National Renewable Energy Laboratory
Innovation for Our Energy Future

Modeling Biopower Projects with SAM

Webinar

Jennie Jorgenson
Paul Gilman

February 13 2012

Outline

- Introduction to SAM
- Setting up a File
- Climate, Financing, and Cost Inputs
- Biopower Model Inputs
- Running the Model and Results

Modeling Biopower Projects with SAM

INTRODUCTION TO SAM

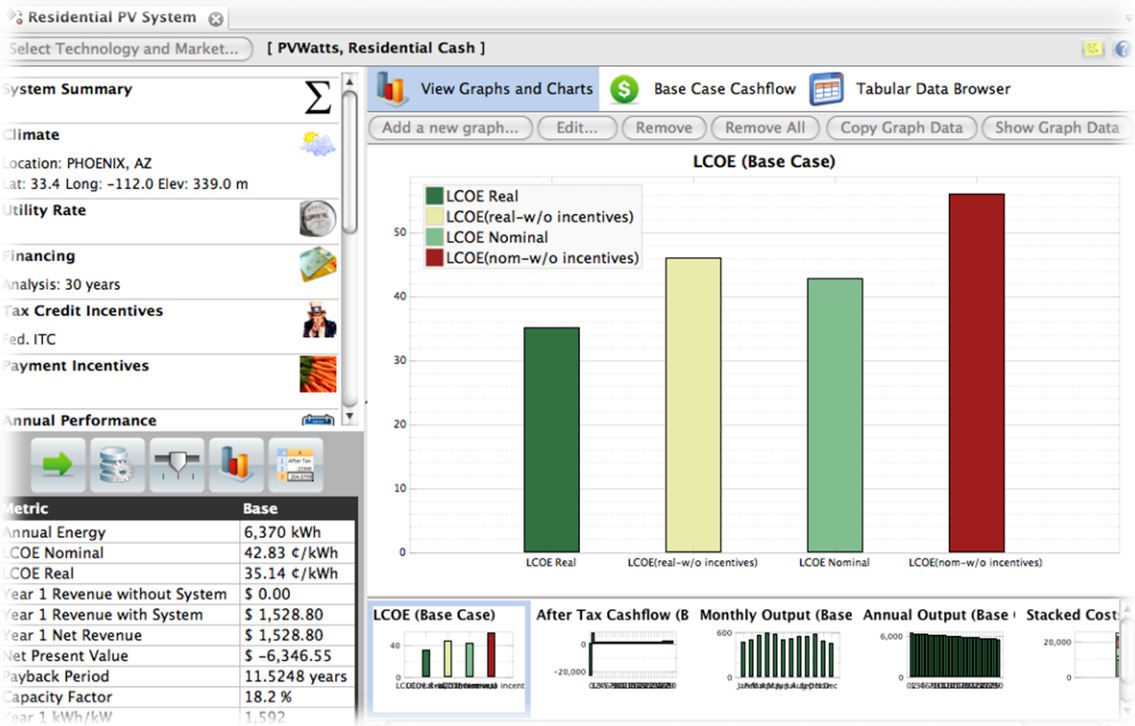
What is SAM?

The System Advisor Model (SAM) is a free computer program that **calculates a renewable energy system's hourly energy output** over a single year, and **calculates the cost of energy** for a renewable energy project over the life of the project.

Performance model makes energy output calculations

Financial model makes cash flow calculations

Default values help you get started



What can you do with SAM?

- Model solar, wind, geothermal, and biomass power systems in a single application
- Evaluate and compare options using consistent models across technologies
- Calculate economic metrics such as LCOE, NPV, payback for projects in different markets
- Present modeling results in graphs and tables
- Perform parametric and uncertainty analyses

Technologies & Markets

- Photovoltaics
- Concentrating Solar Power
  - Parabolic Troughs
  - Power Towers
  - Linear Fresnel
  - Dish-Stirling
- Solar Water Heating
- Wind turbines and farms
- Geothermal power plants
- Biomass power plants

Key outputs

- Hourly energy production (kWh)
- Capacity factor
- Efficiency

- Residential, commercial, and utility-scale projects
- Installation and operating costs
- Tax credit and payment incentives
- Complex electric utility rates

Key outputs

- Levelized Cost of Electricity (LCOE)
- Payback
- Net present value
- Multi-year cash flow

Background

Developed by the Department of Energy, National Renewable Energy Laboratory, and Sandia National Laboratories

Vision

- Model different renewable energy projects in a single platform
- Facilitate technology comparison by handling performance, costs and financing consistently across technologies
- Make high-quality performance models developed by NREL, Sandia, and other partners available to the public

Users and Applications

Feasibility studies

- Project developers, Federal Energy Management Program

Use as benchmark for other models

- System integrators and utilities

Research projects

- Universities and engineering firms

Plant acceptance testing for parabolic trough systems

Evaluate technology research opportunities and grant proposals

- Department of Energy

35,000+ Downloads

Manufacturers
Engineering Firms
Consultants
Developers
Venture Capitalists
Policy Analysts

Current Development Team

Management
- Nate Blair, NREL

Programming
- Aron Dobos, NREL
- Steven Janzou, NREL*
- Tom Ferguson, NREL*

Documentation and User Support
- Paul Gilman, NREL*

PV Model Validation
- Clifford Hansen, Sandia

Biopower
- Jennie Jorgenson, NREL

Geothermal
- Chad Augustine, NREL

Concentrating Solar Power
- Mark Mehos, NREL
- Craig Turchi, NREL
- Ty Neises, NREL
- Mike Wagner, NREL

Water Heating
- Jay Burch, NREL
- Craig Christensen, NREL

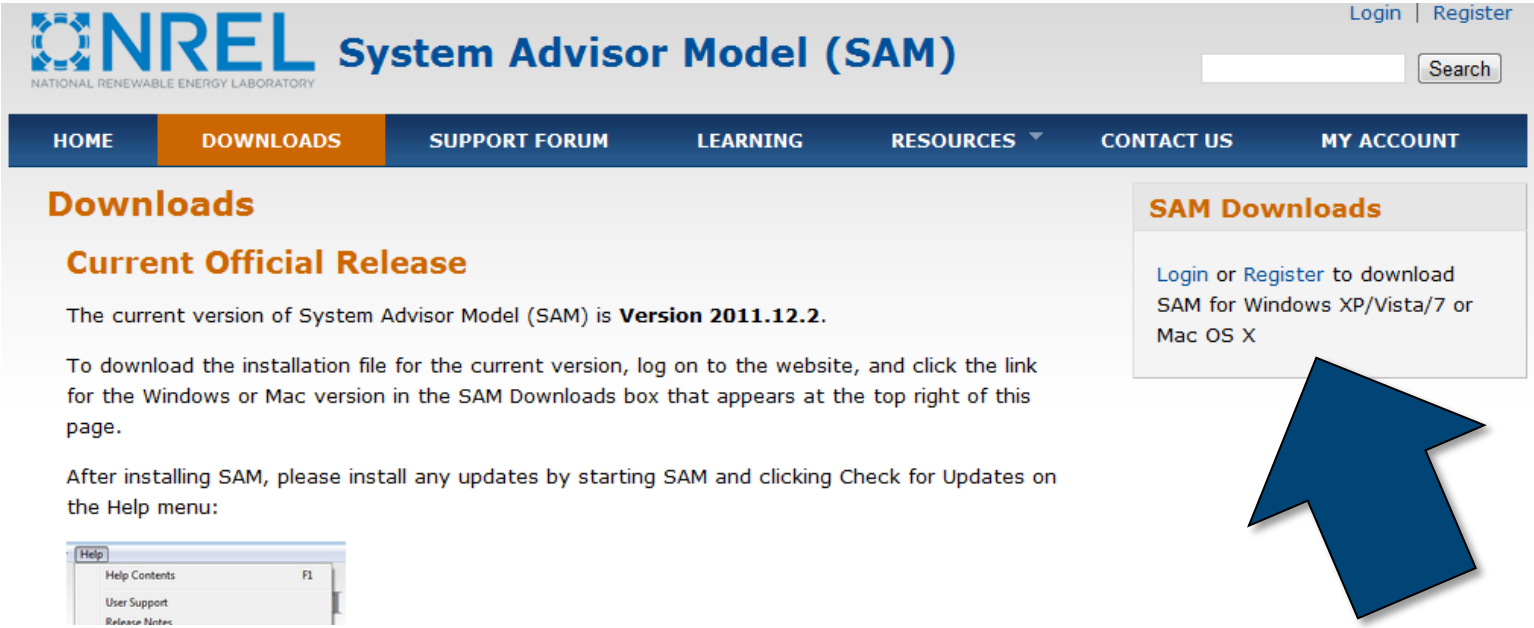
Financial Modeling
- Mike Mendelsohn, NREL

* Contractors

Downloading SAM

http://sam.nrel.gov

1) Register 2) Complete registration form 3) Download



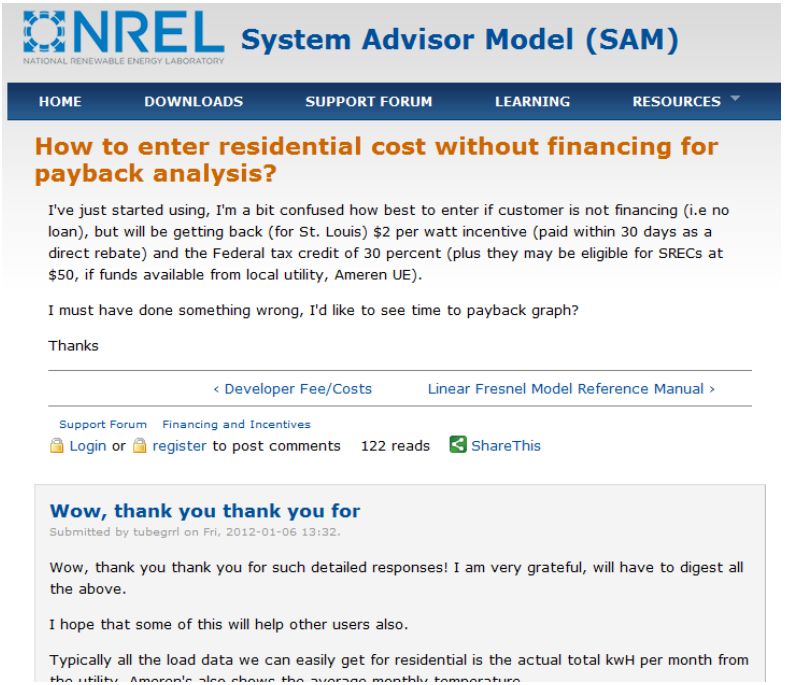
Getting Help

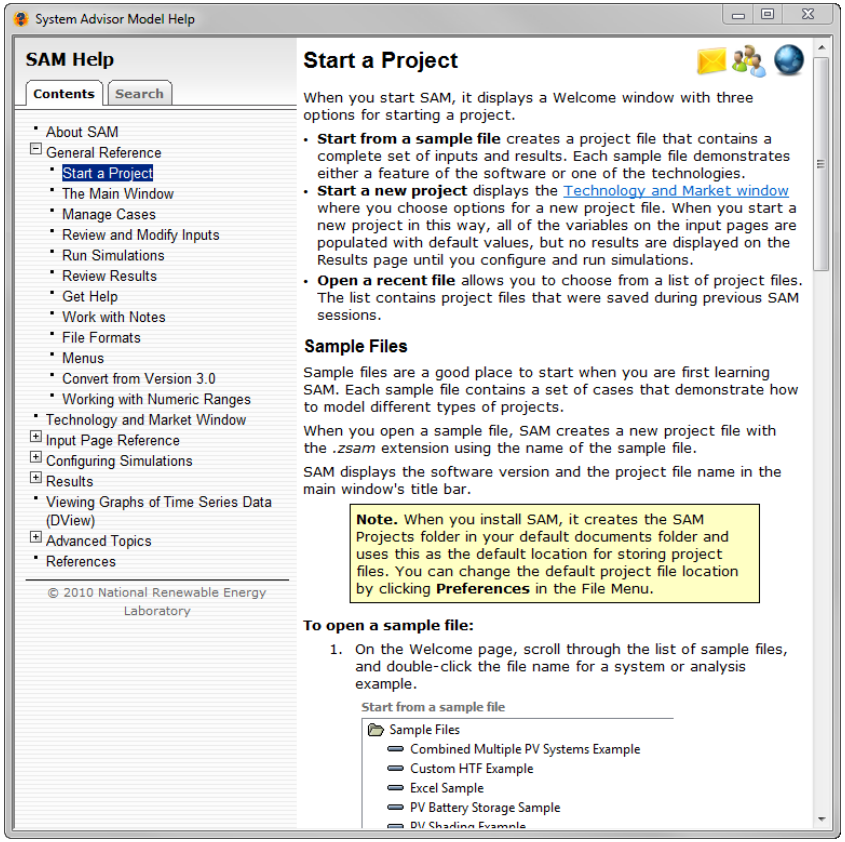
Online Help

– Help menu and buttons

Support Forum

– http://sam.nrel.gov





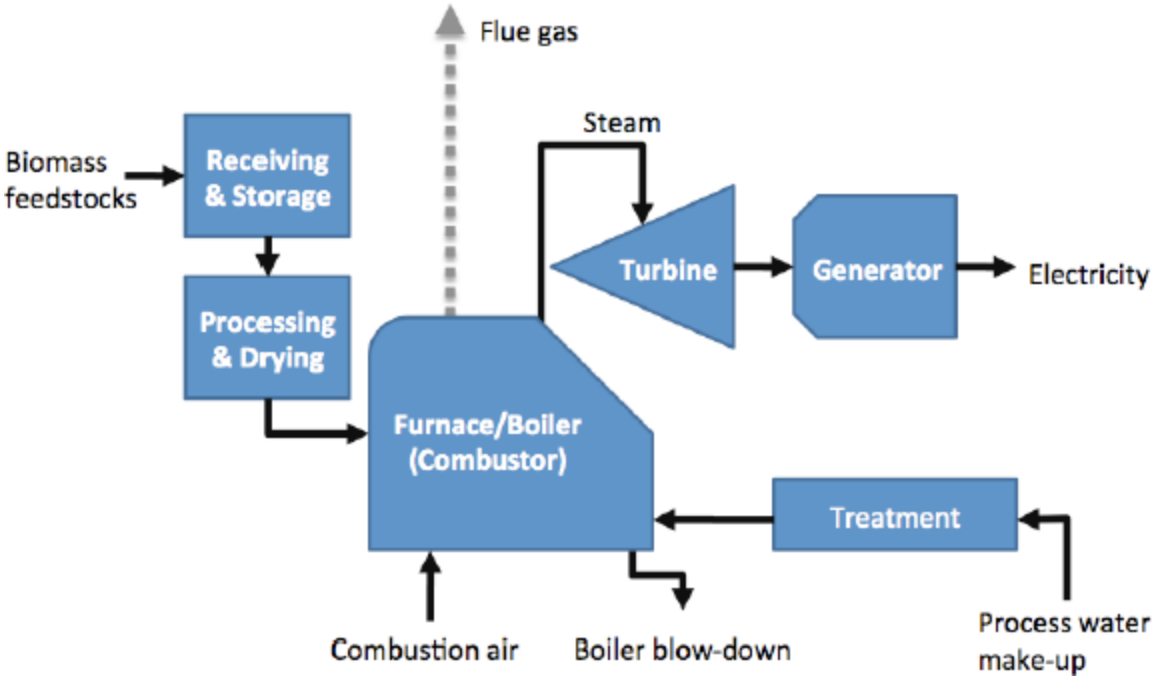
Simulating Biopower Systems in SAM

Biomass combustion for electricity generation

- Feedstock handling
- Combustion system
- Steam Rankine power cycle
- Parasitic loads

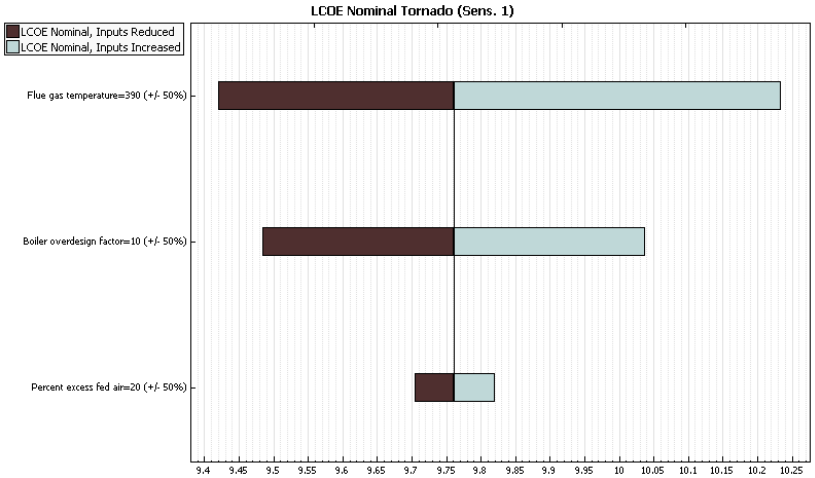
SAM does not model:

