

RECAST ENERGY LOUISVILLE FUEL SWITCH FROM COAL TO BIOMASS



Document Prepared By

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The project is a fuel switch conducted by Recast Energy Louisville by converting an existing coal boiler to biomass combustion in Louisville, Kentucky. The project will generate approximately 53,600 (tCO₂e) GHG reductions annually over a 10 year period by replacing the coal production with renewable biomass combustion.

Prior to the project steam was generated using a combination of coal and natural gas boilers for three existing chemical companies that shared some utilities and infrastructure.

The project involved the acquisition of the boiler house from one of the chemical companies which was discontinuing operations at the location. Recast Energy continued to use natural gas to generate steam for the remaining two chemical companies while implementing the conversion of the existing coal boiler to biomass combustion.

The project (boiler conversion) began in June 2011 and went into operation on Dec 10, 2012. The plant has been in continuous operation since then.

The total GHG emission reductions generated in this period are 34,182 tCO₂e in 2013 and 48,846 tCO₂e in 2014

1.2 Sectoral Scope and Project Type

Sectoral Scope: 01 Energy (renewable/non-renewable)

UNFCCC Clean Development Mechanism AMS-I.C. for Small Scale Thermal Energy Projection without Electricity – Version 19

This project is not grouped.

1.3 Project Proponent

Organization name	Recast Energy Louisville, LLC
Role in the project	Energy Producing Facility
Contact person	Tom Harper
Title	Plant Manager
Address	4200 Bells Lane, Louisville, KY 40211
Telephone	502-772-4135
Email	THarper@recastenergy.com

Organization name	Recast Energy Louisville LLC
Contact person	Donna L Wirick c/o Recast Energy, LLC
Title	EHS Manager
Address	8730 Stony Point Pkwy, Ste 100, Richmond, VA 23235
Telephone	804-212-3181
Email	dwirick@recastenergy.com

1.4 Other Entities Involved in the Project

There are no other entities involved in the development of the Project.

1.5 Project Start Date

December 10, 2012 is the project start date.

1.6 Project Crediting Period

As a non-AFOLU project focusing on the reduction of CO₂ from fossil fuels, the Project Crediting Period is 10 years, with the possibility to renew twice.

The projected start date for the initial 10 year crediting period is April 1, 2013 and ending March 31, 2023

1.7 Project Location

The project is located in Louisville, Kentucky on land owned by one of the project customers, Lubrizol. The project site is leased to the project company, Recast Energy Louisville, LLC under a long term lease. The address and approximate coordinates are as follows:

4200 Bells Lane
Louisville, KY 40211

Latitude: 38.2226280
Longitude: -85.8235880

The boundary of the project encompasses the following equipment

- i) The Recast Energy facility including:
 - (1) The truck tipper
 - (2) Truck scales (Lubrizol truck scales)
 - (3) The wood yard and associated material sizing equipment
 - (4) Material handling equipment, including front end loader, reclaim and wood conveyors.
 - (5) Biomass Fuelled Boiler and emission controls
 - (6) Ash and blowdown handling systems
 - (7) Control rooms
 - (8) Other ancillary equipment
- ii) Steam and Return Condensate lines interconnecting the project activity with the project customers
- iii) Project Customers: Lubrizol Advanced Material, Inc. and Zeon Chemicals, LP, both located on Bells Road, Louisville, KY.

1.8 Title and Reference of Methodology

Title: Indicative simplified baseline and monitoring methodology for selected small-scale CDM project activities.

Reference of VCS methodology: Appendix B of the simplified modalities and procedures for small-scale CDM project activities.

Type I: Renewable Energy Projects

Type I.C. Thermal energy with or without electricity (Version 19)

Tools Applied:

“Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion”, Version 02

“Tool to calculate baseline, project and/or leakage emissions from electricity consumption”
Version 01

“Tool to calculate the emission factor for an electricity system”, V 4.0

Guidance Applied:

“General guidelines for SSC CDM methodologies”, v20.

“Indicative Simplified Baseline and Monitoring Methodologies for Selected Small-Scale CDM Project Activity Categories, General guidance on leakage in biomass project activities” Version 03

“Annex 18, Definition of Renewable Biomass”

“Guidelines of the Demonstration of Additionality of Small-Scale Project Activities” Version 09

1.9 Other Programs

- Emission Trading Programs and Other Binding Limits: The project has not reduced GHG emissions from activities that are included in any emission trading program or any other mechanism that includes GHG allowance trading.
- Other Forms of Environmental Credit: The project has not sought or received another form of GHG related environmental credit during this monitoring period.
- Participation under Other GHG Programs: The project is not registered, nor is it seeking at this time to register under any other GHG program.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The implementation status of the project is as follows:

- The project operated continuously during the verification period supplying steam to the project customers as needed for their manufacturing operations. The normal demand for steam fluctuates with operational needs and the need for building heat during cold weather. However, on 11/4/2013, the biomass boiler was shut down when the de-aeration (DA) tank serving the boiler house failed and had to be replaced. A smaller temporary tank was installed, that resulted in a lower feedwater temperature until the full-sized permanent tank was installed on 6/24/2014. The lower temperature of the feedwater resulted in lower feedwater enthalpy and increased fuel usage for the period. This **DA** tank that failed was a part of the original boiler house and not installed or modified for the biomass boiler conversion project.
- There were no changes to the project activity, proponents or other entities.

2.2 Deviations

2.2.1 Methodology Deviations

1. **Parameter:** Q_{steam} :

AMS-I.C Requirement: In case the project is exporting heat to other facilities, the metering shall be carried out at the recipient's end.

