect the framework developed to assess the value of an energy storage project.

The ESCT is composed of three modules.

	1 Asset Characterization Module	2 Data Input Module	3 Computational Module
Purpose	Determine the list of project benefits.	Filter irrelevant metrics. Guide and assist data entry.	Calculation and present results.
Inputs	Project Details, Applications	List of Benefits	Calculation Dataset, Sensitivity Ranges
Outputs	List of Benefits	Calculation Dataset	Tabular and Graphic Presentation of Monetized Benefits
Key Methodologies	Application-to-Benefit Relational Models	Benefit-to-Input Relational Model	ES Benefit Calculations, Benefit Forecast Methodology

The ESCT User Guide includes detailed explanations of the methodology as well as step-by-step use instructions.

- The first half of the User Guide is dedicated to:
  - Providing context for the tool and explaining its purpose;
  - Explaining the general methodology for assessing the benefits of an energy storage project; and
  - Defining each Application and Benefit.
- The second half of the User Guide is dedicated to:
  - Explaining the general Architecture of the ESCT; and
  - Providing a step-by-step instruction manual for using the ESCT.
- The Appendix of the User Guide documents and explains:
  - The detailed cost and benefit calculations used in the tool; and
  - Key concepts and assumptions (ex. inputs, default values, escalation techniques).

The ESCT, an overview presentation, and a users guide are publicly available for download at no cost at www.SmartGrid.gov.

- The ESCT and related documents can be downloaded at:

http://www.smartgrid.gov/recovery_act/program_impacts/analytical_approach

- DOE will hold webinars to demonstrate the tool to Smart Grid Demonstration Program recipients before the end of the year.

QUESTIONS??