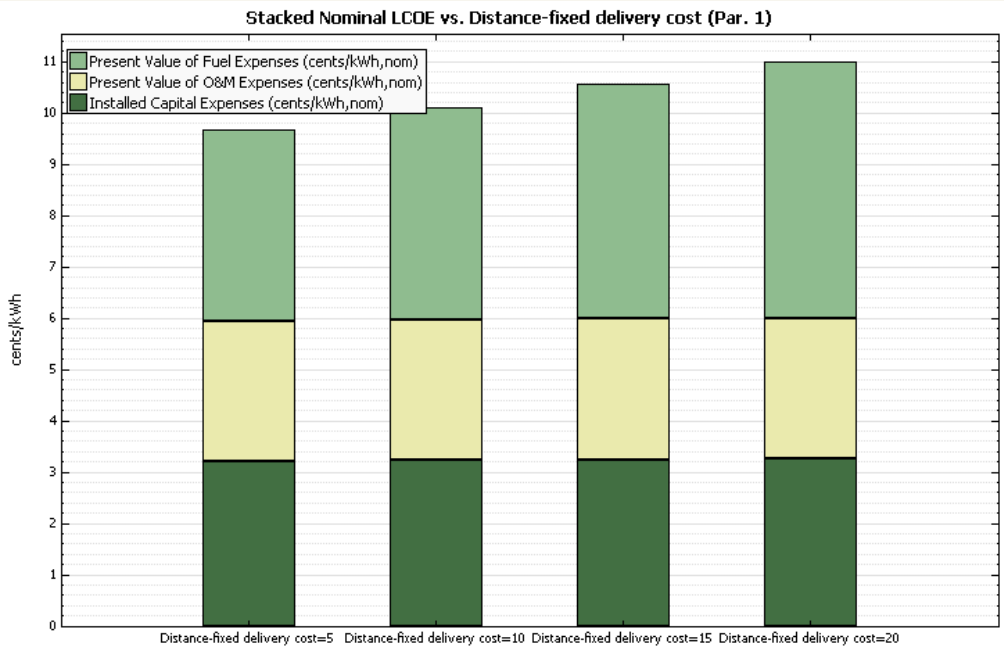
- Gasification
- Anerobic digestion

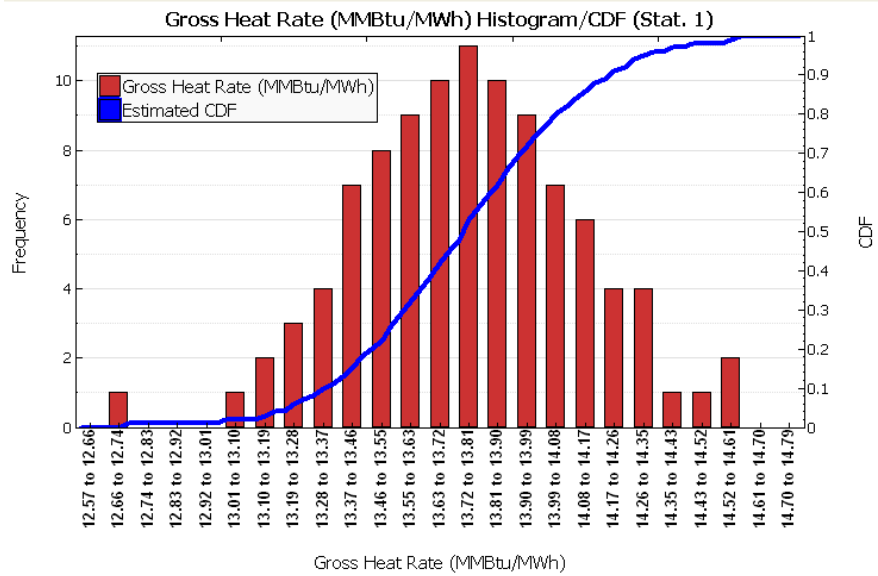


Parametric and Uncertainty Analysis

How does LCOE vary with feedstock delivery cost?
What design factor is LCOE most sensitive to?







Other Advanced Features

Excel Exchange

- SAM has the capability to send values to, and receive values from an Excel spreadsheet when running in Windows
- Costs can be calculated externally based on SAM inputs, then the costs can be automatically updated on SAM's cost input page

Scripting – SamUL

- A language, similar to VBA, that allows a user to control SAM runs
- Easier than using the full API, since no external development environment is necessary

API

- SAM has a full featured Application Programming Interface
- SAM will generate example code in C, VBA, Phython, and Matlab to show how to run a SAM analysis

See help and sample files for more information

Modeling Biopower Projects with SAM

SETTING UP THE SAM FILE

Welcome Page

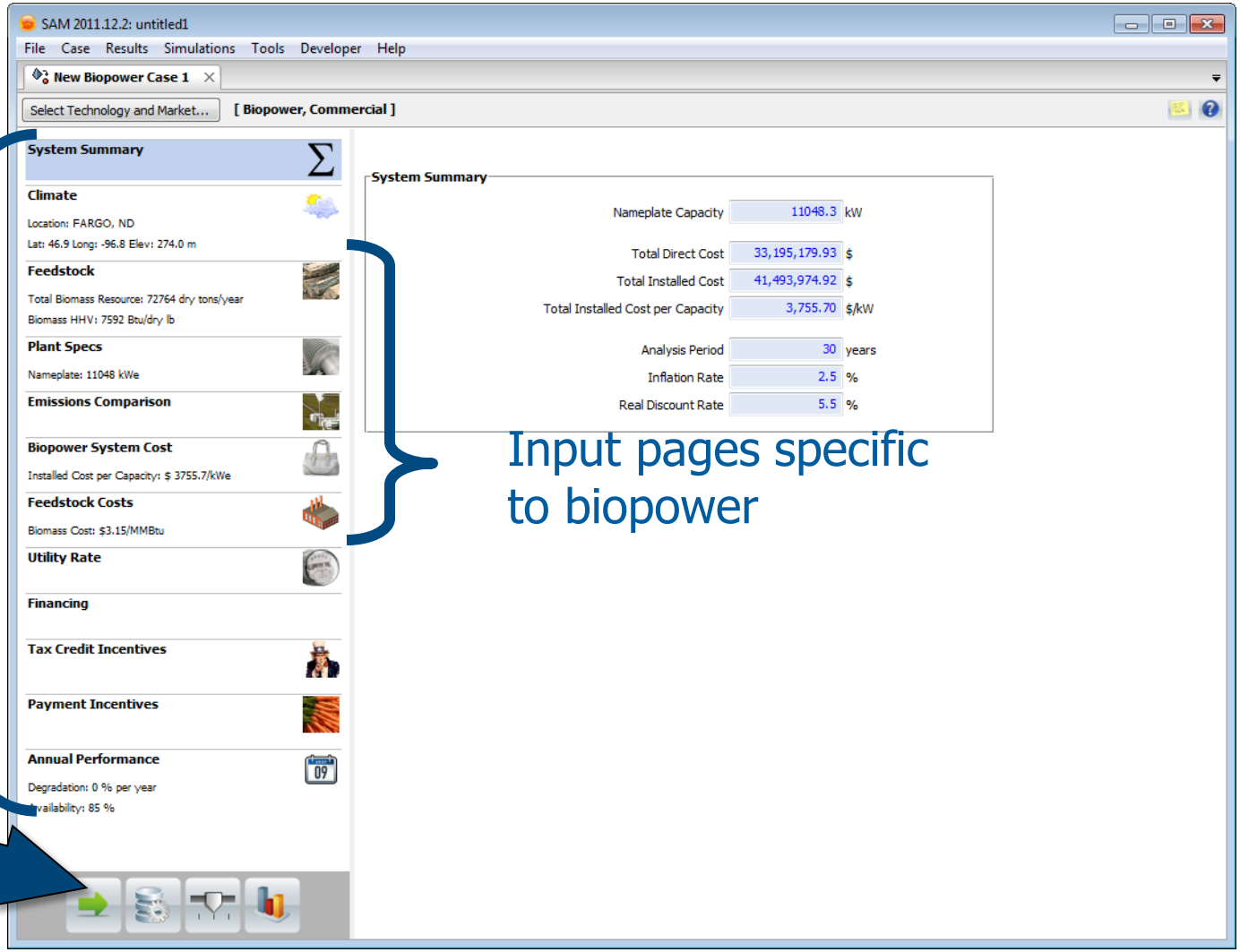
Click “Create a new file…” button to create a case and choose the technology option and financing option

Choose a performance and financing model

1) Under “Select a technology,” click “Biomass Power.”
2) Under “Select a financing option,” click an option.

Navigating Input Pages

Select a page by clicking an item in the navigation menu



Input pages specific to biopower

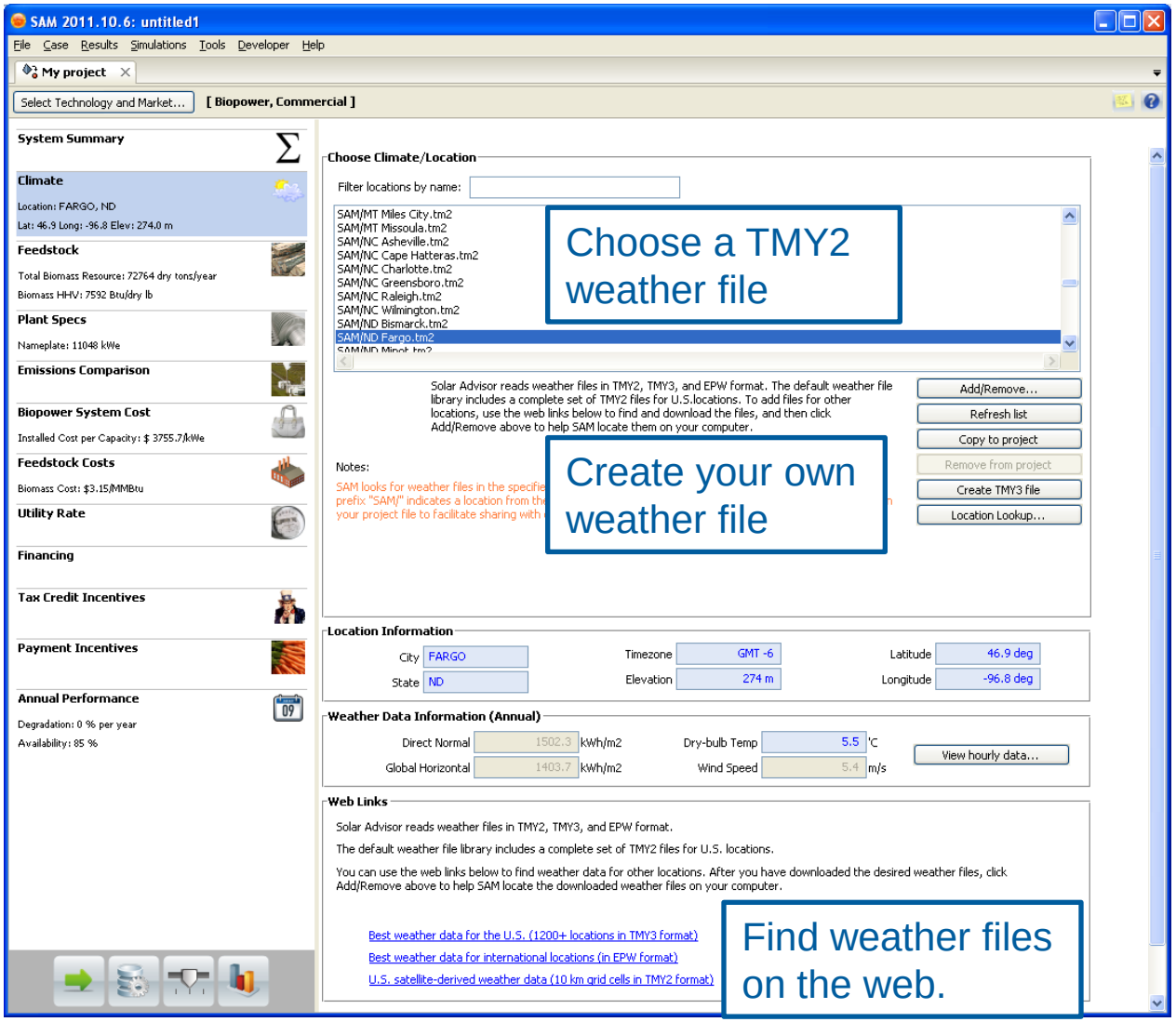
Run the model

Modeling Biopower Projects with SAM

LOCATION, FINANCING, AND COST INPUTS

Climate page

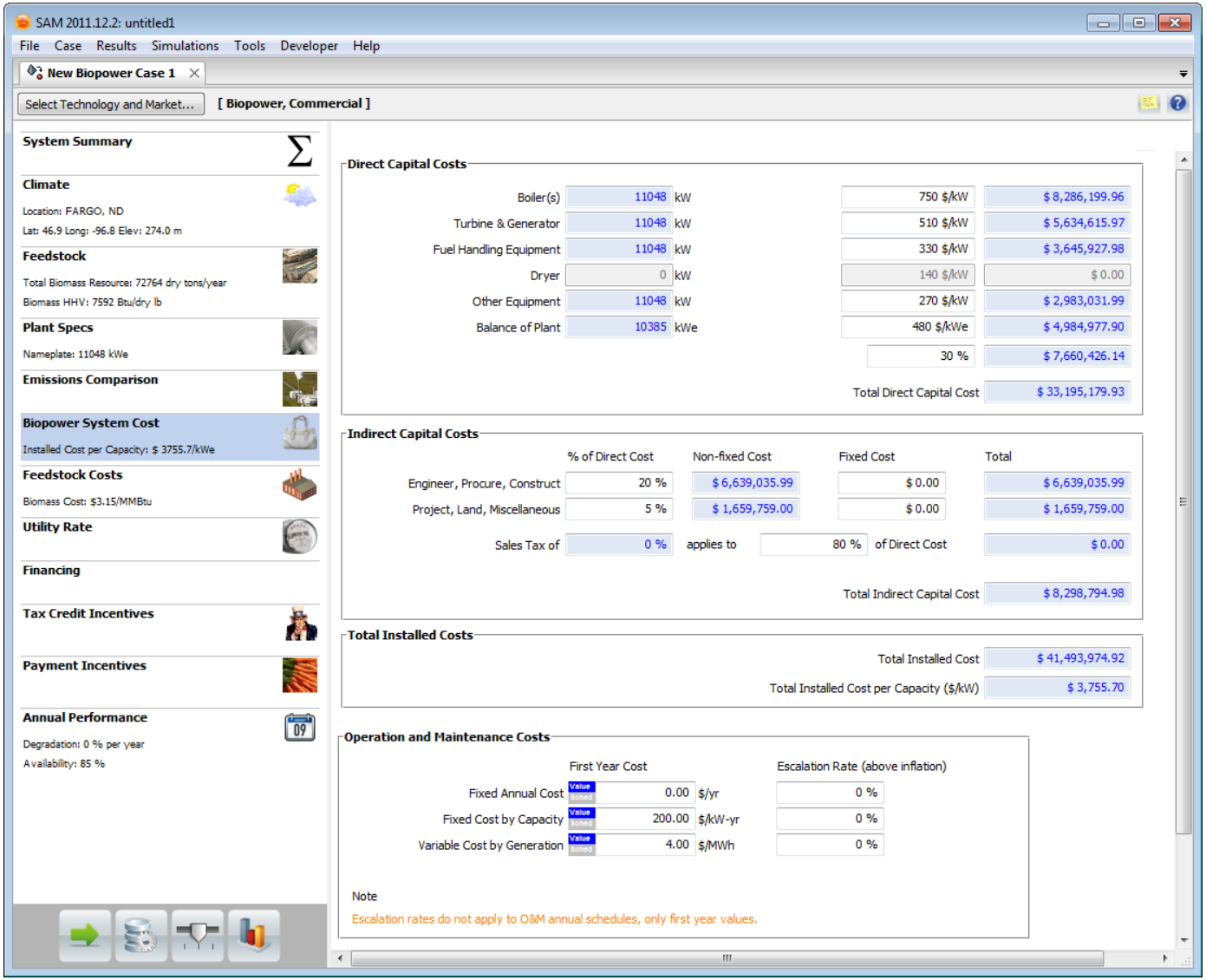
- Ambient conditions for power cycle model and for feedstock moisture content calculations
- Latitude and longitude for accessing resource data from internet