Deviation: Measure thermal energy produced directly from the steam and feed water meters on the biomass boiler, not at the customer meters.

Justification: Steam for delivery to two separate customers is generated by one biomass boiler and up to 4 natural gas boilers. If steam is measured at the customer's meters, steam and feed water measurements will combine mass and energy from all boilers will be used to calculate thermal energy generated by the biomass boiler alone. Recast proposes simply measuring the steam and feed water only at the biomass boiler to eliminate the inaccuracy introduced by deriving the thermal energy using 12 measuring points instead of 2 direct measuring points. Accordingly, the enthalpy values, h_{steam} and $h_{\text{feedwater}}$ will be determined at the biomass boiler. This deviation will result in increased accuracy of the baseline by directly measuring the energy produced from biomass.

2. **Parameter:** EC_y ,

AMS-I.C Requirement: Use "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Deviation from Requirement: Electricity consumption is measured based on the difference in equipment (motor ratings) on Boiler #4 before and after conversion.

Justification: Reliable data is not available for electricity consumption of the boiler house prior to conversion. The converted boiler is one part of a complex boiler house system consisting of other boilers, water pumps, water treatment systems etc. that did not change with the project. A study will be prepared that identifies the changes in equipment for Boiler #4 and the maximum capacity for electricity usage before and after the project. Once per verification period, the list of equipment used to calculate the net change in electricity will be reviewed for any equipment and usage updates, and the net change in electricity recalculated for inclusion in the project emissions calculations. This deviation is conservative, as it measures the maximum potential electricity usage for Boiler #4 pre and post project, which will be larger than the actual usage of the boiler. The deviation is also more accurate, as it is very difficult to isolate the electrical usage of Boiler #4 and the boiler house in general both pre and post project

3. **Parameter:** $EF_{\text{grid, CM, y}}$

AMS-I.C Requirement: Use "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"

Deviation: Data from the US Environmental Protection Agency eGRID tables is used in place of calculating a combined margin emission factor per the Tool. .

Justification: The Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. Emission factors are generated for the US based on the electricity generation in each sub-region.

This deviation is more accurate than a default factor (Option A2) and is more accurate than using Option A1 to calculate a combined margin emission factor based on the closest power producers. The project is connected to a large power grid that will pool

electricity from many sources over the project life, so a regional average will include the full range of fuels producing GHG's in the region of the project

4. Parameter: $FC_{\text{Diesel, loader, y}}$

AMS-I.C Requirement: Use "Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion"

Deviation: Purchased fuel invoices are used to monitor the quantity of diesel fuel used to calculate the project CO₂ emissions from fossil fuel.

Justification: The diesel fuel is metered into the onsite storage tank by the fuel supplier and recorded on the invoices, and this deviation assumes all fuel purchased during the monitoring period is used in the onsite fuel moving equipment. This deviation is conservative by assigning all purchased fuel at the facility to the project emissions calculations.

5. Parameters: $h_{\text{feedwater}}$, h_{steam}

AMS-I.C Requirement: Steam and Feedwater enthalpy shall be calculated from temperature or pressure. Temperature and pressure shall be continuously monitored, integrated hourly and at least monthly recording.

Deviation: Temperature and pressure data was recorded electronically and not recorded manually. The electronic records for April 1, 2013 to August 19, 2013 were inadvertently deleted and could not be recovered. Since data for the remaining monitoring period is available, and shows a low variation, the most conservative values between August 24 and November 3, 2014 (when the DA tank failed) were used in the calculations.

Justification: The deviation impacts data (pressure and temperature) used to calculate the enthalpy of the steam and feedwater from April 1 to August 18, 2013. Equipment and operating data was consistent during this period with the months immediately following (until the DA tank replacement), supporting the conclusion that the pressure and temperature data would also be consistent. The substitution values were selected to produce realistic, yet conservative enthalpy values for the calculations.

During the deviation period, plant operating data was recorded at multiple locations that is consistent with operating data recorded after the deviation period. This includes steam flow, feedwater flow, wood (fuel) usage, and water usage for steam. In addition, Recast is contractually obligated to deliver steam at a minimum of 170 psig to customers, and the customers paid for the steam delivered during the deviation period, indicating the steam met the contractual obligations.

The data monitored from August 19 to November 4, 2013 showed a low daily (one day) average pressure (on full operating days) of 172.35 psi with an average over the entire period of 182.95 psi. For feedwater temperature, the boiler had a high daily (one day) average temperature (on full operating days) of 261.16 F with an average over the entire period of 245.00. Recast elected to use the lowest pressure and highest temperature (rather than the average) as the more conservative approach. Using these values for the entire period of April 1 to August 19 gives conservative enthalpy values for both the steam and feedwater resulting in a lower BE_{Thermal} value than if the average was used or the actual data had been available for use.

To prevent future data loss, additional procedures have been implemented, including data files backed up daily to an offsite location. Additional information is included in the Monitoring Plan section of this report.

This deviation substitutes a conservative value for missing data, and thus does not negatively impact the conservativeness of the quantification of the GHG emissions reductions.

The deviations relates only to the criteria and procedures for monitoring or measurement, and do not relate to any other part of the methodology

2.2.2 Project Description Deviations

There are no Project Description Deviations for this monitoring report.