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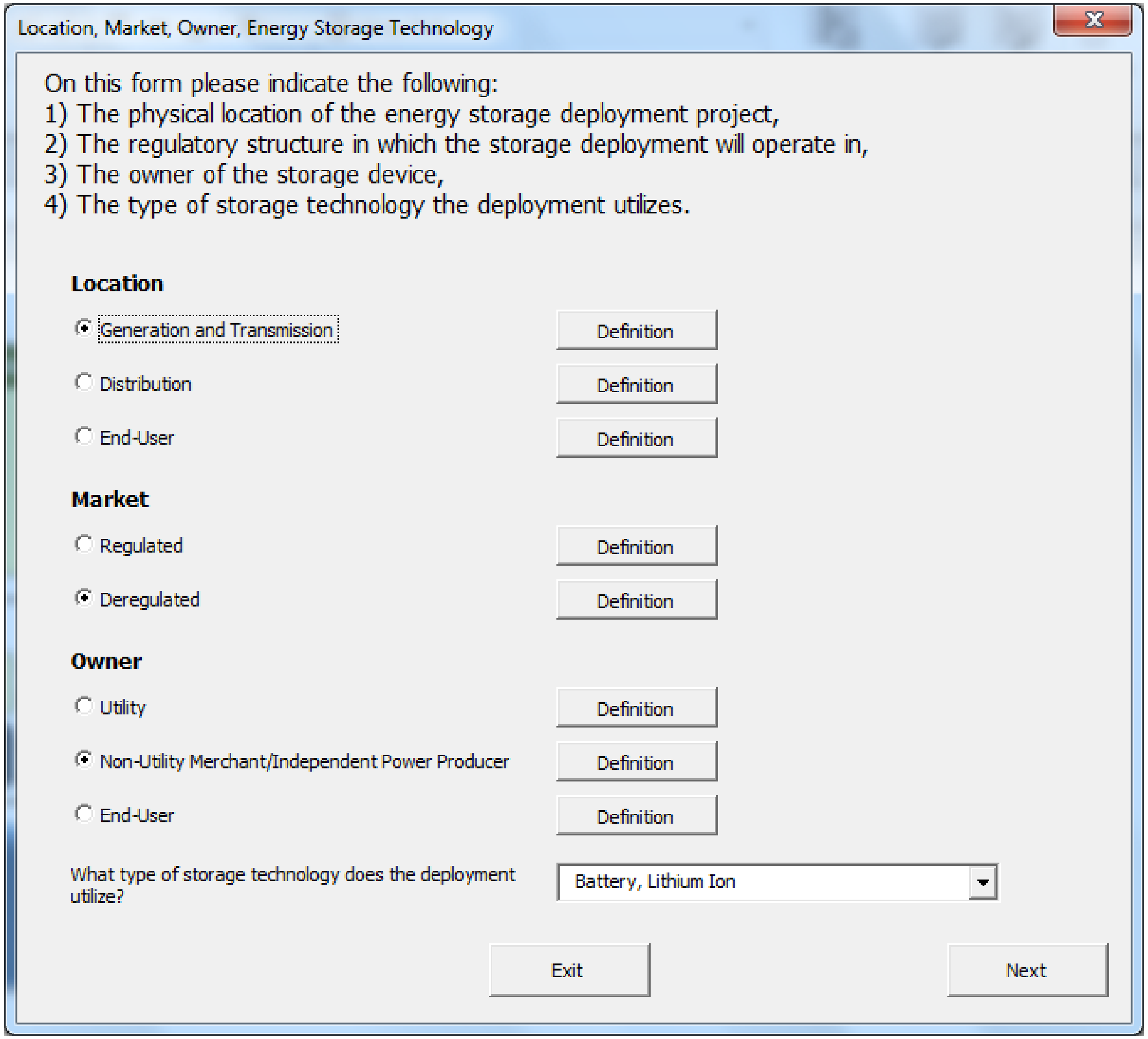