Costs

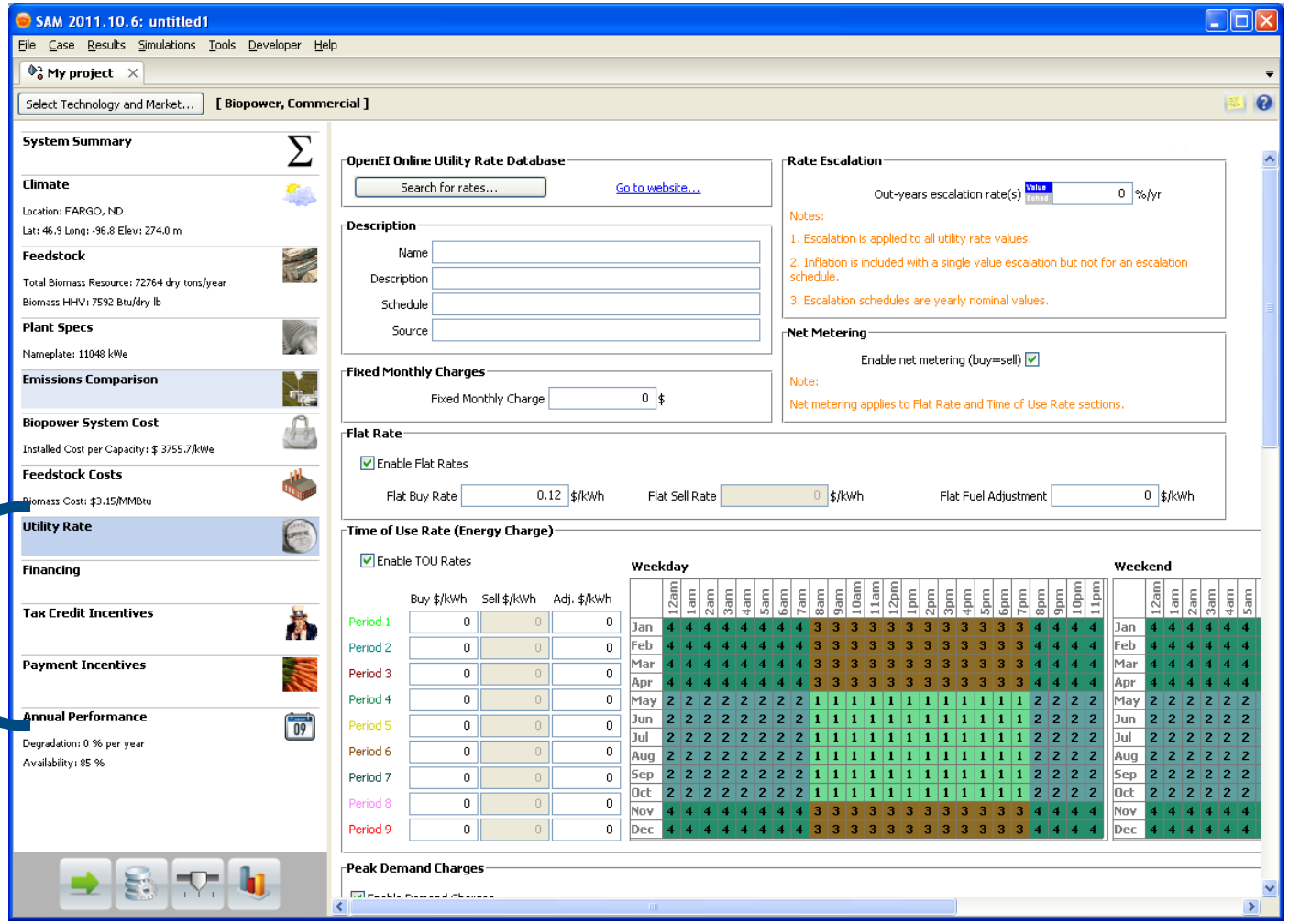
Installation Costs

Operating Costs



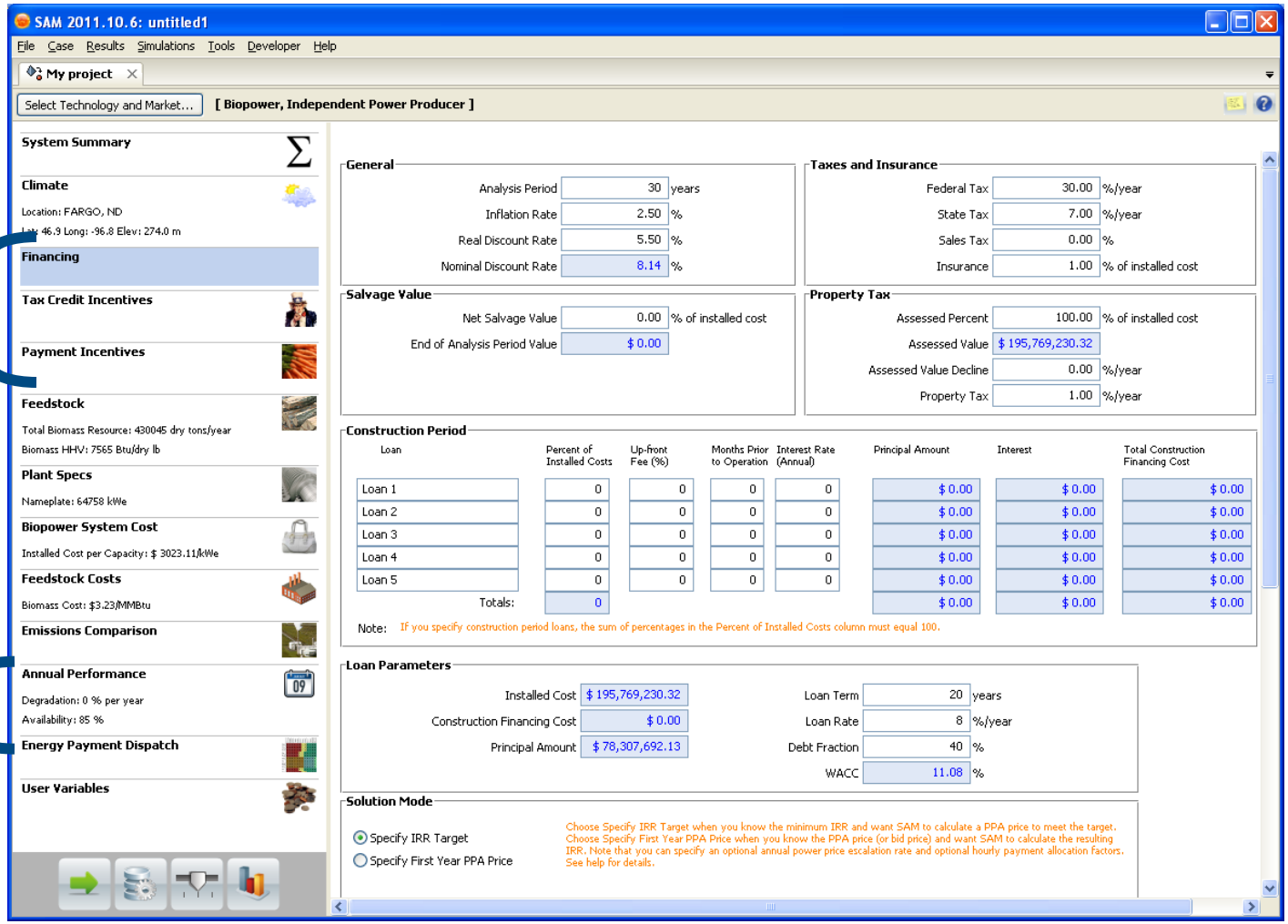
Inputs – Financial Assumptions

Financial input pages for the Commercial financing option



Inputs – Financial Assumptions

Financial inputs for the Utility financing options



Modeling Biopower Projects with SAM

BIOMASS POWER PLANT INPUTS

Biopower model input requirements

Hourly weather data for one year

Feedstock Information

- Use NREL's Biofuels Atlas to determine feedstock based on location and collection radius
- Specify common feedstocks
- Specify additional feedstocks by composition and heating value
- Specify supplemental/primary coal feedstocks.

Plant Specifications

- Boiler, Turbine parameters
- Dispatch schedule

System costs: Installation and operating costs

Feedstock Costs: Biomass and delivery costs

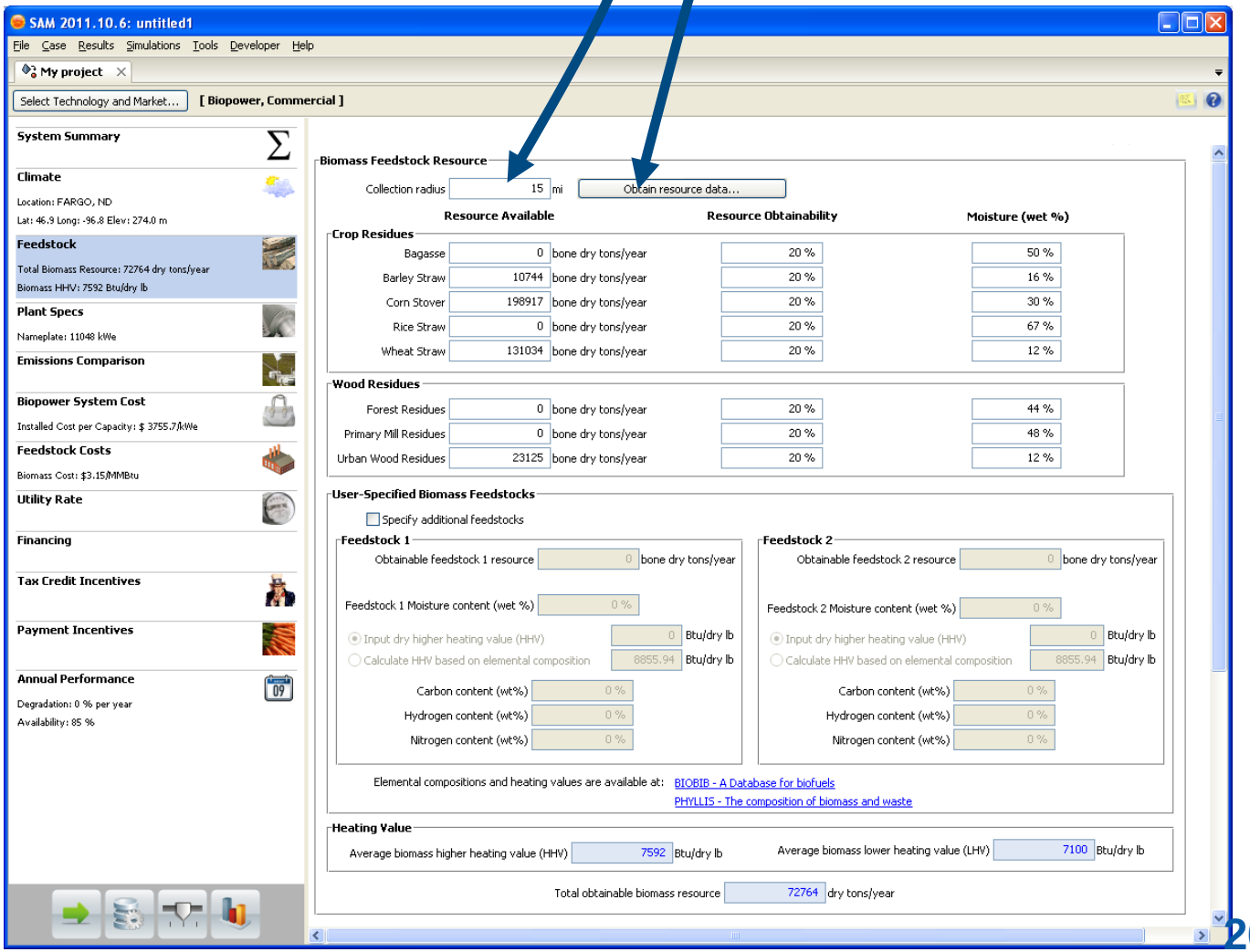
Financial assumptions

- Loan parameters for all projects
- Target IRR for utility projects
- Incentives and tax credits

Inputs – Feedstock Page

1. Input feedstock collection radius

2. Click “Obtain resource data…”



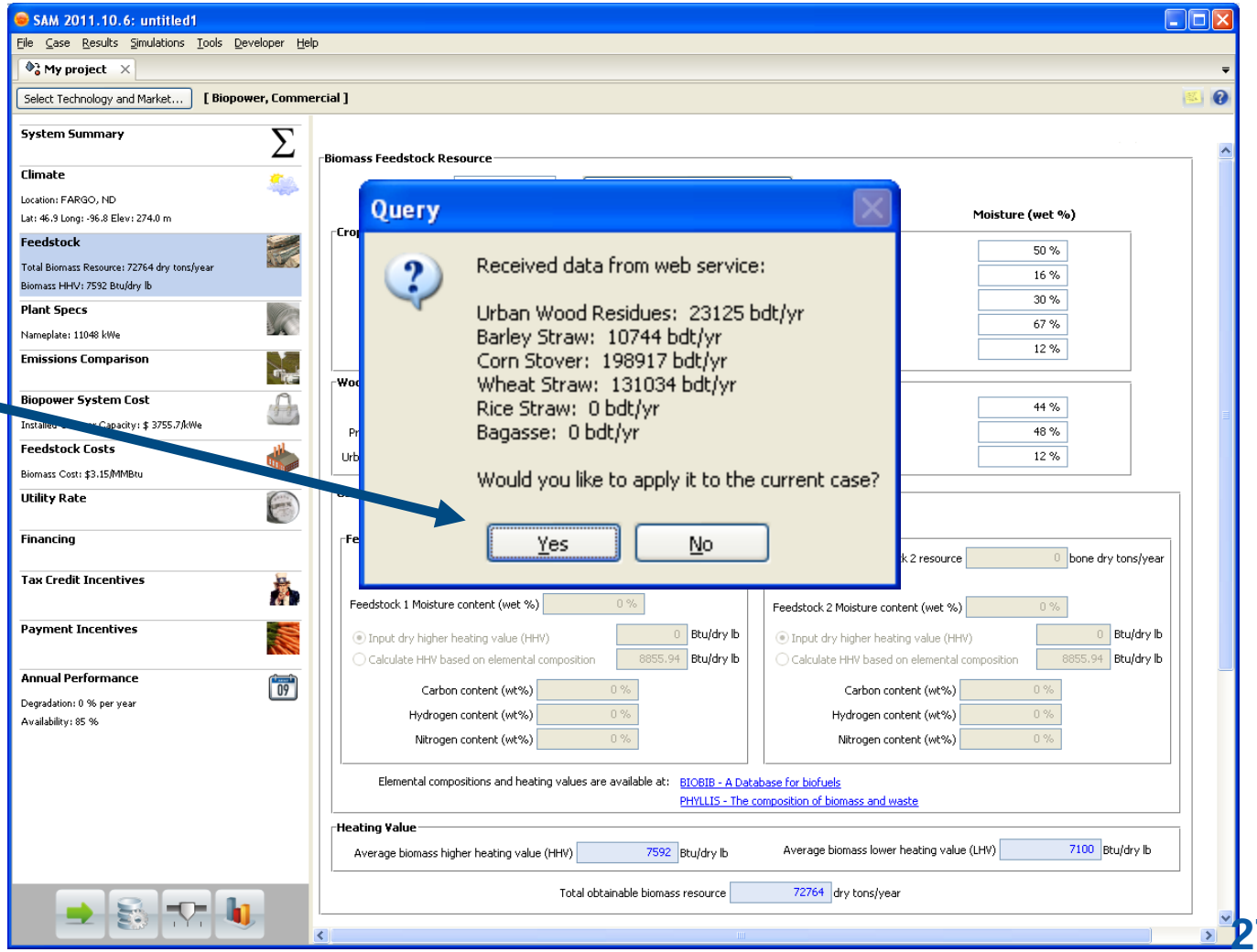
Inputs – Feedstock Page

1. Input feedstock collection radius

2. Click "Obtain resource data…"

SAM queries NREL's Biofuels Atlas

Choose Yes to apply the data to the current case. Choose No to specify feedstock manually



Inputs – Feedstock Page

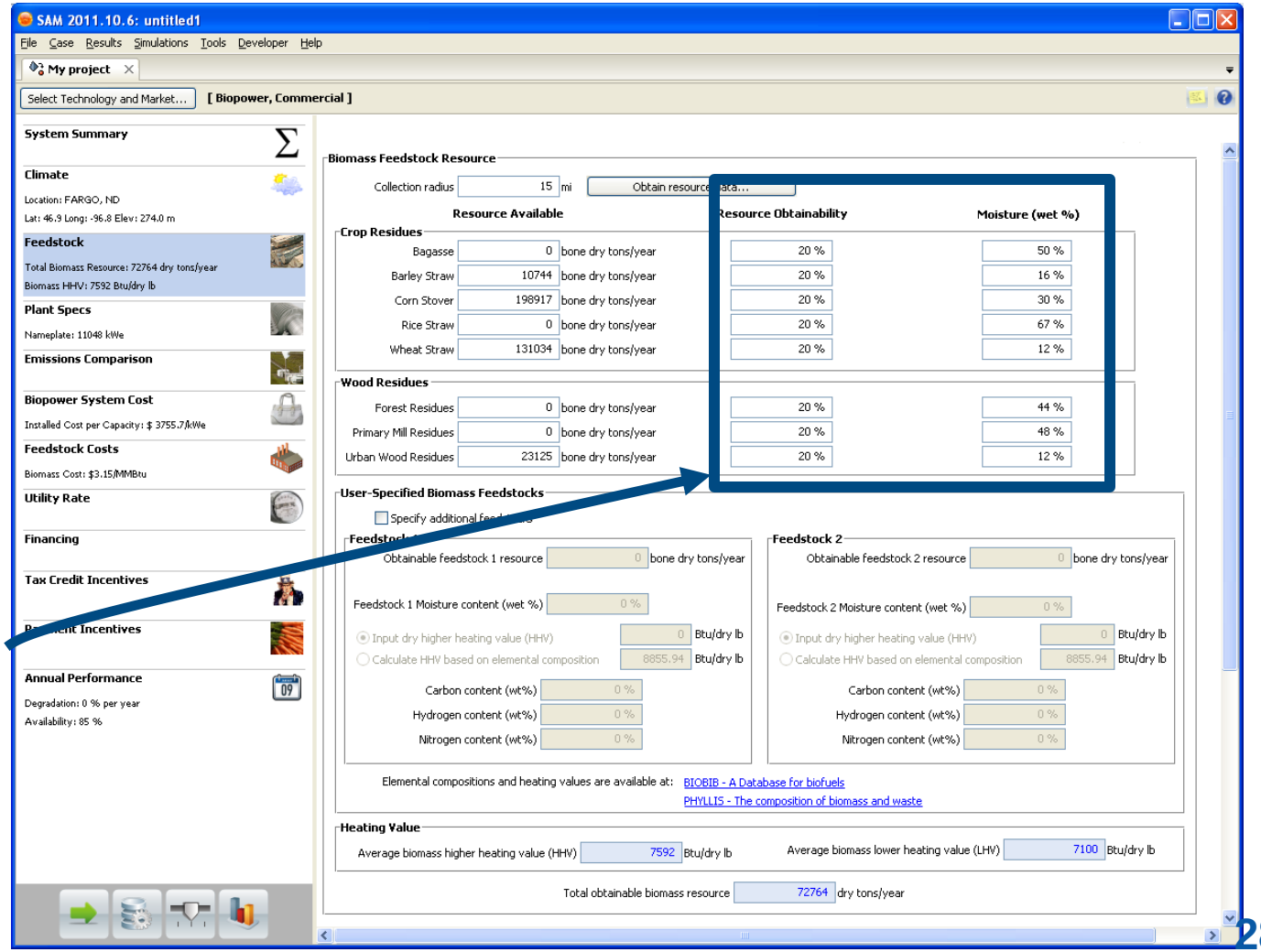
1. Input feedstock collection radius

2. Click "Obtain resource data…"

SAM queries NREL's Biofuels Atlas

Choose Yes to apply the data to the current case. Choose No to specify feedstock manually