2.3 Grouped Project

The project is not grouped.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter	NCV _{Diesel, y}
Data unit	GJ/gallon
Description	Weighted average net calorific value of fuel (diesel) in year y
Source of data	Transportation Energy Data Book, Edition 31, published by Oak Ridge National Labs on July 31, 2014 (http://cta.ornl.gov/data/index.shtml) http://cta.ornl.gov/data/appendix_b.shtml , Table B04
Value applied:	0.1464
Justification of choice of data or description of measurement methods and procedures applied	Data source (c), selected as national default value since preferred source (a) is not available. To be reviewed annually
Purpose of Data	- Calculation of project emissions - Calculation of leakage
Comments	No comments

Data Unit / Parameter:	EF _{CO2,Diesel, y}
Data unit:	tCO ₂ e/GJ
Description:	Weighted average CO ₂ emission factor of fuel type (diesel) in year y

Source of data:	DOE Voluntary Reporting of Greenhouse Gases Program: Fuel and Energy Source Codes and Emission Coefficients. http://www.eia.doe.gov/oiaf/1605/coefficients.html
Value applied:	0.06928
Justification of choice of data or description of measurement methods and procedures applied:	Data source (c), selected as national default value since preferred source (a) is not available. To be reviewed annually
Purpose of Data	Calculation of project emissions and leakage
Any comment:	No comments

Data Unit / Parameter:	Eff_{Diesel,process j,y}
Data unit:	gal/ton
Description:	The diesel fuel consumed to collect and process biomass of type j
Source of data:	Estimate based on manufacturer specification for particular operating conditions. Sum of worst-case fuel economy specified by the manufacturer for typical pieces of collecting /processing equipment.
Value applied:	Mill residues = 0 Forestry residues = 1.54 Crop residues = n/a
Justification of choice of data or description of measurement methods and procedures applied:	For forestry residues, calculated value was compared against published study by University of Georgia and compared with estimates provided by equipment manufacturers
Purpose of Data	Calculation of project leakage
Any comment:	No comments

Data Unit / Parameter:	EF_{CO2, Coal}
Data unit:	tCO2/TJ
Description:	CO2 Emission Factor for Bituminous Coal, calculated on a Gross Calorific Value (GCV) basis
Source of data:	DOE Voluntary Reporting of Greenhouse Gases Program: Fuel and Energy Source Codes and Emission Coefficients. http://www.eia.doe.gov/oiaf/1605/coefficients.html
Value applied:	88.42 (GCV Basis) tCO2/TJ

Justification of choice of data or description of measurement methods and procedures applied:	Data source selected as reliable national value from the US Department of Energy. To be reviewed annually for updates.
Purpose of Data	Calculation of baseline emissions
Any comment:	No comments

Data Unit / Parameter:	$\eta_{BL, Thermal}$
Data unit:	%
Description:	Efficiency of project legacy boiler system, Gross Calorific Value (GCV) basis
Source of data:	Value taken from EPA-600/7-81-111a July 1981, "Emissions and Efficiency Performance of Industrial Coal Stoker Fired Boilers", table 1-2,
Value applied:	83.43%
Justification of choice of data or description of measurement methods and procedures applied:	Value selected using option 30(a) for efficiency of baseline units per methodology. Value extracted from 1981 EPA publication of test results for boilers with similar specifications using coal. The highest measured value from the study was selected, and equipment efficiency is expected to have degraded over time, making this efficiency a conservative value.
Purpose of Data	Calculation of baseline emissions
Any comment:	No comments

3.2 Data and Parameters Monitored

Data / Parameter	$EG_{thermal,y}$
Data unit	TJ
Description	The net quantity of steam/heat supplied by the project activity during the year y
Source of data	Calculation
Description of measurement methods and procedures to be applied	The net quantity of steam calculated from the quantity of steam (Q_{steam}) and enthalpy (h) during the verification period
Frequency of monitoring/recording	At least annually.
Value applied:	For 2013: 336.46 For 2014: 475.21
Monitoring equipment	NA
QA/QC procedures to be applied	Not Applicable.
Purpose of data	Calculation of baseline emissions
Calculation method	$EG_{thermal,y} = Q_{steam,y} * (h_{steam} - h_{feedwater}) * 1.055E-9$
Comments	No comments

Data / Parameter	$EF_{grid, CM,y}$
Data unit	tCO ₂ e/MWh
Description	Combined margin emission factor for the grid in year y
Source of data	USEPA eGrid http://www.epa.gov/cleanenergy/documents/eGRID_9t9h edition V1-0 year 2010 Summary Tables.pdf . Page1, Region SRTV (Tennessee Valley)
Description of measurement methods and procedures to be applied	Annual update using most recent data
Frequency of	At least once per verification period

monitoring/recording	
Value applied:	0.630 tCO ₂ e/MWh (from 2010 report which is the most recent data available)
Monitoring equipment	Not Applicable
QA/QC procedures to be applied	Not Applicable
Purpose of data	Calculation of project emissions
Calculation method	Not Applicable
Comments	No comments

Data / Parameter	TDL _y
Data unit	Not Applicable
Description	Average technical transmission and distribution losses for providing electricity to the project in year y
Source of data	USEPA eGrid http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf . Page9, Eastern Region
Description of measurement methods and procedures to be applied	Annual review of data source for most recent published value appropriate for the verification period.
Frequency of monitoring/recording	Annual Review
Value applied:	0.0582 (from 2010 report which is the most recent data available)
Monitoring equipment	Not Applicable
QA/QC procedures to be applied	Not Applicable
Purpose of data	Calculation of project emissions
Calculation method	Not Applicable
Comments	No comments