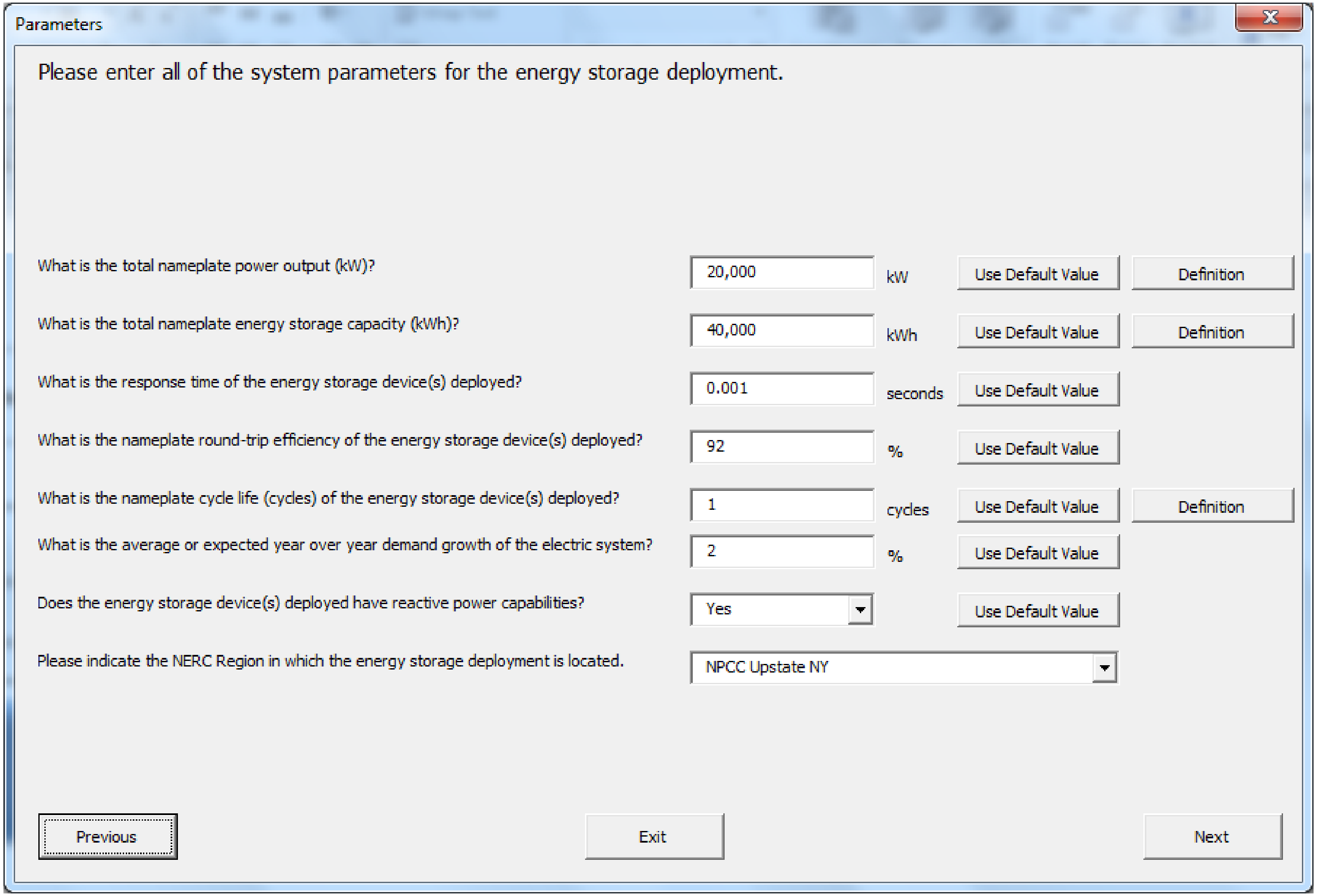
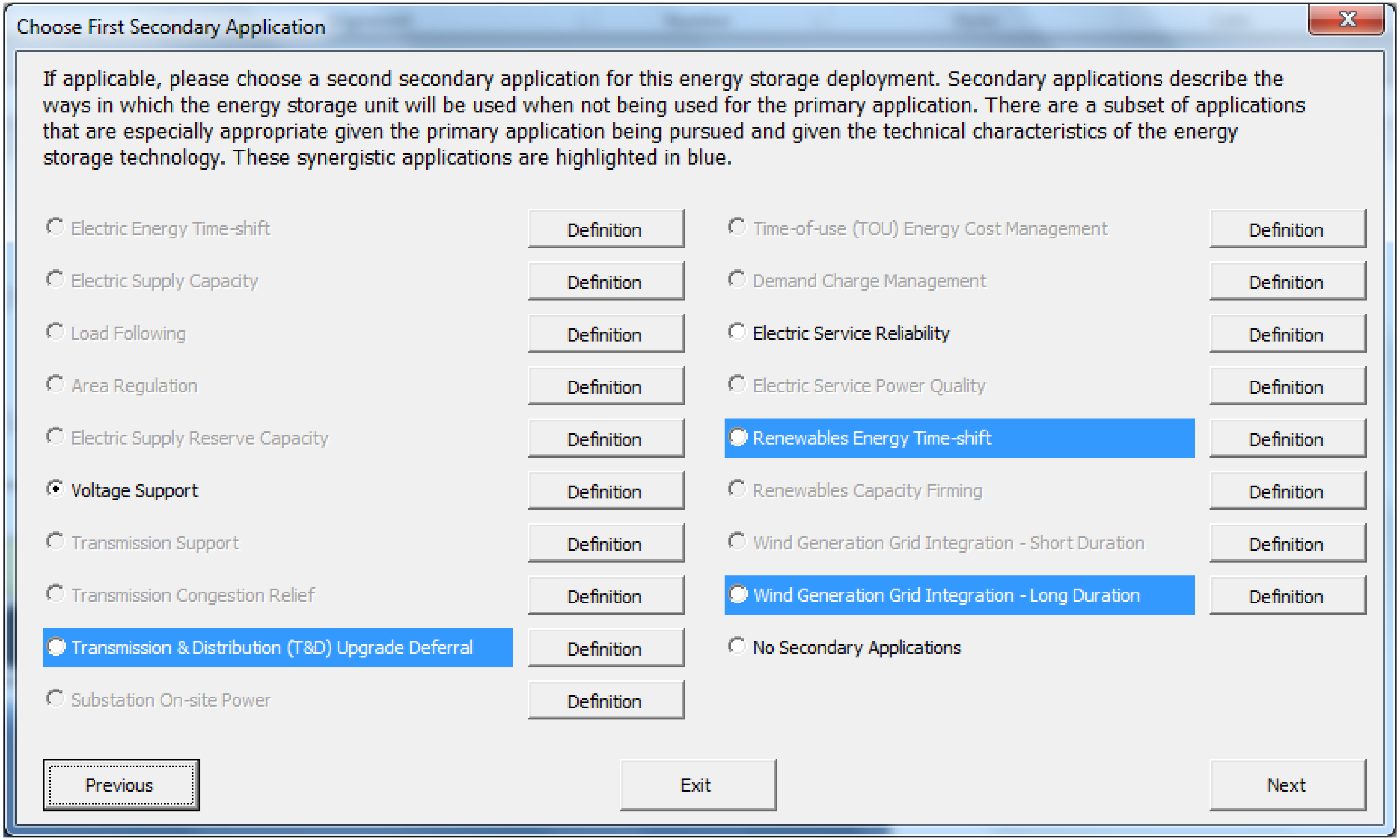
Asset Characterization Module Screen Shots