Pick **Resource Obtainability Factors** to adjust the Available Resource and specify Moisture **(wet %)**



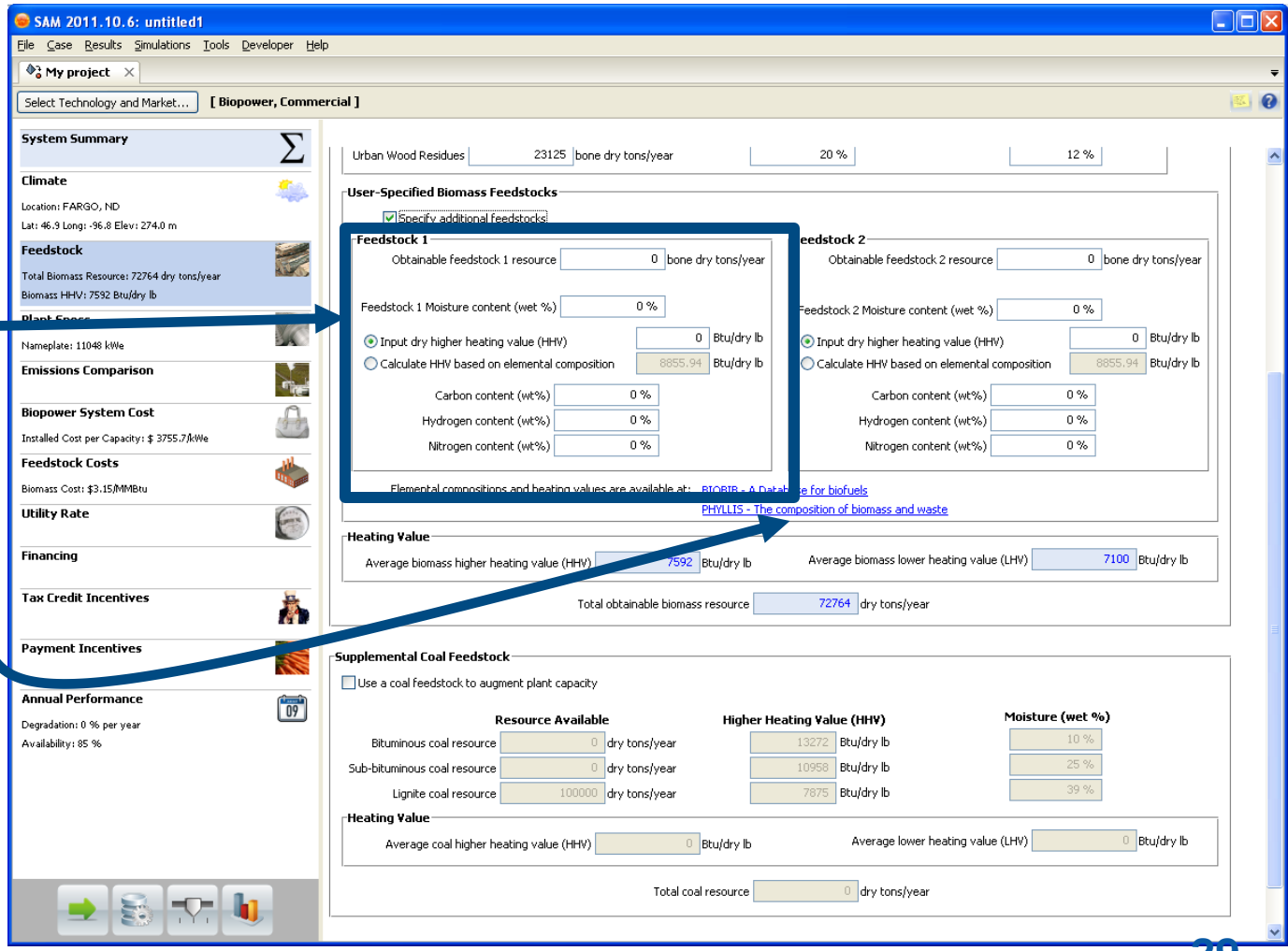
Inputs – Feedstock Page

And/or **Specify additional feedstocks**

Define a new feedstock:

1. **Obtainable Resource**
2. **HHV**
   - **Input** or
   - Empirically **Calculate**
3. Elemental Composition

Find feedstock information on the internet

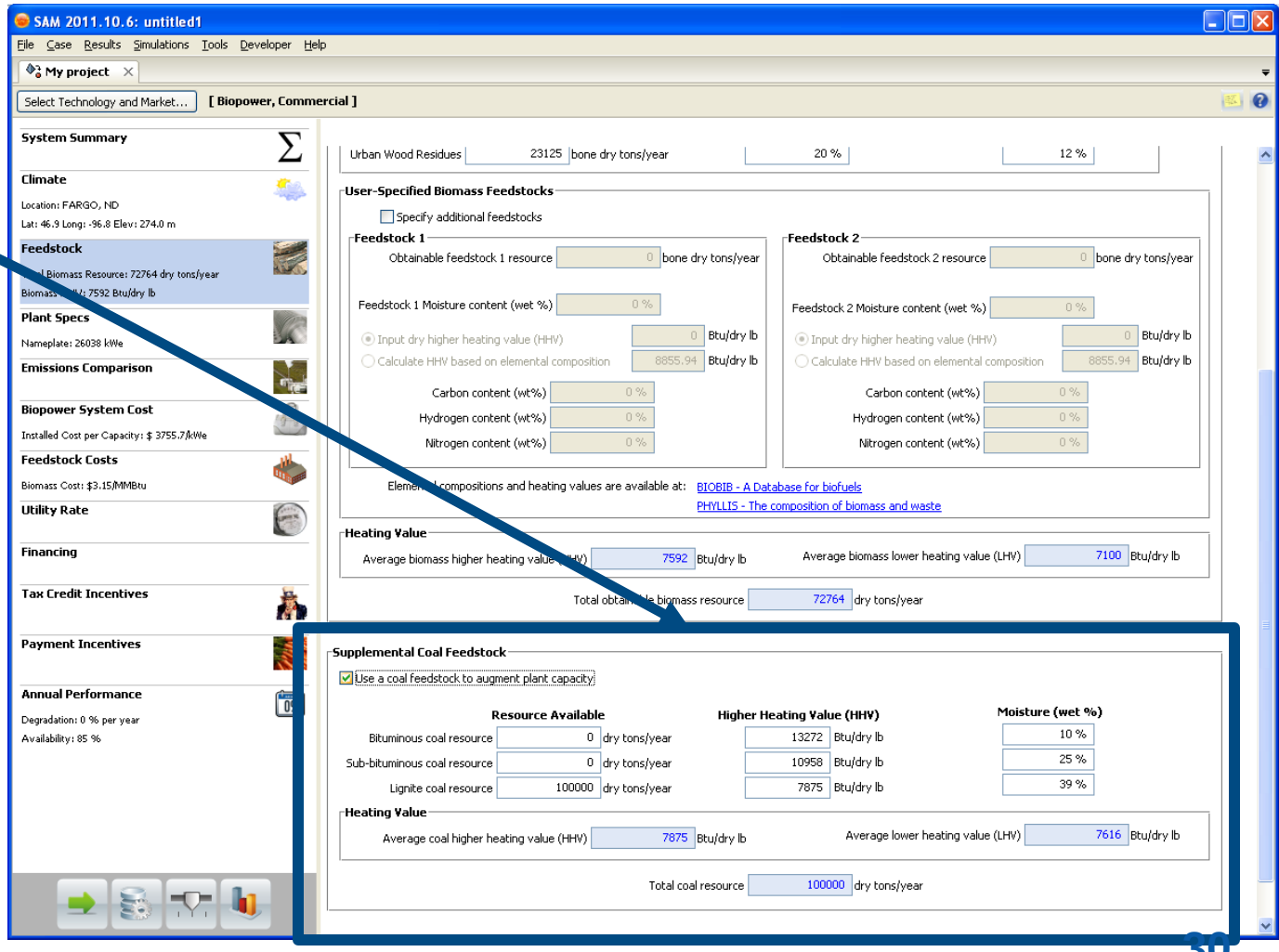


Inputs – Feedstock Page

And/or **Use a coal feedstock to augment plant capacity**

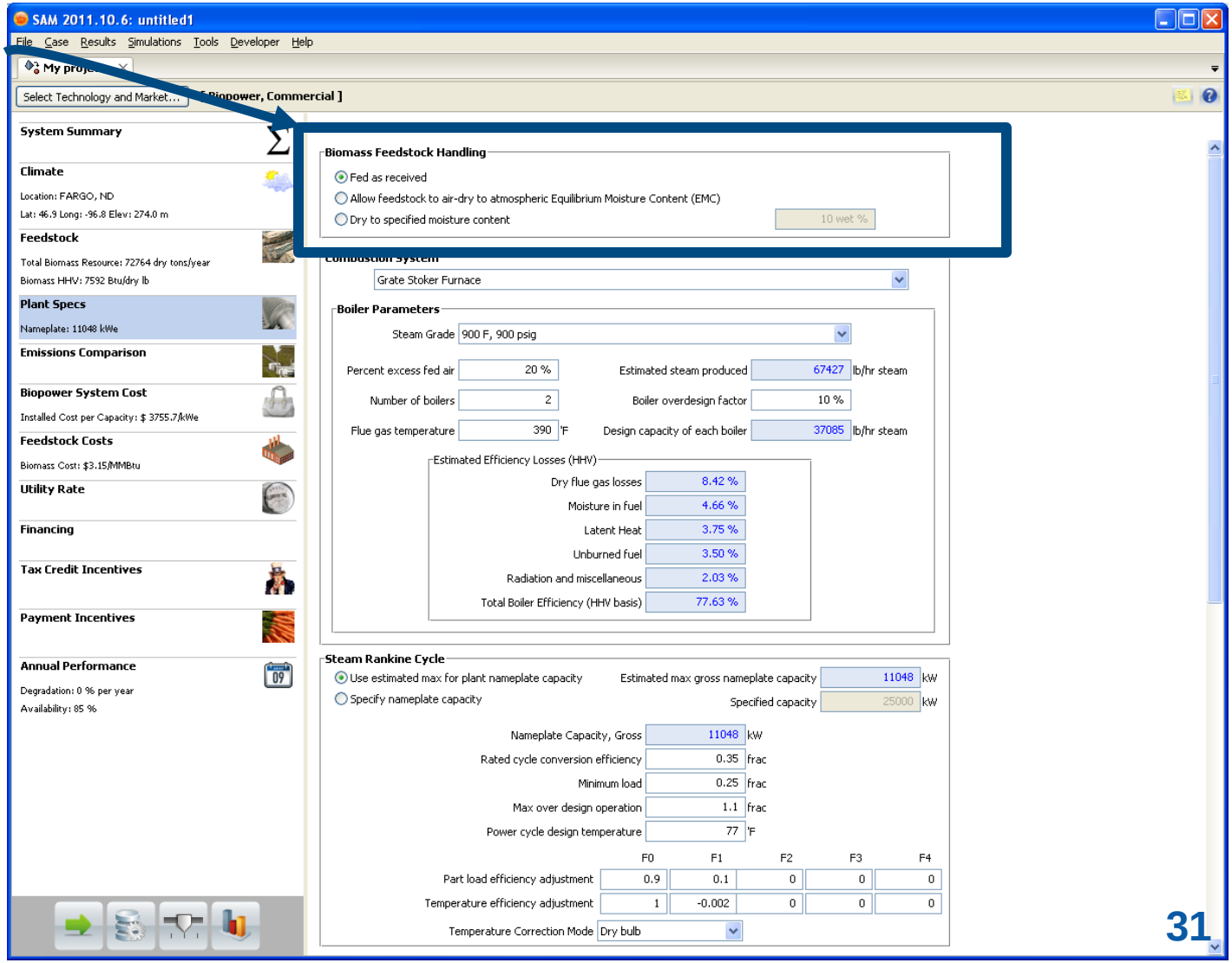
Define a coal feedstock:
- -Rank of coal
- **-HHV**
- **-Moisture (wet %)**