Data Unit / Parameter:	Q _{steam,y}
Data unit:	Lbs

Description:	The quantity of steam generated by the project activity (Boiler #4) in year y
Source of data:	Steam meter reading for Boiler #4
Description of measurement methods and procedures to be applied:	The steam meter sends continuous readings to the automated process control system. A daily sum of the steam produced is recorded by the process control computer and transcribed daily to operator logs and spreadsheets. The monthly totals are added over the monitoring period.
Frequency of monitoring/recording:	Continuous monitoring with at least monthly recording of total steam produced by Boiler
Value applied:	For 2013: 321,760,700 For 2014: 442,032,945
Monitoring equipment:	ABB Vortex Flowmeter FV4000
QA/QC procedures to be applied:	The meter was calibrated at start-up in accordance with the manufacturer's specifications. Per the manufacturer Operating Instructions, there is no recommended recalibration schedule. The meter will be serviced by a qualified technician at least once every three years to verify proper installation and operating parameters. In addition, the sum total of all boiler steam meters is reconciled with the customer delivery steam meters for fuel based billing.
Purpose of Data	Calculation of baseline emissions
Calculation method:	Addition of daily totalized readings
Any comment:	No comments

Data Unit / Parameter:	h_{steam}
Data unit:	Btu/lb
Description:	The enthalpy of steam as it leaves the biomass boiler.
Source of data:	Pressure monitoring assembly located to measure steam exiting Boiler #4.
Description of measurement methods and procedures to be applied:	Automated reading and recording of the pressure was used to calculate enthalpy using standard thermodynamic tables
Frequency of monitoring/recording:	Pressure values were determined at least hourly and recorded at least daily. The average daily pressure was translated into enthalpy using standard thermodynamic tables, assuming saturated steam conditions.
Value applied:	For 2013: 1196.96

	For 2014: 1197.29
Monitoring equipment:	Steam pressure is monitored by a pressure meter (transducer)
QA/QC procedures to be applied:	The meters are calibrated in accordance with the manufacturers' specifications. The manufacturer of the pressure monitoring equipment does not recommend a calibration. The equipment will be evaluated by a qualified technician at least once every three years during the project to verify proper installation and operating parameters.
Purpose of Data	Calculation of baseline emissions
Calculation method:	Microsoft Excel calculations based on IAPWS IF-97 (see www.iapws.org) using code provided by Mangus Homgren at http://www.mathworks.com/matlabcentral/fileexchange/9817-x-steam--thermodynamic-properties-of-water-and-steam-or-equivalent .
Any comment:	No comments

Data Unit / Parameter:	$h_{\text{feedwater}}$
Data unit:	btu/lbs
Description:	The enthalpy of boiler feed water as it enters the biomass boiler (Boiler #4).
Source of data:	Temperature monitoring assembly located on feed water line entering Boiler #4
Description of measurement methods and procedures to be applied:	Automated reading and recording of the temperature was used to calculate enthalpy using standard thermodynamic tables.
Frequency of monitoring/recording:	Temperature value was determined at least hourly and recorded at least daily. The average daily temperature was translated into enthalpy using standard thermodynamic tables.
Value applied:	For 2013: 205.8 For 2014: 178.3
Monitoring equipment:	Temperature monitoring assembly consisting of RTD (Resistance Temperature Detectors) and thermo well with appropriate operating range.
QA/QC procedures to be applied:	The sensors are calibrated in accordance with manufacturer specifications. . The manufacturer of the temperature monitoring equipment does not recommend a calibration frequency. The equipment will be evaluated by a qualified

	technician at least once every three years to verify proper installation and operating parameters.
Purpose of Data:	Calculation of baseline emissions
Calculation method:	Microsoft Excel calculations based on IAPWS IF-97 (see www.iapws.org) using code provided by Mangus Homgren at http://www.mathworks.com/matlabcentral/fileexchange/9817-x-steam--thermodynamic-properties-of-water-and-steam-or-equivalent .
Any comment:	No comments

Data Unit / Parameter:	FC _{Diesel, loader, y}
Data unit:	Gal
Description:	Quantity of diesel fuel used by the front end loader and any other on-site fuel moving equipment
Source of data:	Invoices from the fuel supplier
Description of measurement methods and procedures to be applied:	Individual fuel invoices from the fuel supplier were summed over the entire reporting period, assuming all diesel fuel delivered is consumed by the loader.
Frequency of monitoring/recording:	Each invoice was recorded
Value applied:	For 2013: 9754.90 For 2014: 13,709.8
Monitoring equipment:	NA
QA/QC procedures to be applied:	Purchased fuel invoices were identified, recorded at least monthly and archived
Purpose of Data:	Calculation of project emissions
Calculation method:	Addition
Any comment:	No comments

Data Unit / Parameter:	EC _y
Data unit:	MWh
Description:	Power consumed by the project activity
Source of data:	Engineering study

Description of measurement methods and procedures to be applied:	A study was prepared that identifies the changes in equipment for Boiler #4 and the maximum capacity for electricity usage before and after the project. The difference in usage was applied as the power consumed by the project activity.
Frequency of monitoring/recording:	During this initial verification period, the engineering study was created, and then reviewed and updated as needed after the end of this verification period. The list of equipment used to calculate the net change in electricity was reviewed for any equipment and usage updates. The net change in electricity was recalculated for inclusion in the project emissions calculations.
Value applied:	1957
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	The master list of plant equipment was compared to the equipment listed in the study, including visual confirmation of the presence and specifications of major equipment components.
Purpose of Data:	Calculation of project emissions
Calculation method:	The difference in maximum capacity for electricity usage by Boiler #4 pre and post project. $EC_y = EC_{total,y} - EC_{avg,(pre-project)}$ Where: $EC_{total,y} = \text{maximum electricity capacity for Boiler \#4 in year } y; \text{ MWh}$ $EC_{avg,(pre-project)} = \text{maximum electricity capacity for Boiler \#4 prior to project; MWh}$
Any comment:	No comments