Asset Characterization Module Screen Shots



Asset Characterization Module Screen Shots



Asset Characterization Module Screen Shots

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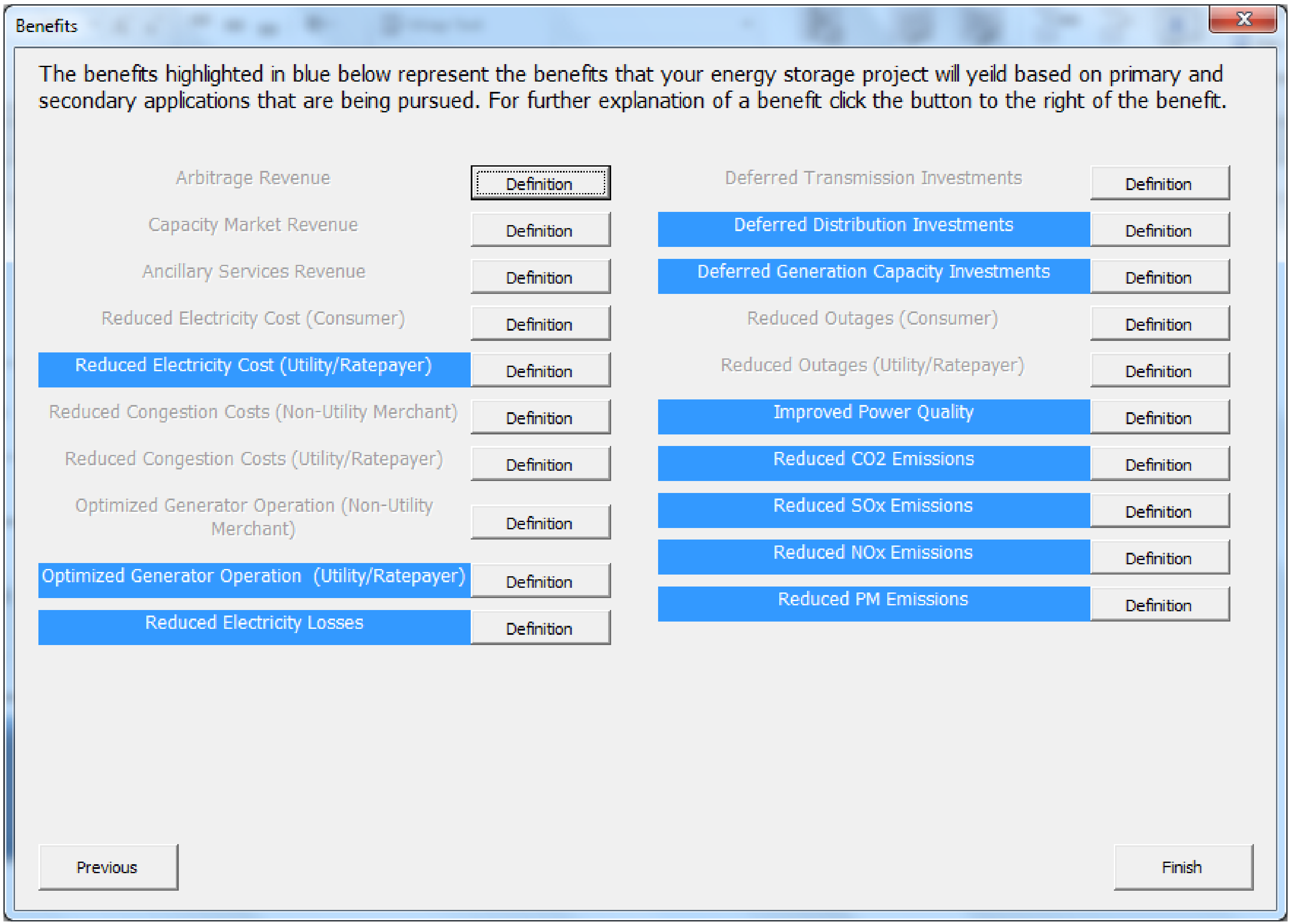
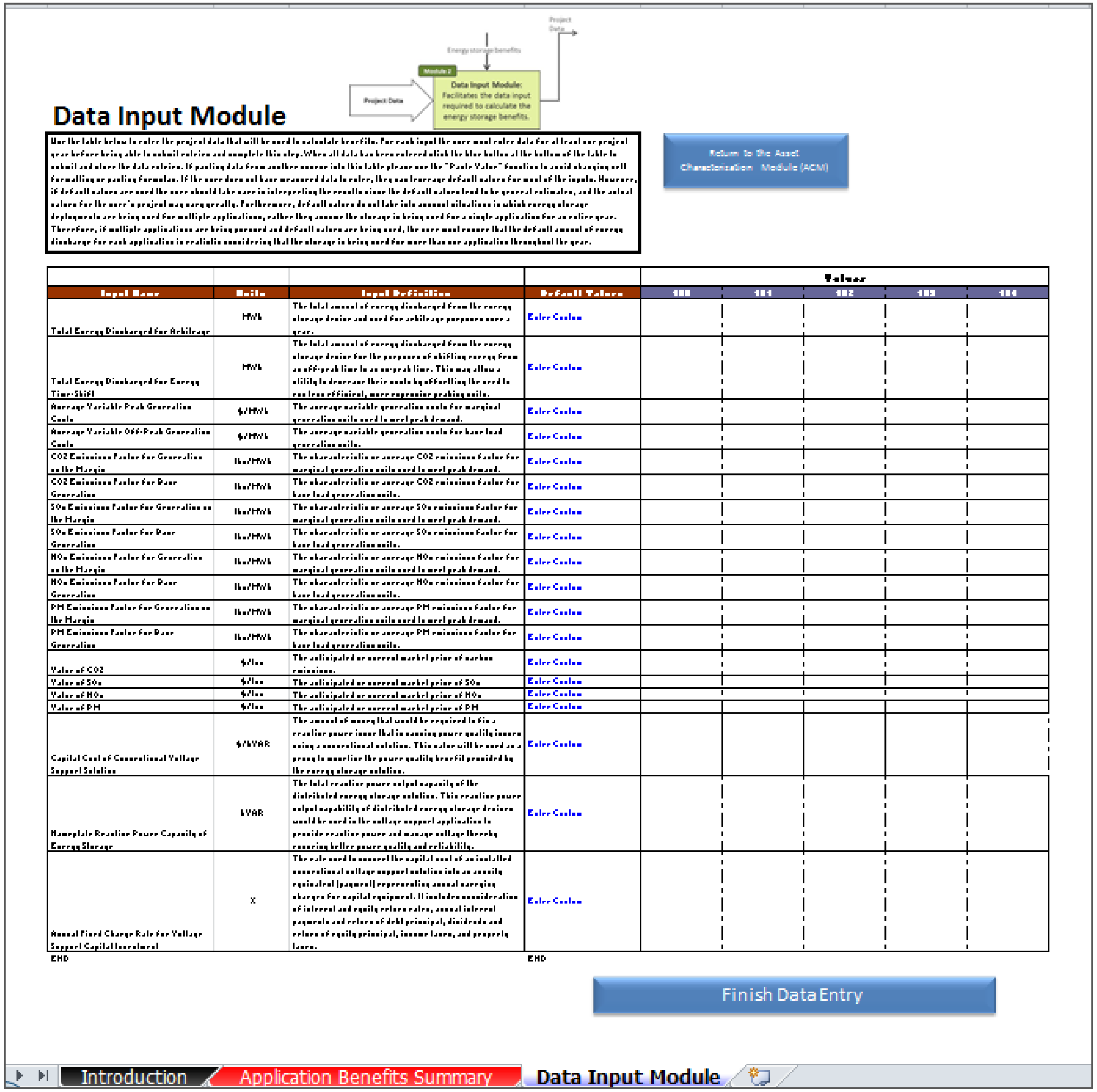