Note: set biomass resource to zero to model a completely coal-fired power plant



Inputs – Plant Specifications

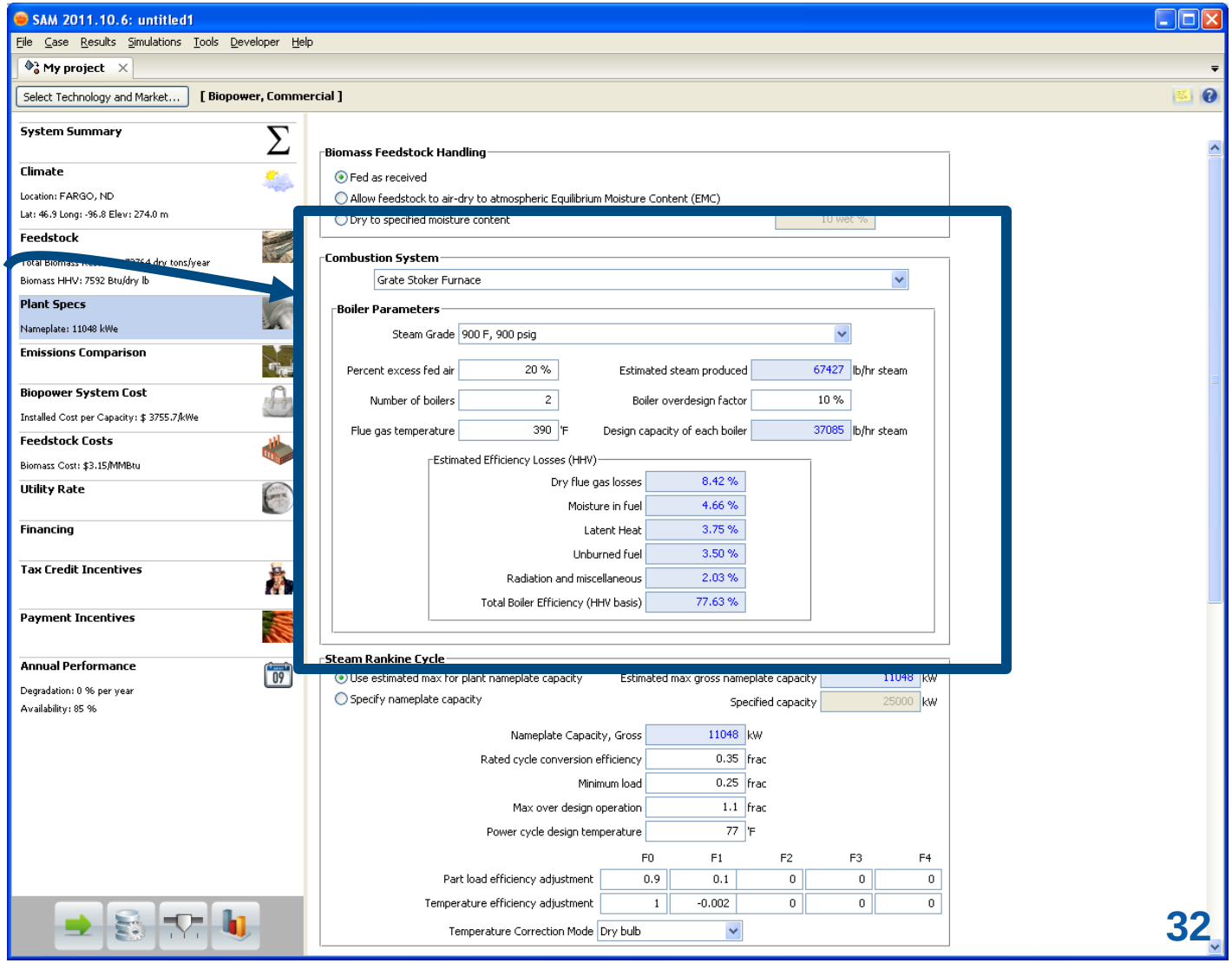
Feedstock Handling
– drying options



Inputs – Plant Specifications

Feedstock Handling
– drying options

Combustion System
parameters

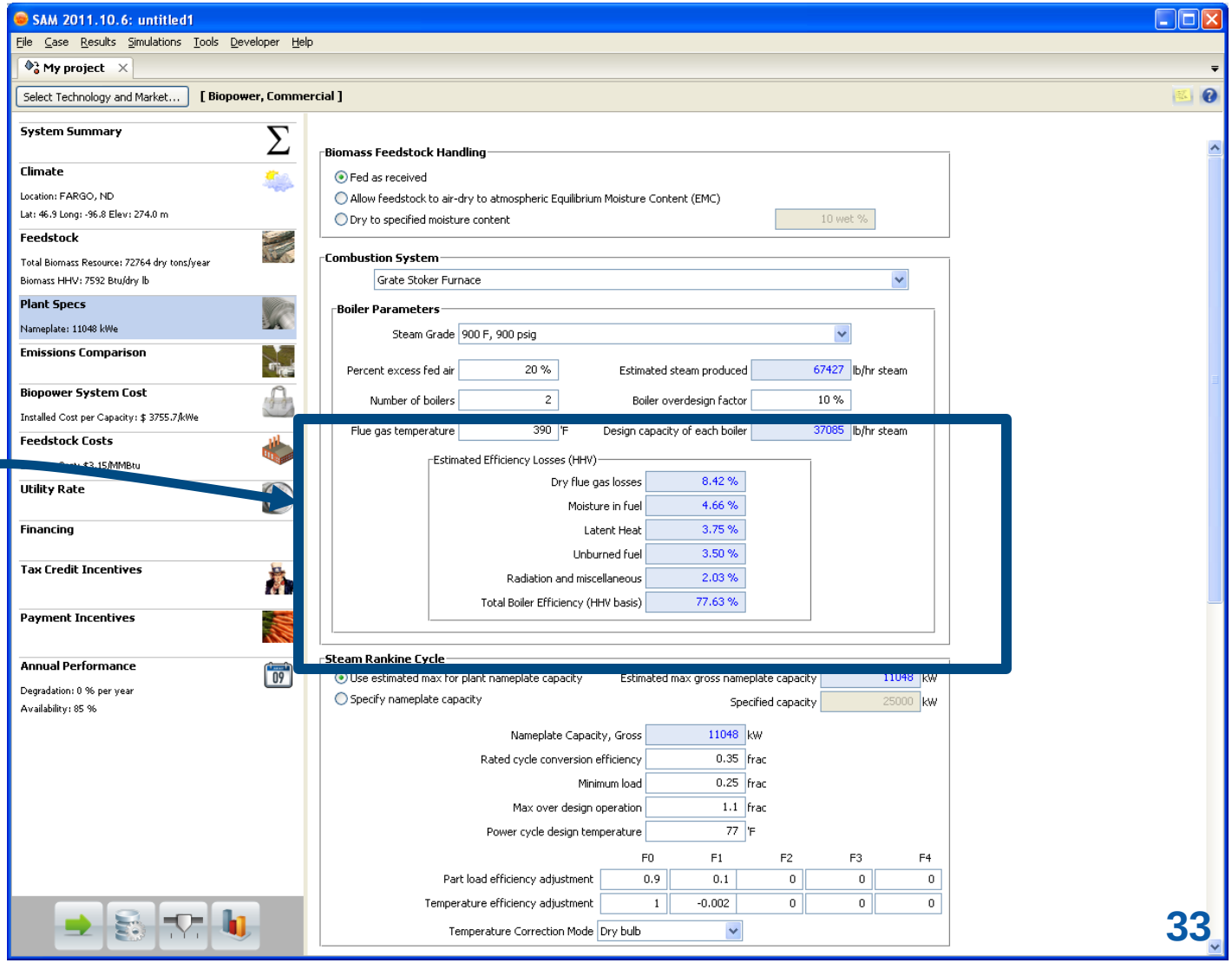


Inputs – Plant Specifications

Feedstock Handling
– drying options

Combustion System
parameters

Visible breakdown of boiler efficiency losses



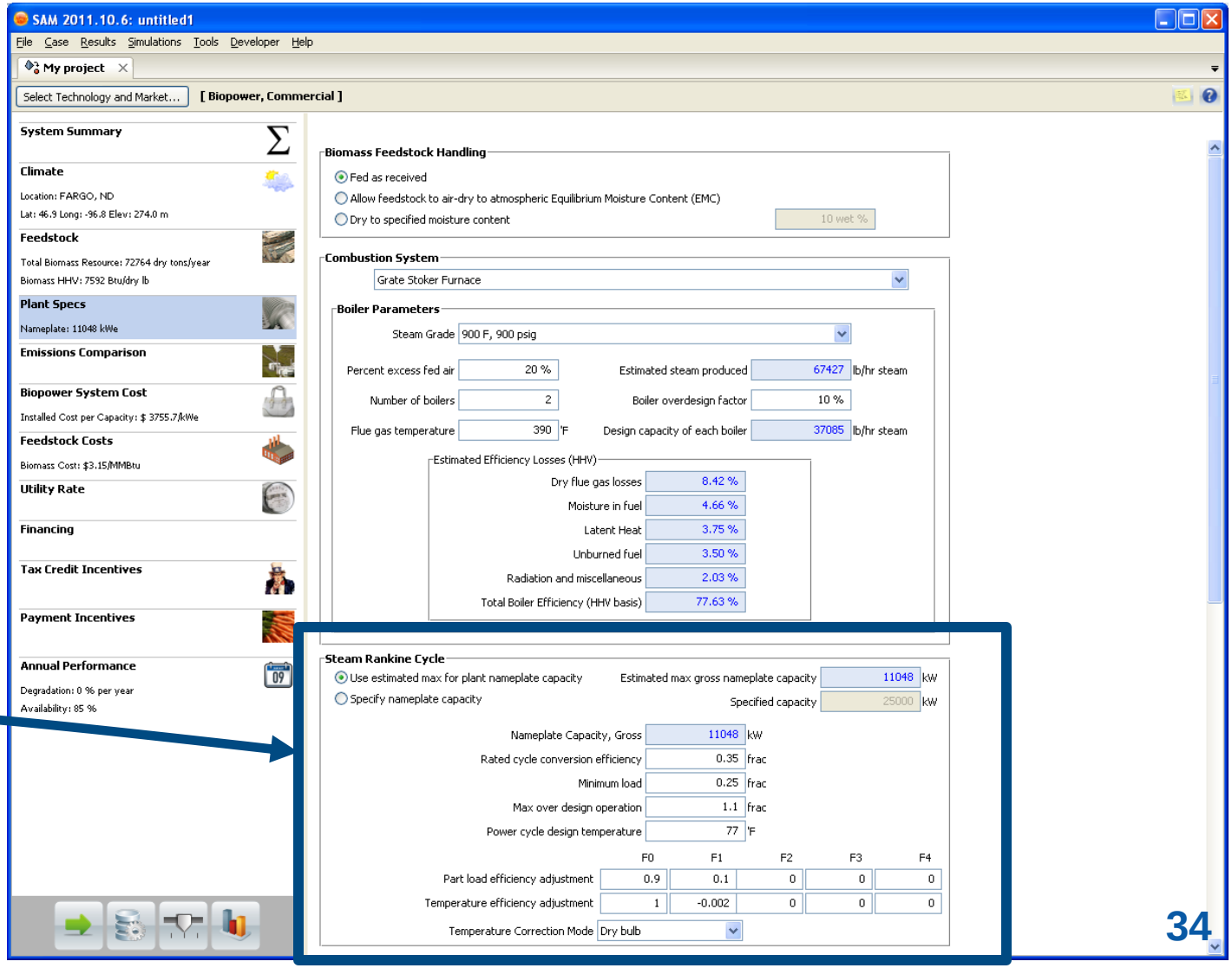
Inputs – Plant Specifications

Feedstock Handling
– drying options

Combustion System
parameters

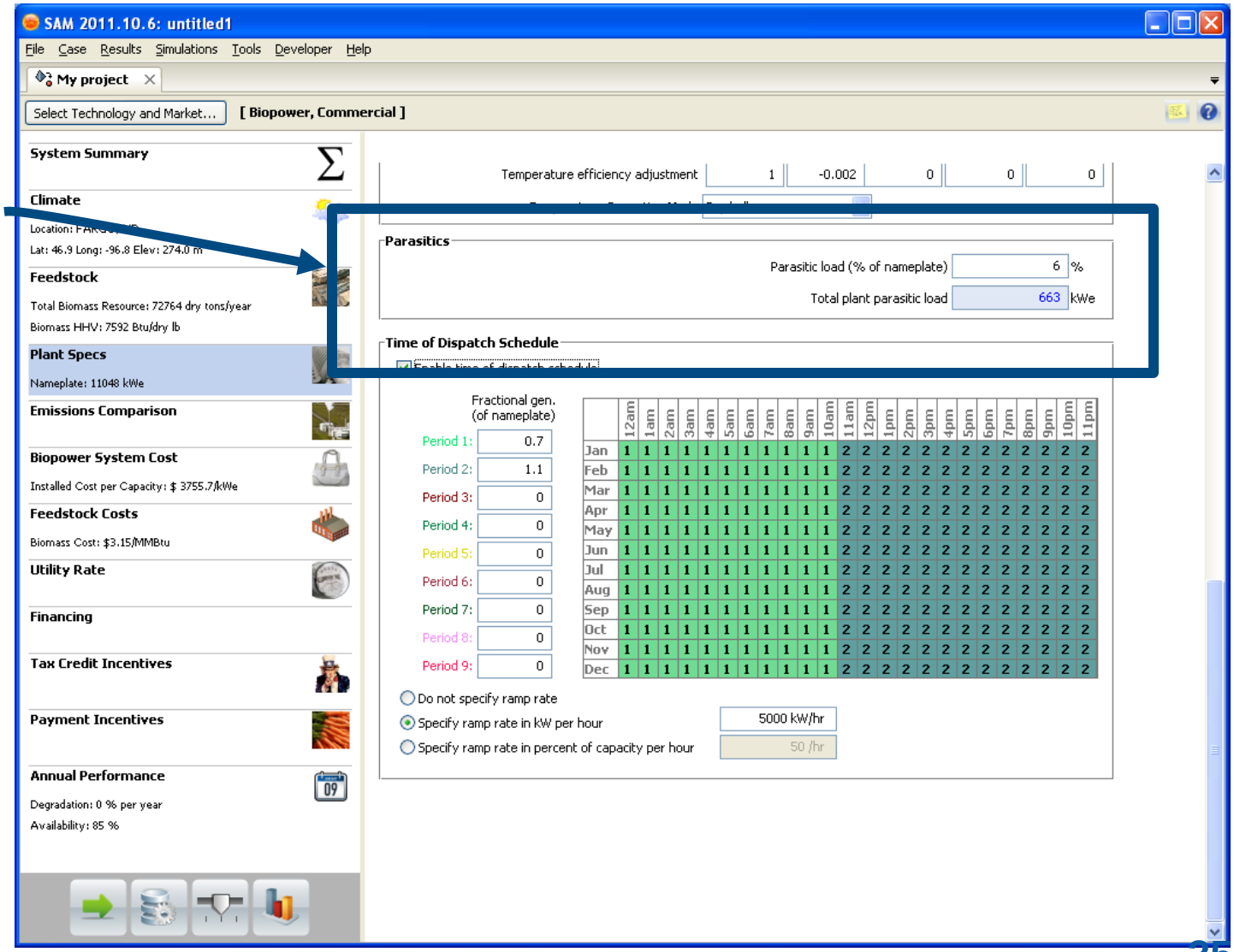
Visible breakdown of boiler efficiency losses

Power Cycle specifications



Inputs – Plant Specifications

Specify Parasitic Load

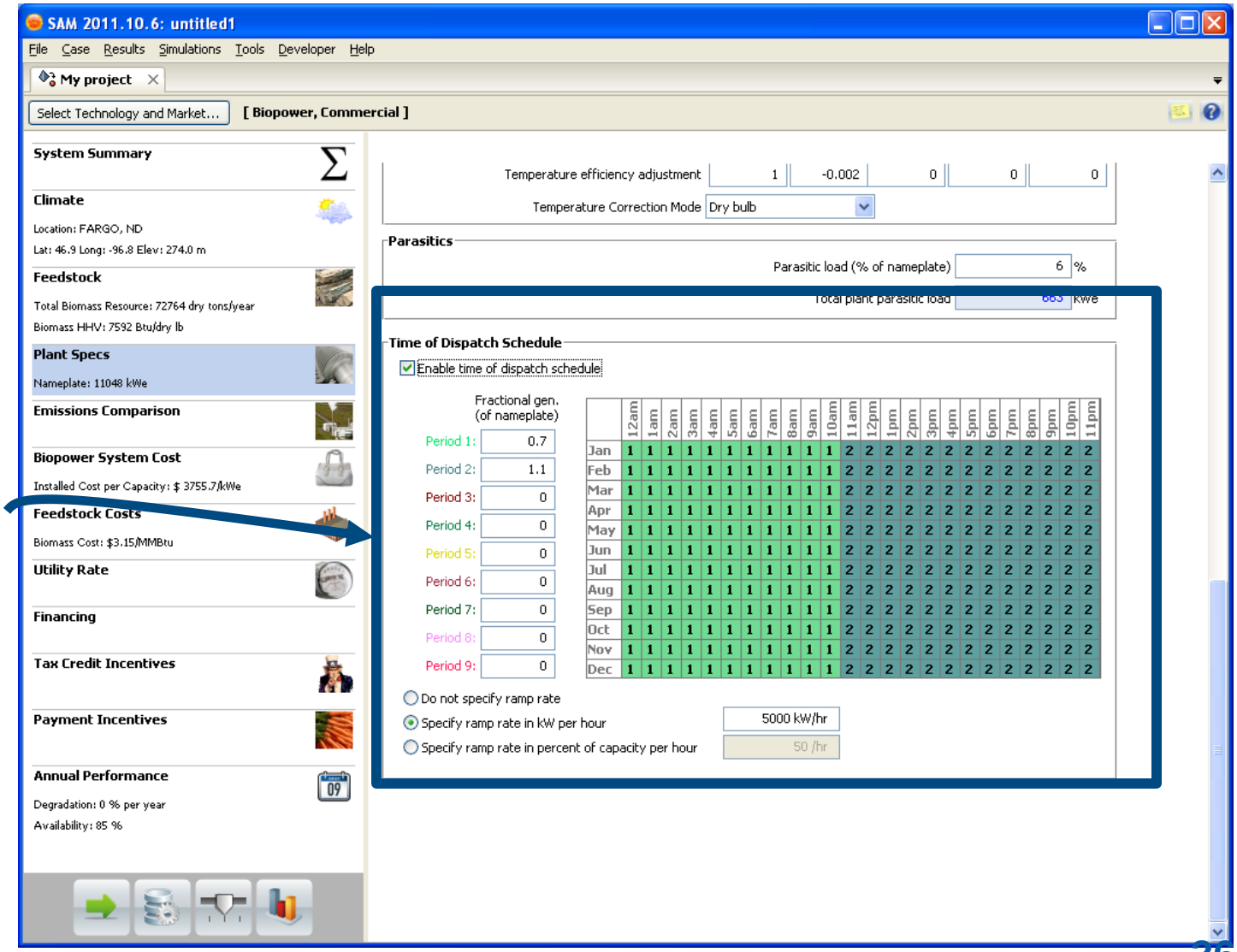


Inputs – Plant Specifications

Specify Parasitic Load

Enable time of dispatch schedule
-Plant can ramp up or down generation according to schedule