Data Unit / Parameter:	DAF _{biomass delivery}
Data unit:	Km
Description:	Estimated round-trip delivery distance
Source of data:	Delivery tickets; Yahoo Maps
Description of measurement methods and procedures to be applied:	The one-way driving distance from the project site to a biomass source was determined using Yahoo Maps and is doubled to arrive at the round-trip distance. The round trip distance is summed over all delivery tickets received

	for each source or destination during the reporting period.
Frequency of monitoring/recording:	Each delivery ticket
Value applied:	[Σ (DAF)] Biomass: For 2013: 65,623 For 2014: 65,923
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Each delivery ticket or electronic record is reviewed and verified by a project employee, reviewed periodically during invoice matching and then archived.
Purpose of Data:	Calculation of leakage
Calculation method:	Summation
Any comment:	For all deliveries from biomass source, the round-trip distance to the source is used (truck scales are on the project site). For deliveries from an industrial point source, (e.g. sawdust from a sawmill), the round-trip distance is calculated to the mill. For deliveries from a distributed source (e.g. in-woods or unidentified mill), the round-trip distance is calculated to the center of the county from which the delivery originated. For the monitoring period, a table was developed listing roundtrip distances for primary industrial locations and surrounding counties used during the monitoring period. For biomass deliveries, all round trip distances less than 400km (200 km radius) are excluded from the summation.

Data Unit / Parameter:	DAF, ash delivery
Data unit:	Km
Description:	Estimated round-trip delivery distance
Source of data:	Delivery tickets; Yahoo Maps
Description of measurement methods and procedures to be applied:	The one-way driving distance from the project site to an ash destination is determined using Yahoo Maps and is doubled to arrive at the round-trip distance. The round trip distance is summed over all delivery tickets received

	for each source or destination during the reporting period.
Frequency of monitoring/recording:	Each delivery ticket
Value applied:	[Σ(DAF)] Ash: For 2013: 0 For 2014: 0
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Each delivery ticket or electronic record was reviewed and verified by a project employee, reviewed periodically during invoice matching and then archived.
Purpose of Data:	Calculation of leakage
Calculation method:	Summation
Any comment:	For ash deliveries the actual delivery round-trip distance is calculated. For the monitoring period, a table was developed listing roundtrip distances for deliver points used during the monitoring period. For ash deliveries, all round trip distances less than 400km (200 km radius) are excluded from the summation.

Data Unit / Parameter:	EFF _{tt,y}
Data unit:	Km/gal
Description:	Fuel efficiency for tractor trailers
Source of data:	Transportation Energy Data Book, Edition 33, published by Oak Ridge National Labs on July 31, 2014, Chapter 5, Table 5.2, 2012 data http://cta.ornl.gov/data/tedb33/Edition33_Chapter05.pdf
Description of measurement methods and procedures to be applied:	The latest published version of the Transportation Energy Data Book is reviewed and the parameter is updated with the most recent value.
Frequency of monitoring/recording:	Annual during verification process for verification period.
Value applied:	9.33 (5.8 miles/gal) is the latest available value (2012)
Monitoring equipment:	Not applicable

QA/QC procedures to be applied:	Not applicable
Purpose of Data:	Calculation of leakage
Calculation method:	Not applicable
Any comment:	No comments

Data Unit / Parameter:	$Q_{\text{biomass},j,y}$												
Data unit:	Tons, as received (wet)												
Description:	Quantity of biomass residues of type j delivered to the project activity, as received.												
Source of data:	Delivery ticket; truck weigh scale												
Description of measurement methods and procedures to be applied:	Truck scale weighs the net biomass delivered from each load; delivery ticket records the net weight and origin. Each load of biomass received for the project will be identified by the source then tagged with an identifier indicating whether processing would have occurred pre-project, or whether the material was processed specifically for the project. All biomass processed specifically for the project will be included in the calculations. Any delivery which cannot be clearly identified and tagged indicating the source processing status will be assumed to be processed for the project.												
Frequency of monitoring/recording:	Each truckload												
Value applied:	2013 <table> <tr> <td>All Biomass Delivered :</td><td>47,489 tons</td></tr> <tr> <td>Biomass Not Processed for Project</td><td>47,489 tons</td></tr> <tr> <td>Biomass Processed for Project</td><td>0 tons</td></tr> </table> 2014 <table> <tr> <td>All Biomass Delivered :</td><td>72,760 tons</td></tr> <tr> <td>Biomass Not Processed for Project</td><td>72,760 tons</td></tr> <tr> <td>Biomass Processed for Project</td><td>0 tons</td></tr> </table>	All Biomass Delivered :	47,489 tons	Biomass Not Processed for Project	47,489 tons	Biomass Processed for Project	0 tons	All Biomass Delivered :	72,760 tons	Biomass Not Processed for Project	72,760 tons	Biomass Processed for Project	0 tons
All Biomass Delivered :	47,489 tons												
Biomass Not Processed for Project	47,489 tons												
Biomass Processed for Project	0 tons												
All Biomass Delivered :	72,760 tons												
Biomass Not Processed for Project	72,760 tons												
Biomass Processed for Project	0 tons												
Monitoring equipment:	Truck scales												
QA/QC procedures to be applied:	Truck scales are calibrated at least once per year in accordance with manufacturer recommendation. Each delivery ticket is reviewed and signed by a project employee upon receipt from the truck driver, reviewed during invoice matching and then archived.												

Purpose of Data:	Calculation of leakage
Calculation method:	Aggregation of the tons of wood identified or tagged as wood processed for the project
Any comment:	The Louisville area has previously developed the following consolidation and distribution activities that are considered “not processed for the project”: • Mulch distribution • Landfilling or other disposal • Commercial aggregating facilities The following activities did not require processing prior to the project: • In place open-burning or decomposition Therefore, of the above categories, only in place open-burning or decomposition require any additional processing/sizing for use by the project and will be included in the aggregation of biomass processed for the project. For this verification period, no biomass was processed exclusively for the project.