Data Input Module Screen Shots



Data Input Module Screen Shots

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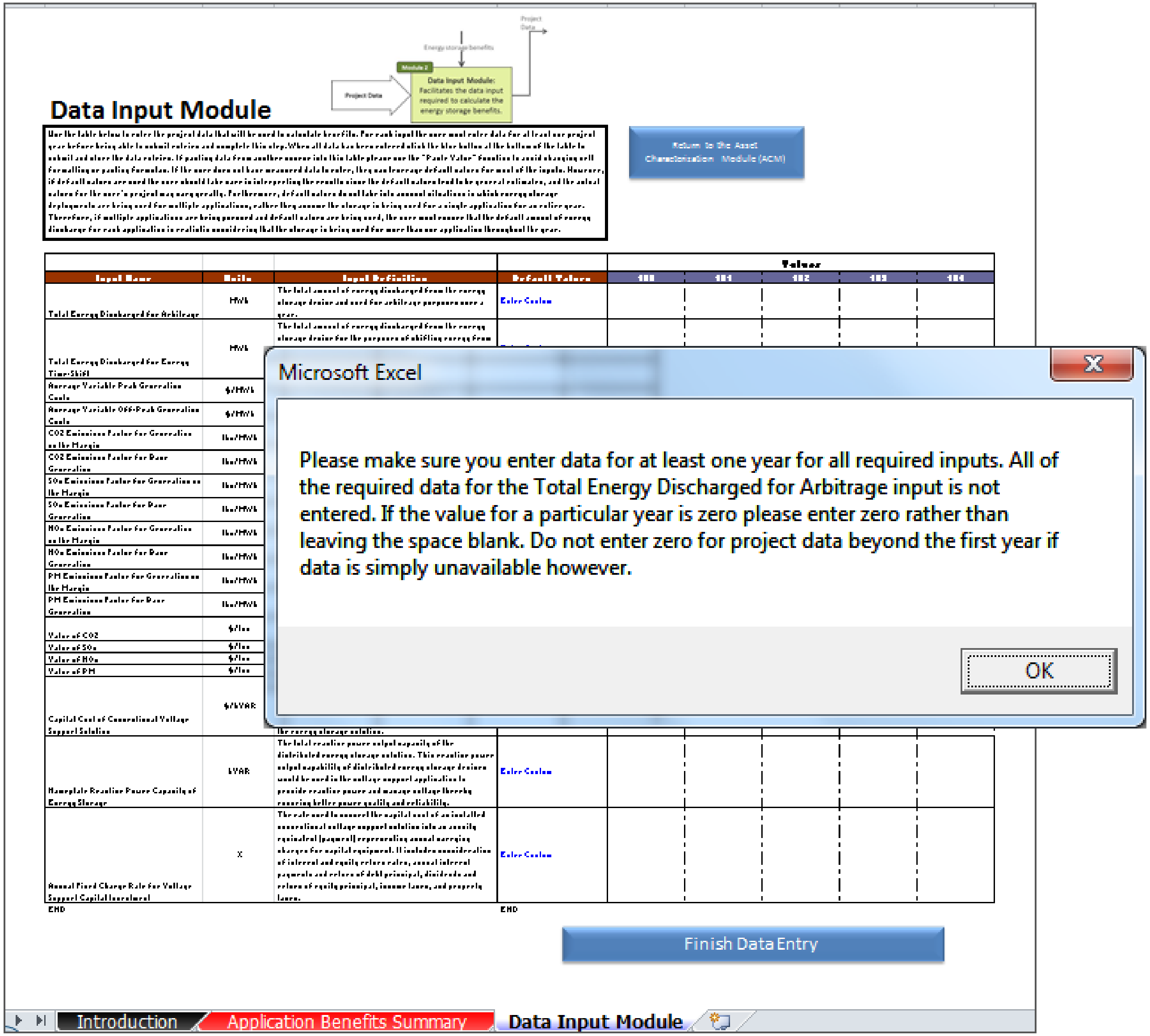