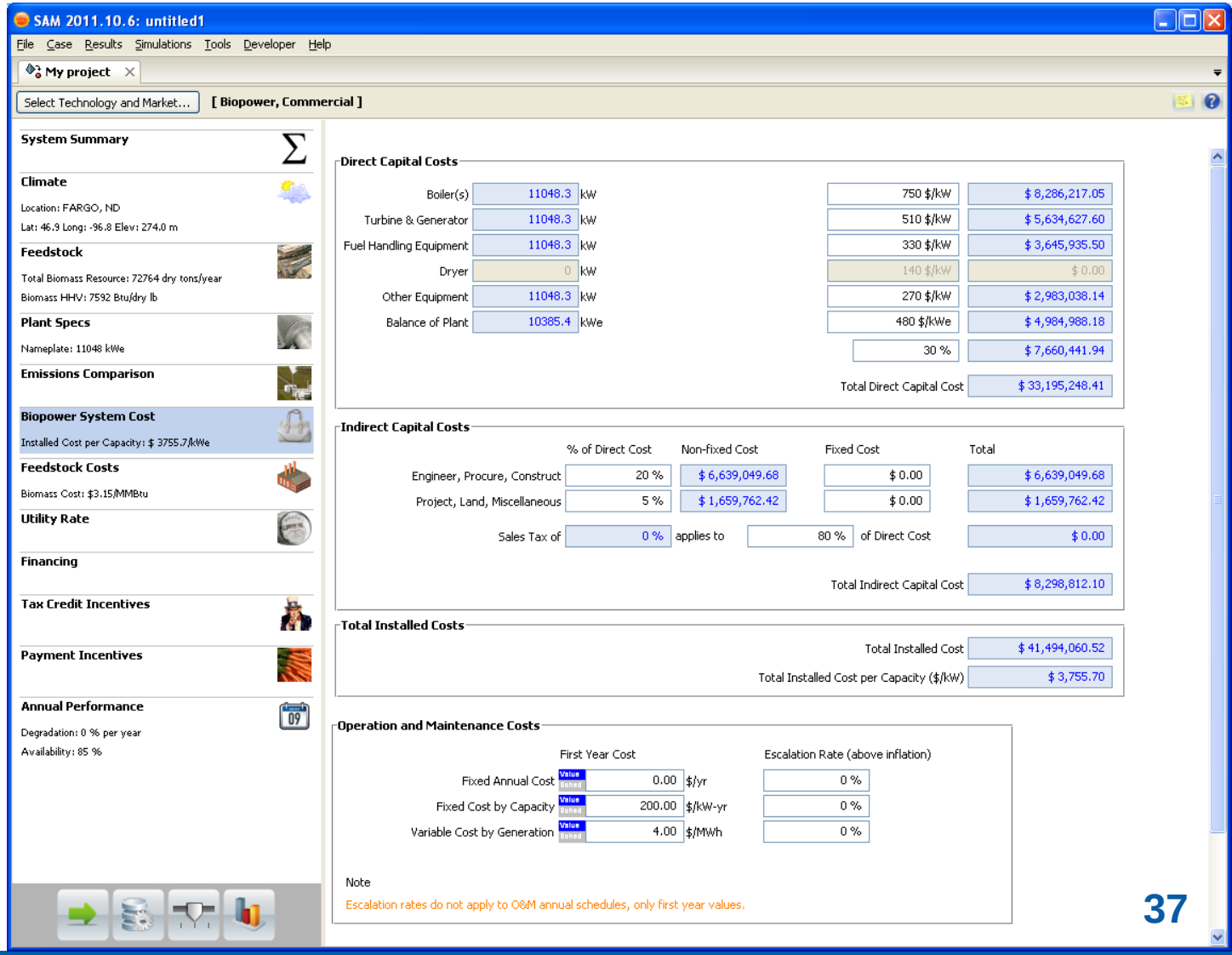
Specify ramp rate in kW/hr or %/hr



Inputs – Biopower System Cost

Input **Direct Capital Costs** for equipment

Input **Indirect Capital Costs** for EPC and PLM

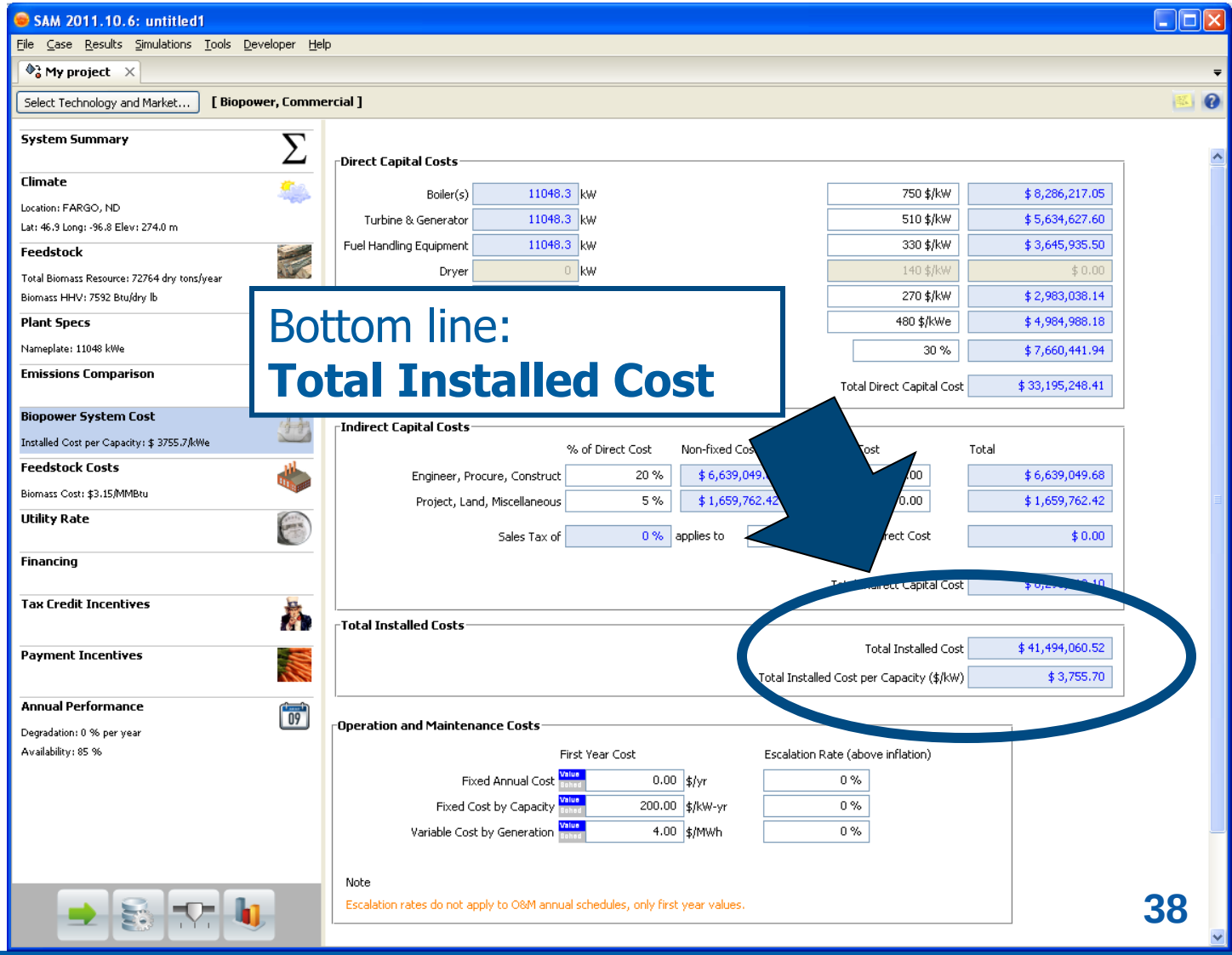


Inputs – Biopower System Cost

Input **Direct Capital Costs** for equipment

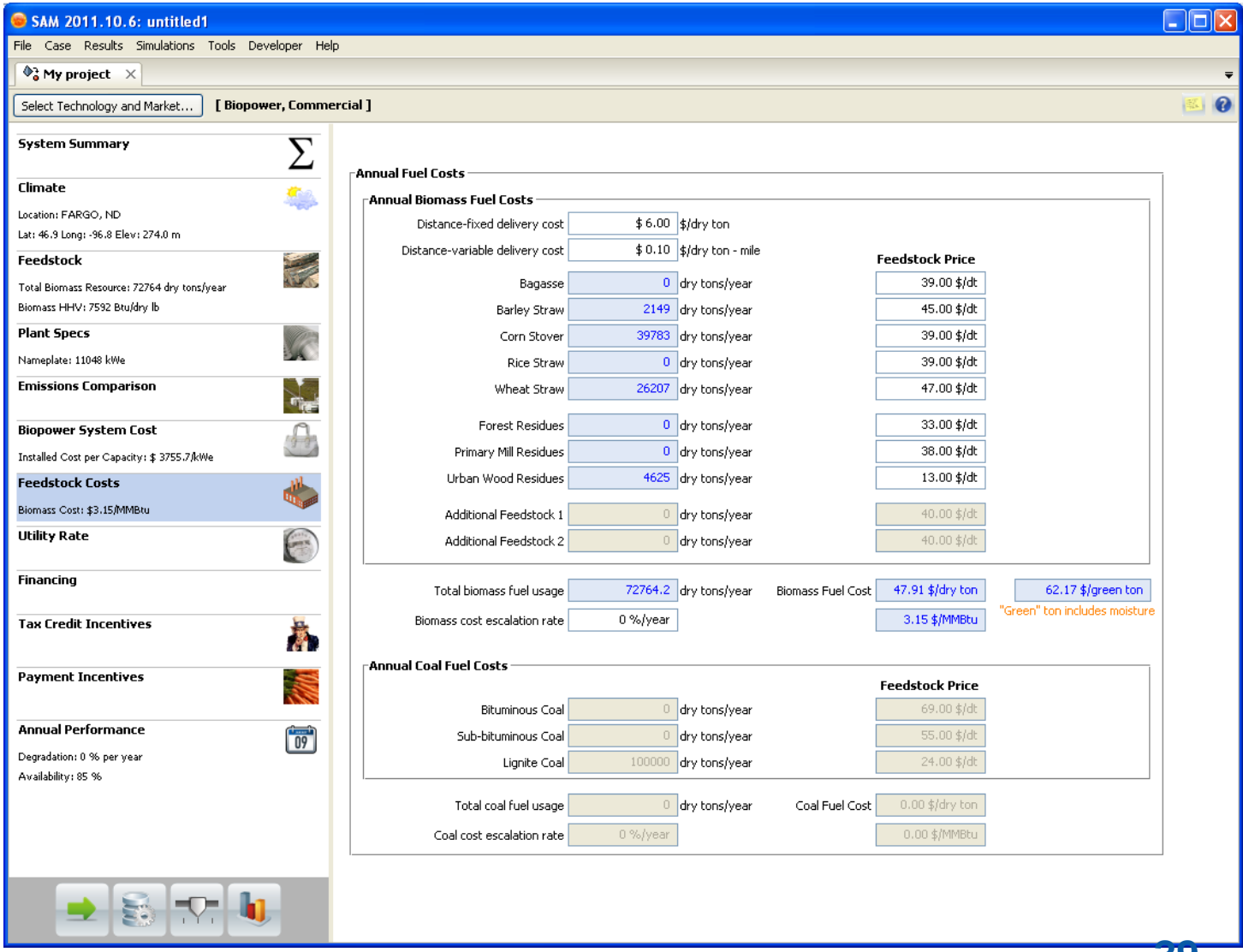
Input **Indirect Capital Costs** for EPC and PLM

Input **Operation and Maintenance Costs**



Inputs – Feedstock Cost

Specify **Feedstock Price**



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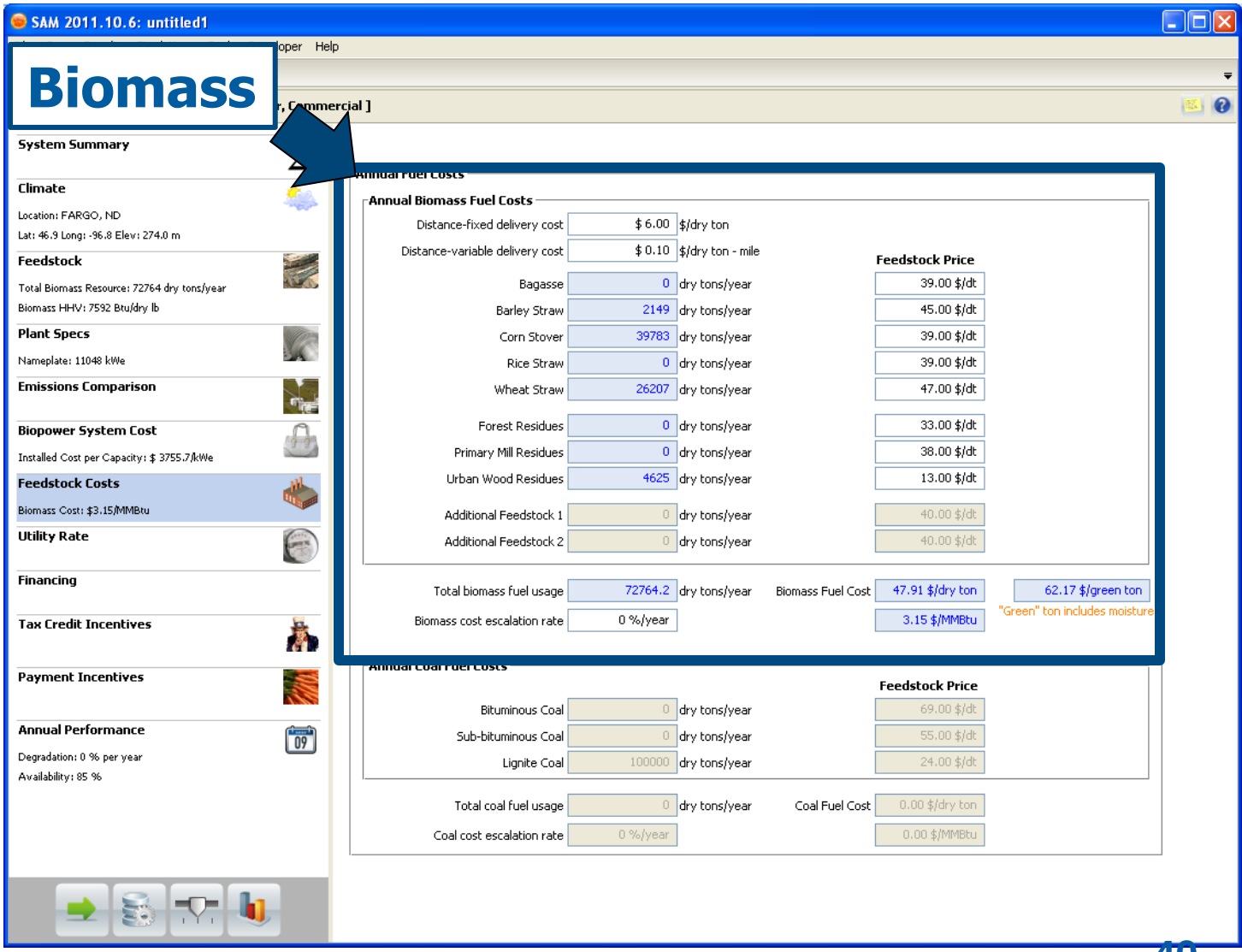

Inputs – Feedstock Cost

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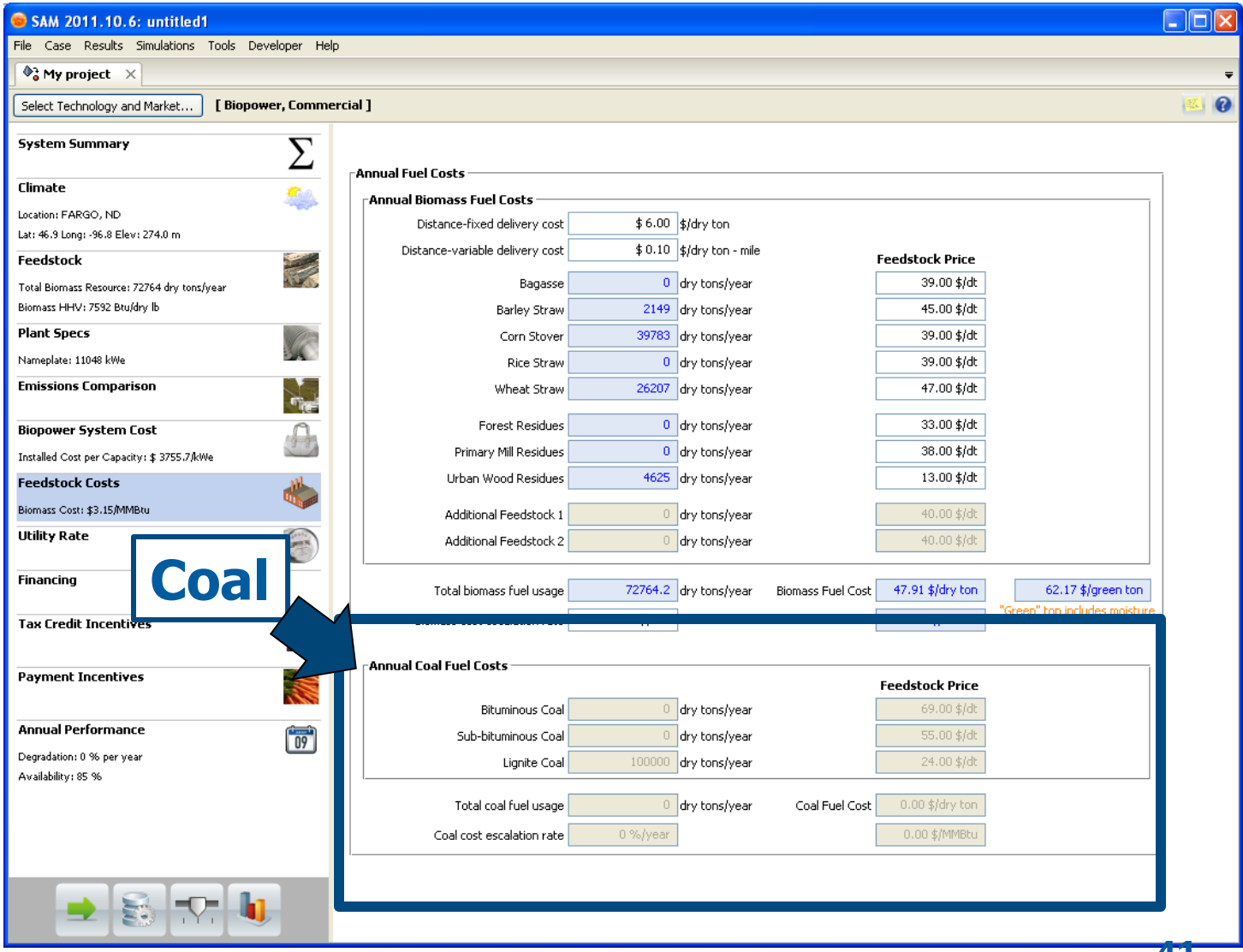
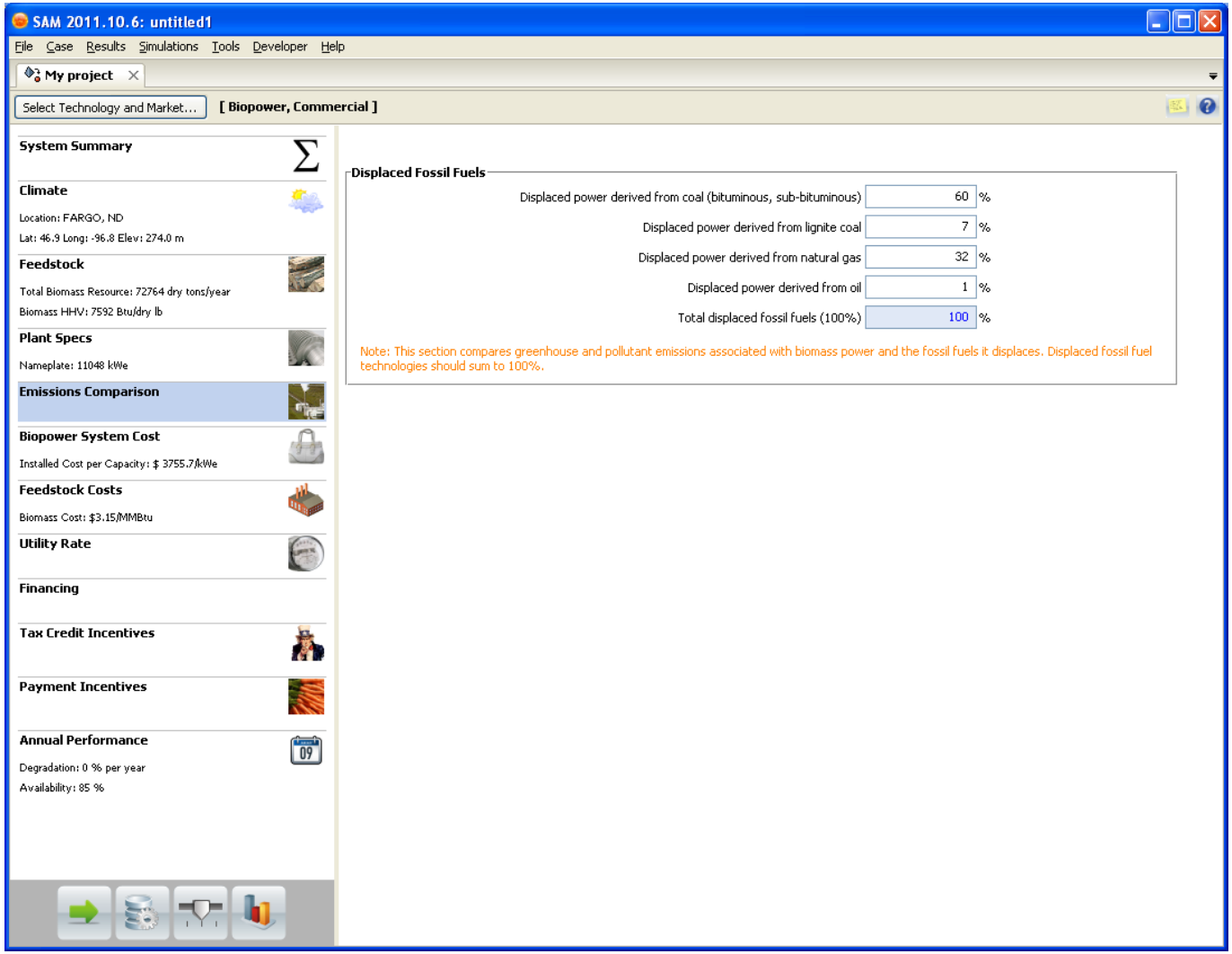