3.3 Monitoring Plan

Recast Energy applies a disciplined approach to managing the real-time operations and performance of its facilities. This includes detailed operational guidelines and procedures as well as an array of management reporting metrics and tools. The purpose of monitoring is to:

- Ensure accurate and timely communications
- Facilitate operational decision making
- Retain records for mandatory reporting to government regulators and
- Verify GHG emission reductions.

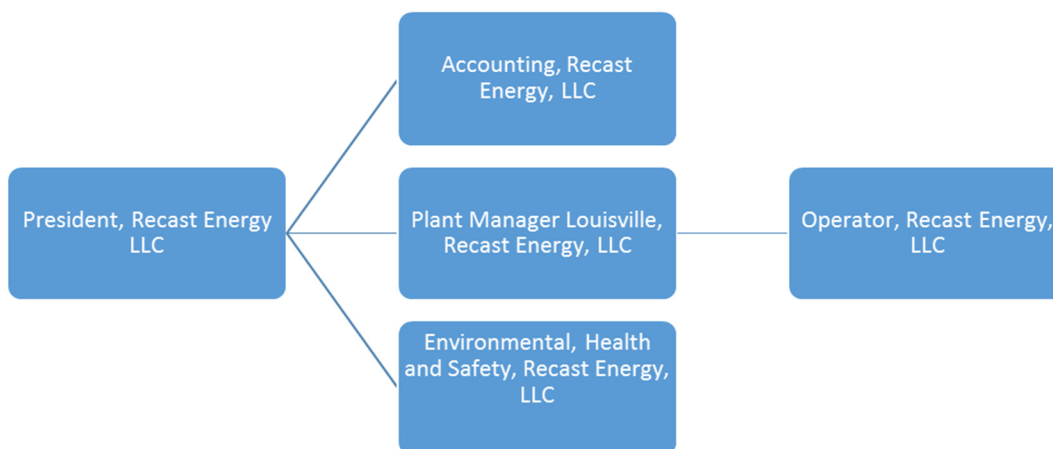
The reference manual “Louisville Operating Procedures” details the project’s general operating procedures, including data monitoring and reporting. A copy is stored onsite and revised from time to time.

Table 3.3 lists the project-specific parameters monitored for the purposes of verifying GHG emission reductions; additional parameters generated from third-party sources are monitored as needed and specified in later sections of this document.

Table 3.3 Project-specific Parameters Monitored Under Monitoring Plan

Data Parameter	Units	Frequency	Measured, Estimated, Reported	Party Responsible for Recording Data
Steam	Lbs	Monthly	Measured	Recast Operator
Steam Pressure	Psi	Daily	Measured	Recast Operator
Feed water Temperature	°F	Daily	Measured	Recast Operator
Feed water Flow	Gal/hr	Daily	Measured	Recast Operator
Electricity consumption	KWh	Once per monitoring period	Engineering Study	Recast EHS
Diesel fuel consumption (at project)	Gallons	Monthly	Reported by Supplier	Recast Accounting
Diesel fuel consumption for biomass processing	Gallons	Annually	Estimated	Recast EHS
Biomass delivery weight	Lbs	Each delivery	Measured	Recast Accounting
Biomass Origin		Each delivery	Reported by Supplier	Recast Accounting
Distance to origin	Km	Each delivery	Estimated	Recast EHS
Ash transportation weights	Loads	Each delivery	Measured	Recast Accounting
Ash destinations		Each delivery	Estimated	Recast EHS

Recast Energy operators are located at the facility in Louisville KY. Recast Energy Accounting and EHS are located at the corporate headquarters in Richmond VA. The organization structure is as follows:



Recast Operators are trained in boiler house operations, equipment maintenance and process record keeping. The boiler house is staffed at all times by at least two operators who are responsible for monitoring operations and delivery of steam to the project customers.

Recast Accounting is responsible for Accounts Payable, Accounts Receivable and all associated record keeping for financial audits.

Recast EHS is responsible for maintaining all environmental permits, monitoring environmental data and submitting required reports to designated agencies.

The project emissions are monitored with a combination of project-specific parameters and data published by third part authorities. Project-specific parameters include those listed in **Table 3.3**.

The parameters used to calculate baseline emissions are monitored using a continuous steam mass flow rate meter and the integrated digital display; flow, temperature and pressure readings are computer-logged. The boiler system is configured to operate at pre-set conditions, as needed to deliver required steam loads to the project customer's steam tie-in point using primarily the biomass boiler supplemented by the natural gas boilers as needed. The instrumentation is calibrated on a schedule that is consistent with the manufacturer recommendations.

Steam mass flow and pressure are measured as it leaves the biomass boiler and prior to combining with steam from other boilers, conditions at which the legacy baseline boiler system would also have delivered steam. Condensate return and make-up water temperature is also measured as feed water entering the biomass boiler. These measurements and standard thermodynamic reference tables are used to calculate the net enthalpy rise in the fluid, thereby determining the useful energy generated. These parameters are monitored and recorded using either: 1) direct visual measuring and manual recording or 2) automated telemetric meter reading.

Process data from the automated telemetric meter reading used to calculate the baseline emissions is recorded in raw form by the process control computer system in daily data files. From this data, cumulative data (ie. Daily steam flow) is recorded both manually by operators onto daily log sheets and in various spreadsheets. During this verification period, Boiler pressure and feedwater temperature *daily averages* were not recorded manually or in spreadsheets. The information was retrieved from the raw data files, but during the verification process, four months of the data could not be retrieved because the files had been inadvertently deleted from the process computer.