Computational Module Screen Shots

Computational Module (CM) Main Page

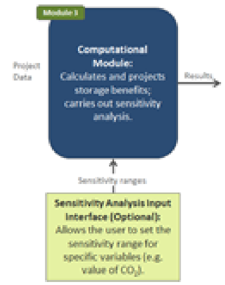
Instructions

Welcome to the Computational Module (CM) phase of the Energy Storage Computational Tool (ESCT). The CM is the calculation engine of the tool, it crunches the numbers and generates the output. The CM also allows the user to complete a sensitivity analysis if desired.

Running the CM with Reference Inputs - To run the CM with the inputs that were entered in the DIM phase, simply click the button in the "Reference Case" section that says "Run CM with Reference Case Inputs". The CM will take about 20 seconds to complete the analysis. Once the analysis is complete the results can be viewed by clicking the "View Reference Case Results" button.

Running the a Sensitivity Analysis - Before running a sensitivity analysis the CM should be run with the reference case inputs by following the directions above. To run a sensitivity analysis first change the High and Low sensitivity ranges of the desired inputs by using the toggles that are to the right of every input. After all of the desired sensitivity ranges have been set click the button in the "Sensitivity Analysis" section that says "Run CM with Sensitivity Case Inputs". The CM will take about a 40 seconds to complete the analysis.

Go Back to the DIM



Reference Case

Run CM with Reference Case Inputs

View Reference Case Results

Sensitivity Analysis

Run CM with Sensitivity Case Inputs

View Sensitivity Results

Reset all values to 100%

Input Name	Unit	Select % using toggle			2011 Values		
		Low	Reference	High	Low	Reference	High
Total Energy Discharged for Arbitrage	MWh	100%	100%	100%	$ 18,000	$ 18,000	$ 18,000
Total Energy Discharged for Energy Time-Shift	MWh	100%	100%	100%	18,000	18,000	18,000
Average Variable Peak Generation Costs	$/MWh	100%	100%	100%	$ 46	$ 46	$ 46
Average Variable Off-Peak Generation Costs	$/MWh	100%	100%	100%	$ 24	$ 24	$ 24
CO2 Emissions Factor for Generation on the Margin	lbs/MW	100%	100%	100%	845	845	845
CO2 Emissions Factor for Base Generation	lbs/MW	100%	100%	100%	-	-	-
SOx Emissions Factor for Generation on the Margin	lbs/MW	100%	100%	100%	0.075	0.075	0.075
SOx Emissions Factor for Base Generation	lbs/MW	100%	100%	100%	-	-	-
NOx Emissions Factor for Generation on the Margin	lbs/MW	100%	100%	100%	0.25	0.25	0.25
NOx Emissions Factor for Base Generation	lbs/MW	100%	100%	100%	-	-	-
PM Emissions Factor for Generation on the Margin	lbs/MW	100%	100%	100%	0.040	0.040	0.040
PM Emissions Factor for Base Generation	lbs/MW	100%	100%	100%	0.200	0.200	0.200
Value of CO2	$/ton	100%	100%	100%	$ 20	$ 20	$ 20