Inputs – Emissions Comparison

Specify which resources are displaced by biomass power



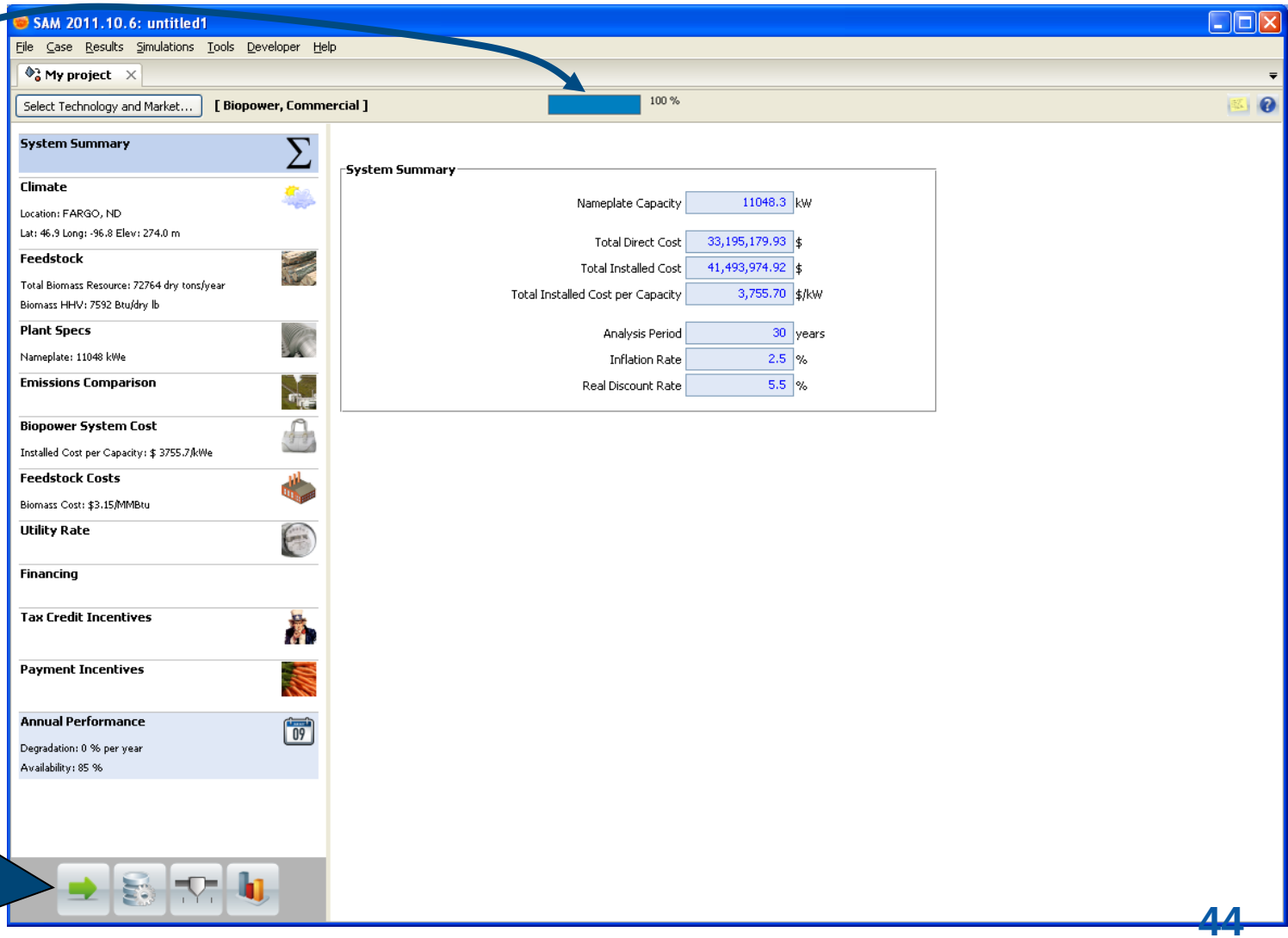
SAM Demo

RUNNING SAM, RESULTS

Running the model

Click the green arrow on the bottom left to run the model

SAM displays a progress bar while the model is running

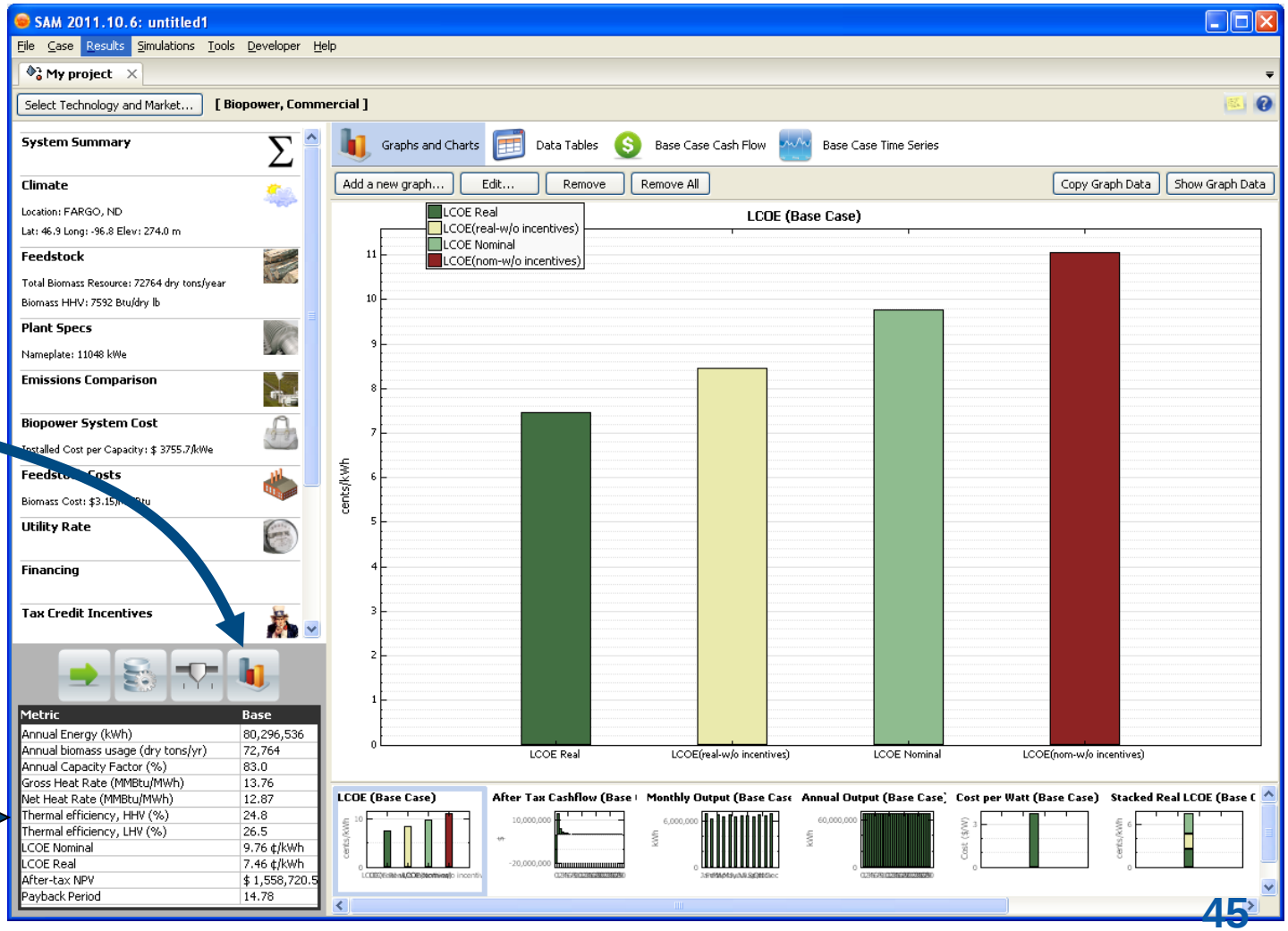


Default Results Page

When SAM completes the model run, it will default to display graphic results

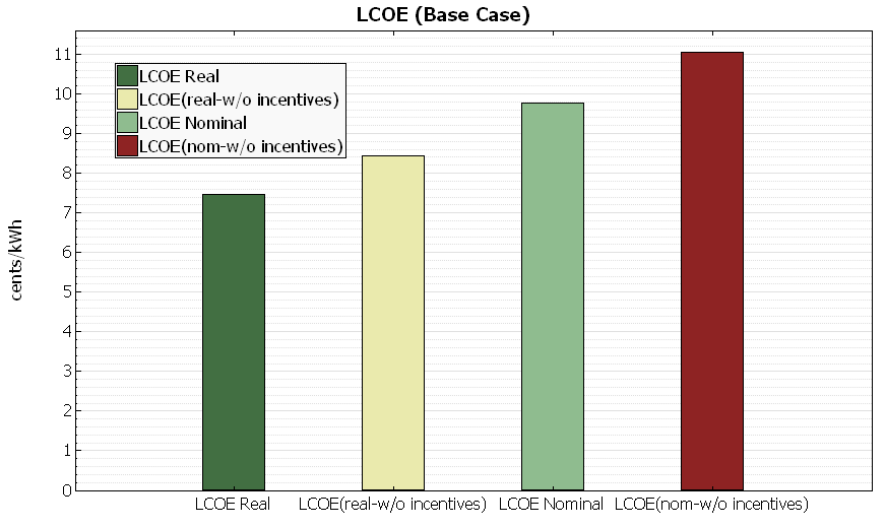
You can always see the most current set of results by clicking on the "Results" button

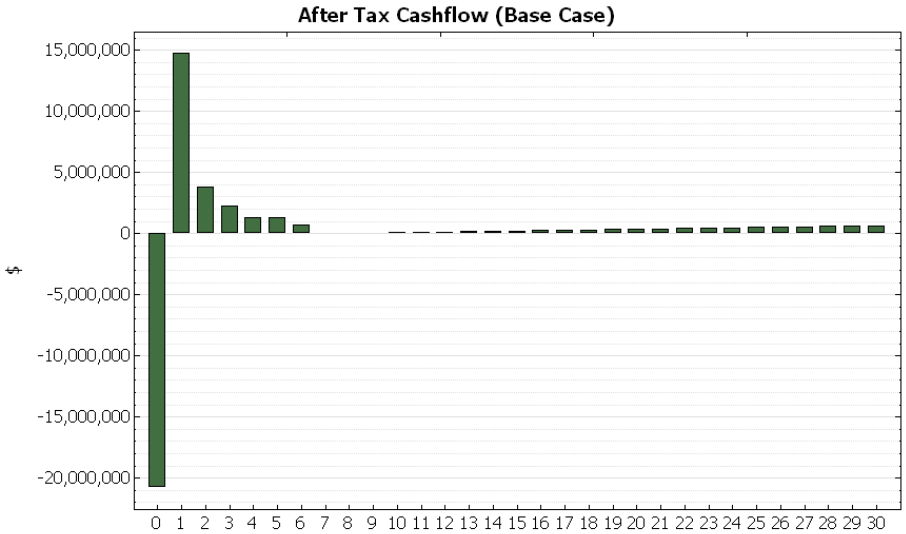
When showing results, SAM displays basic metrics on the bottom left

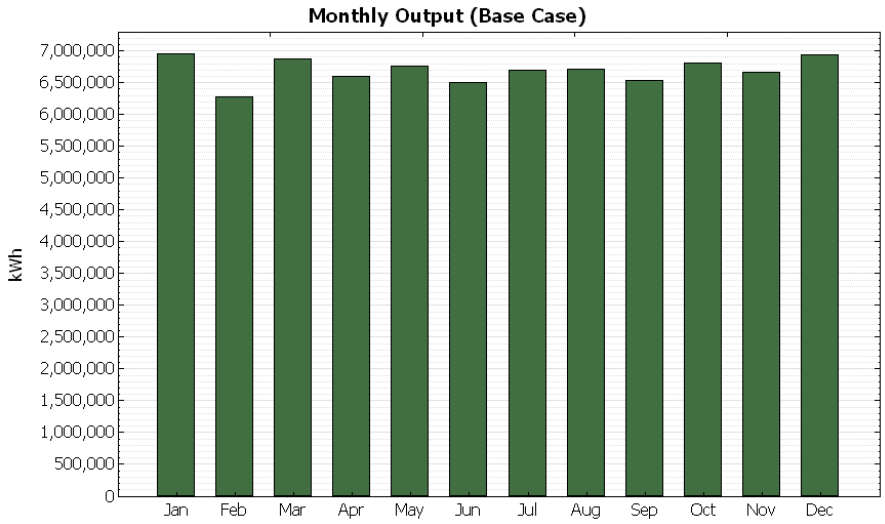


Results – Default Graphs

SAM creates several graphs by default, showing financial and energy generation results