Procedures have been implemented to prevent future data loss. All data used to calculate the baseline is recorded in the daily operators log sheet and transferred to spreadsheets after quality review. Data summaries are also transferred electronically into spreadsheets stored within the data system. And finally, all process data files and spreadsheets are backed up to a second off site location at least daily.

Electricity consumption from the grid is determined from an engineering study that will be reviewed during each monitoring period for updated equipment information. With the exception of the front-end loader, all major pieces of equipment at the project site are powered with electricity supplied by the grid. Diesel fuel consumption by the onsite front-end loader(s) used in the biomass fuel yard is reported with each invoice/statement from the diesel fuel supplier. The net weight of biomass is monitored by the truck scale and recorded either on the delivery ticket issued and signed for each delivery or by an automated system. The biomass origin is used to calculate the transportation and account for the diesel fuel consumed for processing of certain biomass residues. Note that due to the use of contractors who collect and process fuels and their use of subcontractors to haul the fuels, exact mileage from in-woods or in-field job sites is not tracked. Instead, the county of origin is tracked and all deliveries from a specific county are assumed to have originated from the center of the county for the purpose of calculating distance.

The procedures used for handling any internal auditing performed and any non-conformities identified are as follows:

- For information collected and recorded by operators, the data is transferred daily to a master spreadsheet (dashboard) by a supervisor and any anomalies or suspected errors are investigated and corrected immediately. This data is reviewed and used for multiple purposes in operations.
- For information collected by the accounting department, invoices are reviewed when received and approved by the plant manager. Any suspected errors are investigated and corrected prior to payment. Wood tickets are reviewed and recorded daily at the plant and the accounting department compares the list to the invoices from vendors. Anomalies and suspected errors are investigated and corrected.
- The EHS group reviews the information recorded on each wood ticket and works with the wood manager to confirm the origin location and type of material based on knowledge of the vendor and source locations associated with the vendor. Any corrections to source location and type of material is documented on the wood log used to calculate distances the fuel travels to the project.

All documents and records used in this monitoring plan shall be stored in a secure and retrievable manner for at least two years after the end of the project crediting period.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

For this project, the simplified baseline is the fuel consumption of the technology that would have been used in the absence of the project activity, times the emission factor for the fossil fuel displaced.

The conversion of the boiler to wood burning is displacing the use of coal in the same boiler. Therefore, the net quantity of steam/heat generated by the wood-fuelled boiler will be measured, corrected for efficiency of the coal-fuelled boiler and multiplied by the CO₂ emission factor of the coal.

Baseline emissions for this project will be calculated using equation (2) from paragraph 22 “Baseline emissions for power and heat production” of the methodology:

$$BE_{\text{thermal, CO}_2, y} = (EG_{\text{thermal, y}} / \eta_{\text{BL, thermal}}) * EF_{\text{FF, CO}_2}$$

Where:

$BE_{\text{thermal, CO}_2, y}$	=	The baseline emissions from steam/heat displaced by the project activity during the year y (tCO ₂)
$EG_{\text{thermal, y}}$	=	The net quantity of steam/heat supplied by the project activity during the year y (TJ)
$EF_{\text{FF, CO}_2}$	=	The CO ₂ emission factor of the fossil fuel that would have been used in the baseline plant (coal)
$\eta_{\text{BL, thermal}}$	=	The efficiency of the plant using fossil fuel that would have been used in the absence of the project activity

Calculation of EG_{thermal} :

EG_{thermal} represents the thermal energy produced by combusting biomass fuel in Boiler #4. It is calculated from the quantity of steam produced and the difference in heat content (enthalpy) between the boiler feedwater and steam produced.

$$EG_{\text{thermal, y}} = Q_{\text{steam, y}} * (h_{\text{steam}} - h_{\text{feedwater}}) * 1.055\text{E-9}$$

Where:

Q_{steam}	=	The quantity of steam generated by the project activity
$(h_{\text{steam}} - h_{\text{feedwater}})$	=	The difference in enthalpy of the steam and feedwater

Monitoring Period Baseline Emissions Calculation Results:

		2013	2014	Units
EG_{thermal,y}	=	336.46	475.21	TJ
η_{BL,thermal}	=	83.43	83.43	%
EF_{FF,CO2}	=	88.42	88.42	tCO2e/TJ
BE_{thermal}	=	35,658	50,362	tCO2e

4.2 Project Emissions

Project emissions are in accordance with paragraph 45 of CDM “AMS-I.C and include:

- CO2 emissions from on-site consumption of diesel fuel in equipment used to move wood fuel within the facility.
- CO2 emissions from electricity consumption by the project activity that is in excess of the electricity used by the boiler prior to the activity

Project Emissions from diesel fuel.