Introduction | Application Benefits Summary | Input Review | CM Main Page

Computational Module Screen Shots

Reference Case Output: Annual and Cumulative Results Tables

The tables below display the annual and cumulative project benefits and costs. The benefits are organized by category. The total gross benefit, total cost, and net benefit are also displayed at the bottom of each chart. All values are present value terms. To calculate additional benefits navigate to the additional benefits worksheets from the Additional Benefits tab.

Annual Benefit and Cost Table

	Benefits	Additional Benefits - Total Present Value over the Deployment Period	+	Primary and Secondary Benefits - Total Present Value over the Deployment Period	=	Total Benefit - Present Value over the Deployment Period	2011	2012	2013	2014	2015
Market Revenue	Arbitrage Revenue	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Capacity Market Revenue	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Ancillary Services Revenue	$ -		$ 44,855,400		$ 44,855,400	$ 5,303,900	$ 5,038,700	$ 4,786,700	$ 4,547,400	$ 4,320,000
Improved Asset Utilization	Optimized Generator Operation (Non-Utility Merchant)	$ -		$ 154,200		$ 154,200	$ 18,200	$ 17,300	$ 16,500	$ 15,600	$ 14,900
	Optimized Generator Operation (Utility/Ratepayer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Deferred Generation Capacity Investments	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Reduced Congestion Costs (Non-Utility	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Reduced Congestion Costs (Utility/Ratepayer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
T&D Capital Savings	Deferred Transmission Investments	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Deferred Distribution Investments	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
Energy Efficiency	Reduced Electricity Losses	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
Electricity Cost Savings	Reduced Electricity Cost (Consumer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Reduced Electricity Cost (Utility/Ratepayer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
Power Interruptions	Reduced Outages (Consumer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Reduced Outages (Utility/Ratepayer)	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
Power Quality	Improved Power Quality	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
Air Emissions	Reduced CO2 Emissions	$ -		$ 216,500		$ 216,500	$ 25,600	$ 24,300	$ 23,100	$ 21,900	$ 20,900
	Reduced SOx Emissions	$ -		$ -		$ -	$ -	$ -	$ -	$ -	$ -
	Reduced NOx Emissions	$ -		$ 27,900		$ 27,900	$ 3,300	$ 3,100	$ 3,000	$ 2,800	$ 2,700
	Reduced PM Emissions	$ -		$ 12,100		$ 12,100	$ 1,400	$ 1,400	$ 1,300	$ 1,200	$ 1,200
	Total Gross Benefit	**$ -**		**$ 45,266,100**		**$ 45,266,100**	**$ 5,352,400**	**$ 5,084,800**	**$ 4,830,600**	**$ 4,588,900**	**$ 4,359,700**
	Costs										
	Capital Cost of Deployment (fixed charge rate)					$ 19,156,400	$ 2,387,000	$ 2,267,700	$ 2,154,300	$ 2,046,600	$ 1,944,200
	Operating and maintenance costs not related to energy (labor for operation, plant maintenance, equipment wear leading to loss-of-life)					$ 1,283,900	$ 160,000	$ 152,000	$ 144,400	$ 137,200	$ 130,300
	Decommissioning and Disposal Costs					$ -	$ -	$ -	$ -	$ -	$ -
	Total Annual Cost of Deployment					**$ 20,440,300**	**$ 2,547,000**	**$ 2,419,700**	**$ 2,298,700**	**$ 2,183,700**	**$ 2,074,500**
	Total Net Benefit					**$ 24,825,800**	**$ 2,805,400**	**$ 2,665,100**	**$ 2,531,900**	**$ 2,405,200**	**$ 2,285,200**

Application Benefits Summary | Input Review | CM Main Page | **Result Tables** | Result Charts | Additional Benefits

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