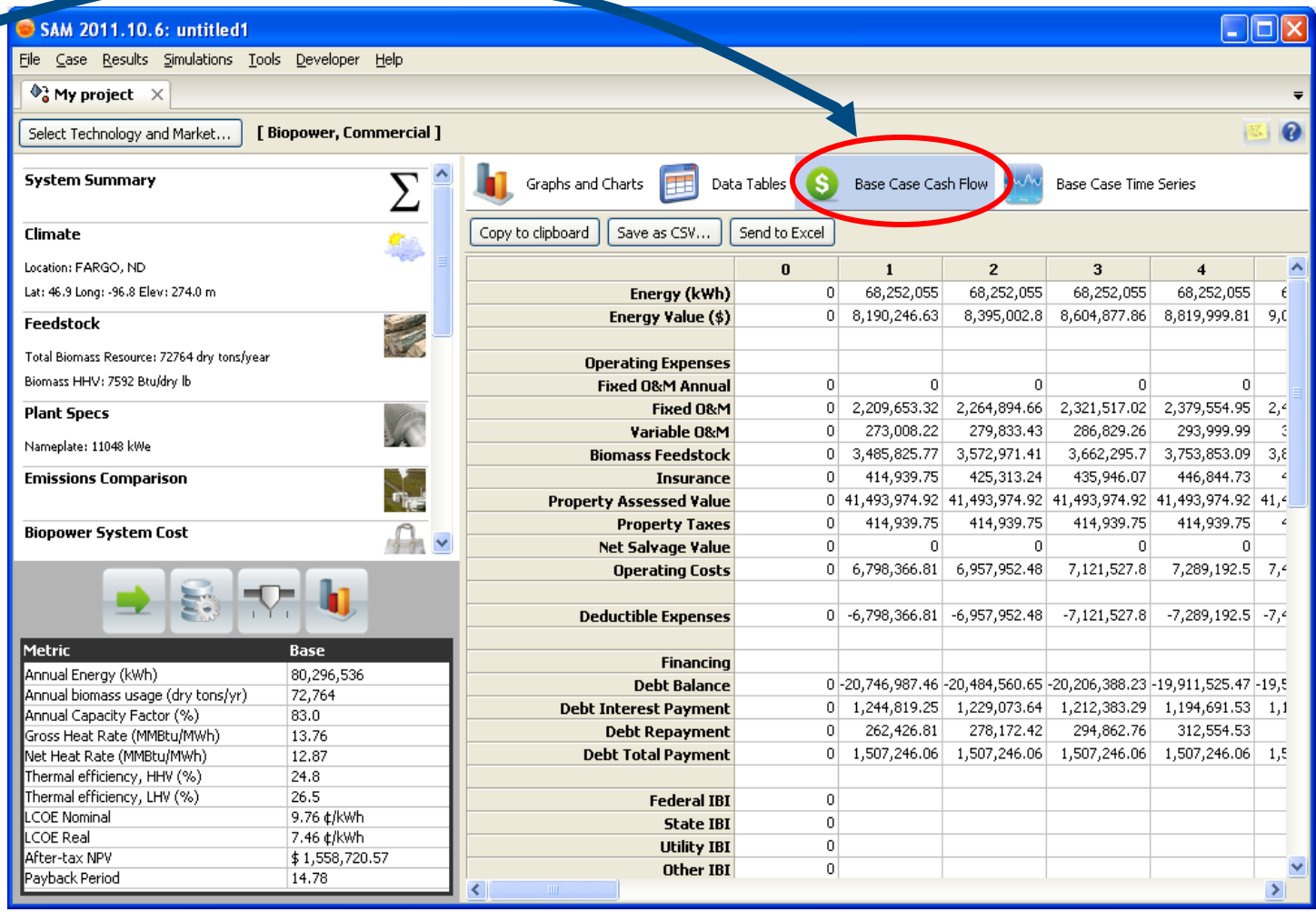




Results – Tabular Cash Flow

Numeric values can easily be viewed and exported

Select
"Base Case Cash Flow"
or
"Data Tables" to view
numeric data

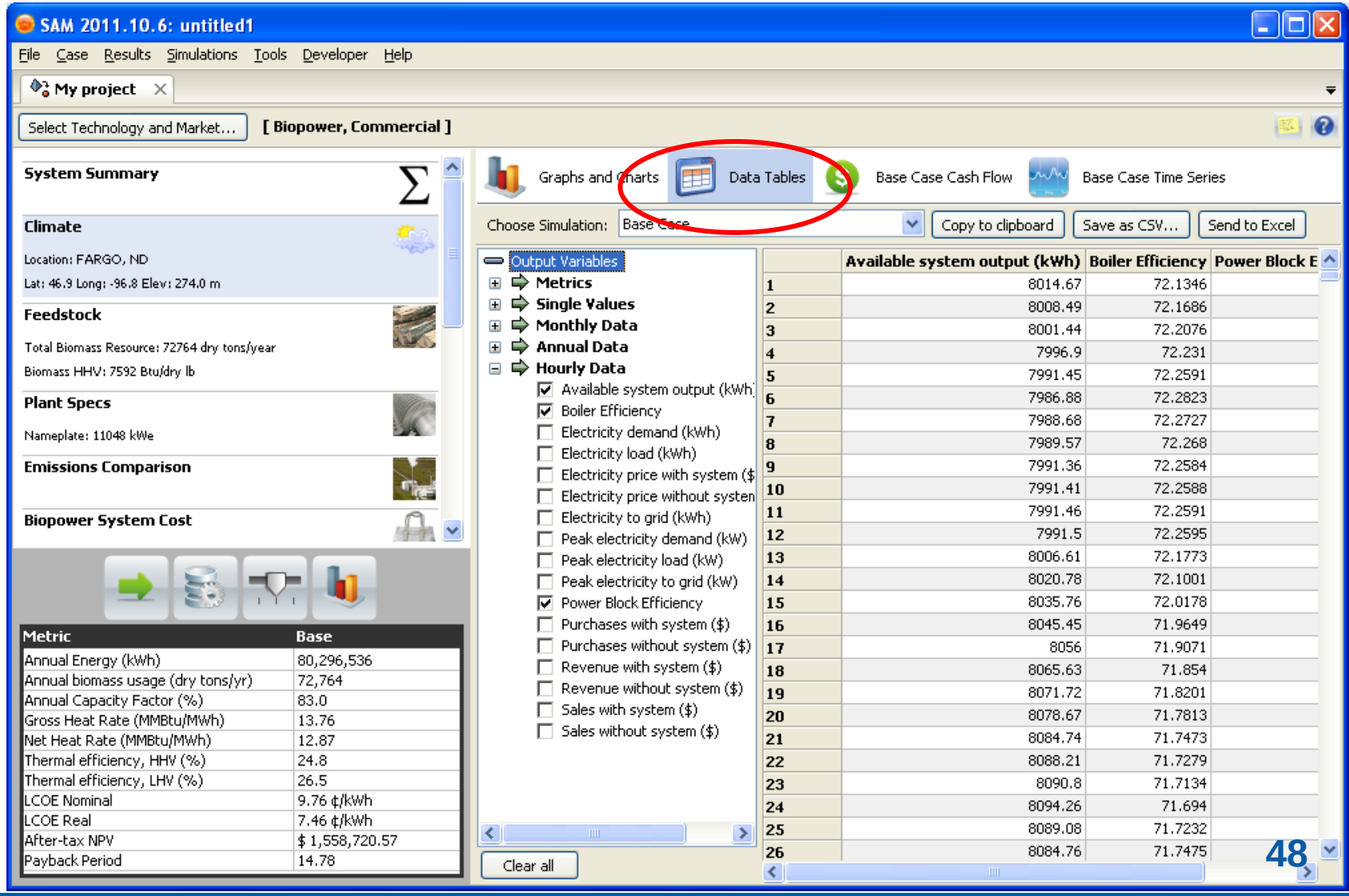


Metric	Base
Annual Energy (kWh)	80,296,536
Annual biomass usage (dry tons/yr)	72,764
Annual Capacity Factor (%)	83.0
Gross Heat Rate (MMBtu/MWh)	13.76
Net Heat Rate (MMBtu/MWh)	12.87
Thermal efficiency, HHV (%)	24.8
Thermal efficiency, LHV (%)	26.5
LCOE Nominal	9.76 ¢/kWh
LCOE Real	7.46 ¢/kWh
After-tax NPV	$ 1,558,720.57
Payback Period	14.78

	0	1	2	3	4
Energy (kWh)	0	68,252,055	68,252,055	68,252,055	68,252,055
Energy Value ($)	0	8,190,246.63	8,395,002.8	8,604,877.86	8,819,999.81
Operating Expenses					
Fixed O&M Annual	0	0	0	0	0
Fixed O&M	0	2,209,653.32	2,264,894.66	2,321,517.02	2,379,554.95
Variable O&M	0	273,008.22	279,833.43	286,829.26	293,999.99
Biomass Feedstock	0	3,485,825.77	3,572,971.41	3,662,295.7	3,753,853.09
Insurance	0	414,939.75	425,313.24	435,946.07	446,844.73
Property Assessed Value	0	41,493,974.92	41,493,974.92	41,493,974.92	41,493,974.92
Property Taxes	0	414,939.75	414,939.75	414,939.75	414,939.75
Net Salvage Value	0	0	0	0	0
Operating Costs	0	6,798,366.81	6,957,952.48	7,121,527.8	7,289,192.5
Deductible Expenses	0	-6,798,366.81	-6,957,952.48	-7,121,527.8	-7,289,192.5
Financing					
Debt Balance	0	-20,746,987.46	-20,484,560.65	-20,206,388.23	-19,911,525.47
Debt Interest Payment	0	1,244,819.25	1,229,073.64	1,212,383.29	1,194,691.53
Debt Repayment	0	262,426.81	278,172.42	294,862.76	312,554.53
Debt Total Payment	0	1,507,246.06	1,507,246.06	1,507,246.06	1,507,246.06
Federal IBI	0				
State IBI	0				
Utility IBI	0				
Other IBI	0				

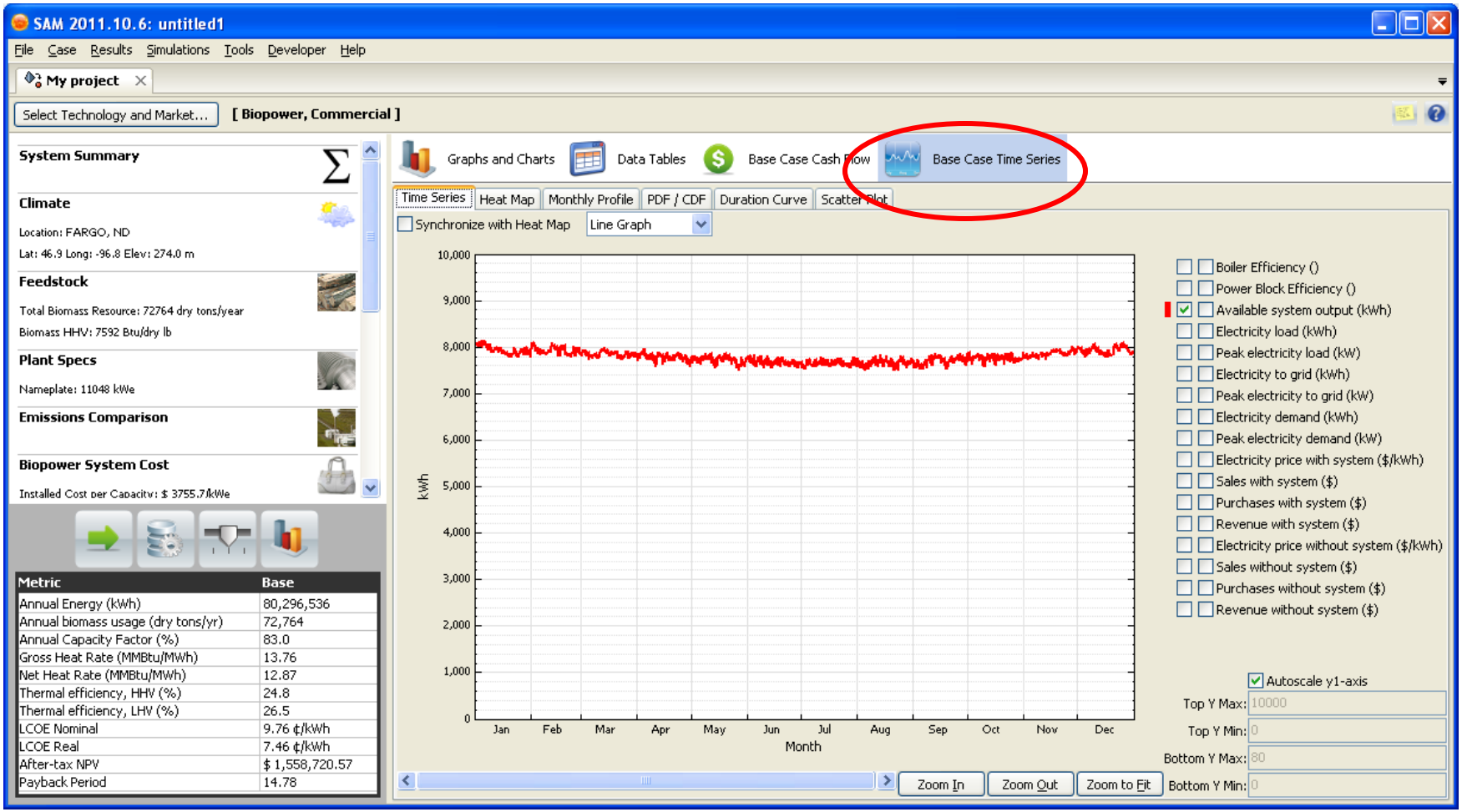
Results – Data Tables

Numeric values can easily be viewed and exported



Results – Base Case Time Series

View results as time series graphs



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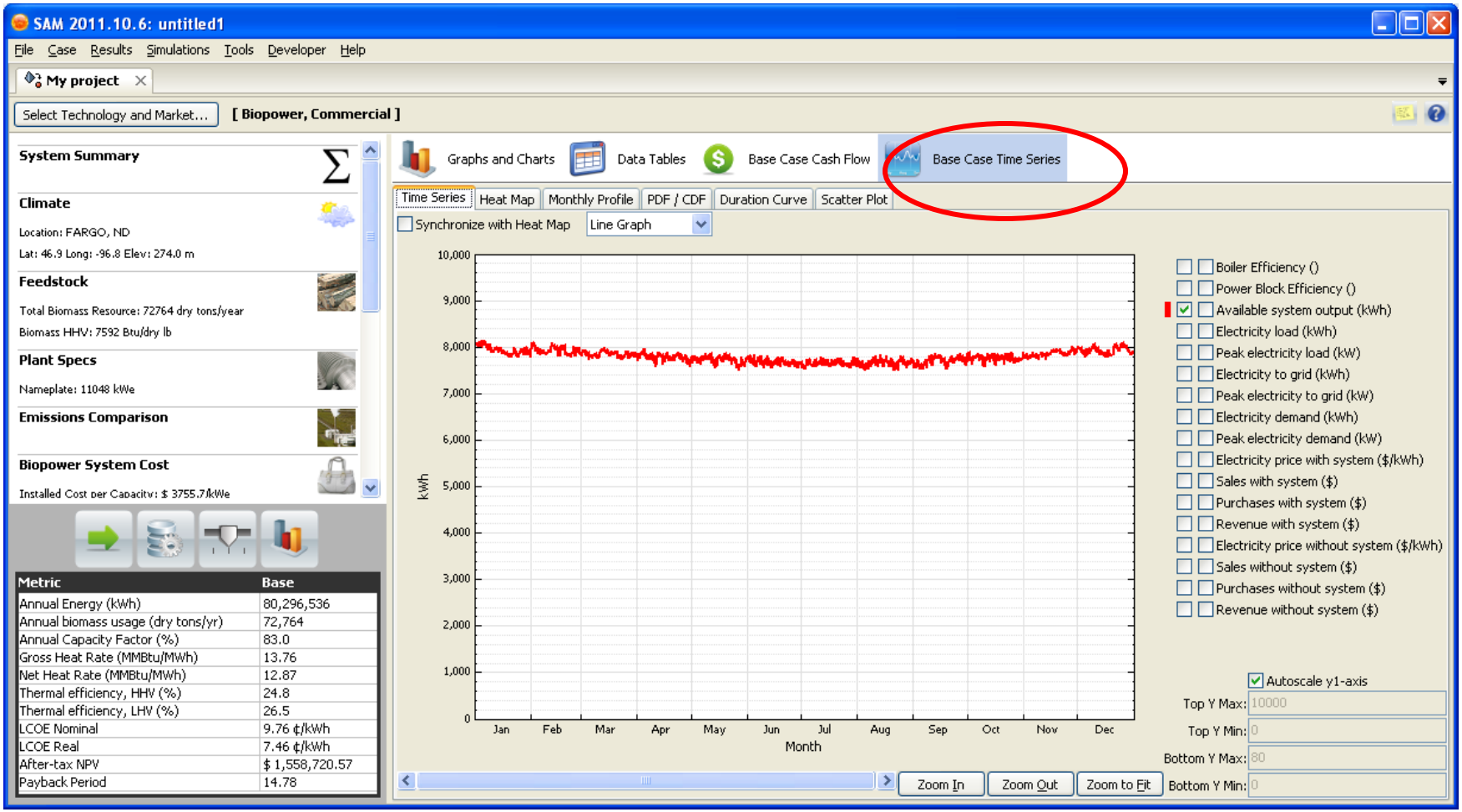
Annual biomass usage (dry tons/yr)	72,764
Annual Capacity Factor (%)	83.0
Gross Heat Rate (MMBtu/MWh)	13.76
Net Heat Rate (MMBtu/MWh)	12.87
Thermal efficiency, HHV (%)	24.8
Thermal efficiency, LHV (%)	26.5
LCOE Nominal	9.76 ¢/kWh
LCOE Real	7.46 ¢/kWh
After-tax NPV	$ 1,558,720.57
Payback Period	14.78

Results – Base Case Time Series

View results as time series graphs



Metric	Base
Annual Energy (kWh)	80,296,536
Annual biomass usage (dry tons/yr)	72,764
Annual Capacity Factor (%)	83.0
Gross Heat Rate (MMBtu/MWh)	13.76
Net Heat Rate (MMBtu/MWh)	12.87
Thermal efficiency, HHV (%)	24.8
Thermal efficiency, LHV (%)	26.5
LCOE Nominal	9.76 ¢/kWh
LCOE Real	7.46 ¢/kWh
After-tax NPV	$ 1,558,720.57
Payback Period	14.78

Modeling Biopower Projects with SAM

Thank You!