The CO2 emissions from on-site consumption of diesel fuel will be measured in accordance with CDM “Tool to calculate project or leakage CO2 emissions from fossil fuel combustion. The emissions will be calculated by multiplying the quantity of fuel purchased in the reporting period (from fuel supplier invoices) by the emission factor for diesel fuel:

$$PE_{FC,loader,y} = FC_{Diesel, loader, y} * COEF_{Diesel,y}$$

Where:

$FC_{Diesel,loader,y}$	=.	The quantity of diesel fuel combusted to operate the fuel moving equipment during the year
$COEF_{Diesel,y}$	=	The CO2 emissions coefficient for diesel fuel during the year y; tCO2e/gal
$COEF_{Diesel, y}$	=	$NCV_{Diesel, y} * EF_{CO2,Diesel,y}$
$NCV_{Diesel,y}$	=	is the weighted average net calorific value of the fuel type (diesel) in year y
$EF_{CO2,Diesel, y}$	=	is the weighted average CO ₂ emission factor of the fuel type (diesel) in year y

Project emissions from power consumption

No electricity is generated by the project activity and no captive power plant supplies any of the electricity consumed by the project activity; all electric power is purchased from the local utility, Louisville Gas and Electric (LG&E).

$$PE_{EC,y} = EC_y * EF_{EL,y} * (1 + TDL_y)$$

Where:

$EF_{EL,y}$	=	the CO2 emission factor for the grid purchased electricity; tCO2e/MWh
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And under Scenario A:, Option A1:

$EF_{EL,y}$	=	$EF_{grid, CM,y}$ = Combined margin emission factor for the grid in year y
EC_y	=	the electricity consumed by the project activity during year y; MWh
TDL_y	=	Average technical transmission and distribution losses for providing electricity to project in year y

Monitoring Period Project Emission Calculation Results:

The following estimates the annual project emissions for the project activity:

$$PE_y = PE_{FC,loader,y} + PE_{EC,y}$$

		2013	2014	Units
$PE_{FC,loader,y}$	=	99.04	139.20	tCO2e
$PE_{EC,y}$	=	1,304.46	1,304.46	tCO2e
PE_y		1,403.51	1,443.66	tCO2e

4.3 Leakage

The project boundary includes the immediate site leased by Recast Energy. Activities relating to the project outside this boundary include: the collecting, processing and transporting of biomass residues. Emissions outside the project boundary are estimated as the project leakage. The following equation is used to determine the annual project leakage:

$$LE_y = LE_{biomass\ process,y} + LE_{biomass\ transp,y} + LE_{ash\ transp,y} + LE_{L2,y}$$

Where:

LE_y	=	The project leakage during the year y; tCO2e
$LE_{biomass\ process,y}$	=	The emissions from off-site consumption of diesel fuel during the collecting and processing of biomass residues into a transport-ready fuel format; tCO2e
$LE_{biomass\ transp,y}$	=	The emissions from off-site consumption of diesel fuel during the transporting of biomass residues from more than 200km to the project site; tCO2e
$LE_{ash\ transp}$	=	The emissions from off-site consumption of diesel fuel during the transportation of ash (combustion residuals) from the Project to beneficial use outlets or other final destination; tCO2e

$LE_{L2,y}$	=	The emissions from type L2, if applicable; tCO ₂ e
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Project leakage from biomass collecting and processing

$LE_{process,y}$	=	$\sum_j (Q_{biomass\ j,y} * EFF_{Diesel,process\ j,y}) * COEF_{Diesel,y}$
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Where:

$Q_{biomass\ j,y}$	=	The quantity of biomass residues of type j during the year y; tons
$EFF_{Diesel, process\ j,y}$	=	The diesel fuel efficiency of processing biomass of type j during the year y; gal/ton
$COEF_{Diesel,y}$	=	The CO ₂ emissions coefficient for diesel fuel during the year y; tCO ₂ e/gal

Project leakage from biomass transportation:

Biomass residues transported over a distance of more than 200 kilometres due to the implementation of the project activity must be considered a leakage source attributed to the transportation.

$LE_{biomass\ transp,y}$	=	$\sum_{deliveries} (DAF_{biomass\ delivery}) * COEF_{Diesel,y}/EFF_{tt,y}$
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Where:

$DAF_{biomass\ delivery}$	=	The roundtrip distance of each delivery; km
$COEF_{Diesel,y}$	=	The CO ₂ emissions coefficient for diesel fuel during the year y; tCO ₂ e/gal
$Eff_{tt,y}$	=	The fuel efficiency of a typical tractor trailer during the year y; km/gal

Project leakage from ash transportation

Ash residues transported over a distance of more than 200 kilometres due to the implementation of the project activity are considered a leakage source attributed to the transportation.

$LE_{\text{ash transp},y}$	=	$\sum_{\text{deliveries}} (DAF_{\text{ash delivery}}) * COEF_{\text{Diesel},y} / EFF_{\text{tt},y}$
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Where:

DAF _{ash delivery}	=	The roundtrip distance of each delivery; km
COEF _{Diesel,y}	=	The CO ₂ emissions coefficient for diesel fuel during the year y; tCO ₂ e/gal
EFF _{tt,y}	=	The fuel efficiency of a typical tractor trailer during the year y; km/gal

Project Leakage Forecast

The following estimates the annual project leakage for the project activity:

$$LE_y = LE_{\text{biomass transp},y} + LE_{\text{biomass process},y} + LE_{L2,y} + LE_{\text{ash transp},y} + LE_{L2,y}$$

Where

		<u>2013</u>	<u>2014</u>	<u>Units</u>
$LE_{\text{process},y}$	=	0	0	tCO ₂ e
$LE_{\text{biomass transp},y}$	=	71.38	71.71	tCO ₂ e
$LE_{\text{ash transp},y}$	=	0	0	tCO ₂ e
LE_y	=	71.38	71.71	tCO ₂ e

4.4 Net GHG Emission Reductions and Removals

The estimated emissions reductions (ERy) are calculated as the difference between the baseline emissions and the project emissions and project leakage.

$$ERy = BEy - PEy - LEy$$

Year	Baseline emissions or removals (tCO ₂ e)	Project emissions or removals (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions or removals (tCO ₂ e)
2013	35,657.6	1,403.5	71.4	34,182
2014	50,362.1	1,443.7	71.7	48,846
Total	86,019.7	2,847.2	143.1	83,028