QUANTIFICATION PROTOCOL FOR WASTE HEAT RECOVERY PROJECTS

ABRIDGED

Submitted to:

Alberta Environment

May, 2007

Disclaimer

The following document presents an abridged version of the Waste Heat Recovery Projects Protocol prepared for Alberta Environment and Alberta Agriculture, Food and Rural Development which has completed an initial round of technical review. This document has been prepared as a means of supporting a broader stakeholder consultation process. As such, this document should not be used as a quantification protocol.

Two versions of the Waste Heat Recovery Protocol have been developed in recognition of two groupings of projects. The project types covered under the first protocol represent the streamlined projects which typically include only one entity or site. For these projects, waste heat from one operation is used to supplement the heat requirement at another point. As such, there is no impact to the operation of the unit where the waste heat is being utilized. Electricity generation is not included as part of this protocol.

This second protocol covers a broader range of projects that may include multiple entities and multiple sites. Further, more complex heat and power generation configurations from multiple sources are contemplated. Under this scenario, there may be changes to the operation of the unit where the waste heat is being utilized. Electricity generation is contemplated under this protocol.

To illustrate the parallels between the two protocols, numbering and naming of sources and sinks remains constant across the two protocols. As such, it may appear that there are gaps in the numbering of sources and sinks in the streamlined protocol. However, these gaps correspond to sources and sinks considered as part of the broader protocol.

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1.0 Project and Methodology Scope and Description

This quantification protocol is applicable to the quantification of direct and indirect reductions of greenhouse gas (GHG) emissions resulting from the implementation of waste heat recovery projects. The protocol quantifies the emission reductions from the avoidance of fossil fuel consumption resulting from the capture and utilization of heat that is currently being wasted. The waste heat recovery may be transferred into the project site where it is utilized, or may be recovered and used within the project site. Project configurations where the waste heat is supplemented are also included. **FIGURE 1.1** offers a project element life cycle chart for a typical project.

The waste heat recovery protocol does not prescribe the configuration of the scheme. Rather, this protocol serves as a generic 'recipe' for project proponents to follow in order to meet the measurement, monitoring and GHG quantification requirements. The project must achieve some level of fuel savings by capturing and utilizing waste heat.

The baseline condition for projects applying this protocol are sites where there is currently waste heat that can have a beneficial use under the project condition, which would offset the fulfillment of the heat and power load requirements through the combustion of fossil fuels. The baseline condition is defined based on the provision of the equivalent heat load as under the project condition. This is accomplished by applying an energy balance to the generating, distribution and utilization systems. **FIGURE 1.2** offers an element life cycle chart for a typical baseline configuration.

The approach to quantifying the baseline will be projection based as there are suitable models for the applicable baseline condition that can provide reasonable certainty. The baseline scenario for this protocol is dynamic as the emissions profile for the baseline activities would be expected to change materially relative to fluctuating heat and power supply and demand, as well as other market conditions.

The boundary of the waste heat recovery protocol encompasses the recovery, distribution and utilization systems, which may cross site boundaries. Further, the utilization systems are defined as those within the impacted unit, i.e. equipment, processes, facilities, etc., whose heat load is partially or wholly impacted by the operation of the waste heat recovery system.

To demonstrate that a project meets the requirements under this protocol, the project proponent must supply sufficient evidence to demonstrate that:

1. The heat collected was not being used in either a passive or an active manner, where this redistribution of this heat source is not accounted for as supplementary heat under this protocol, as confirmed by an attestation from the supplier of the waste heat; and
2. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol.

FIGURE 1.1: Project Element Life Cycle Chart

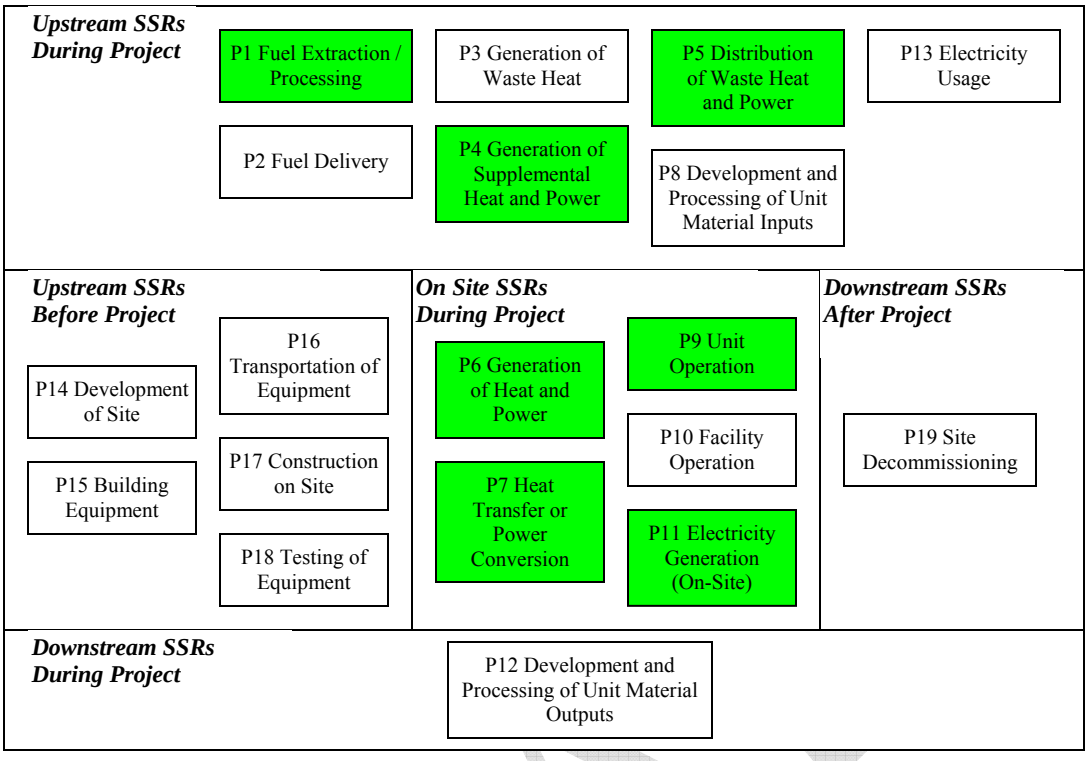
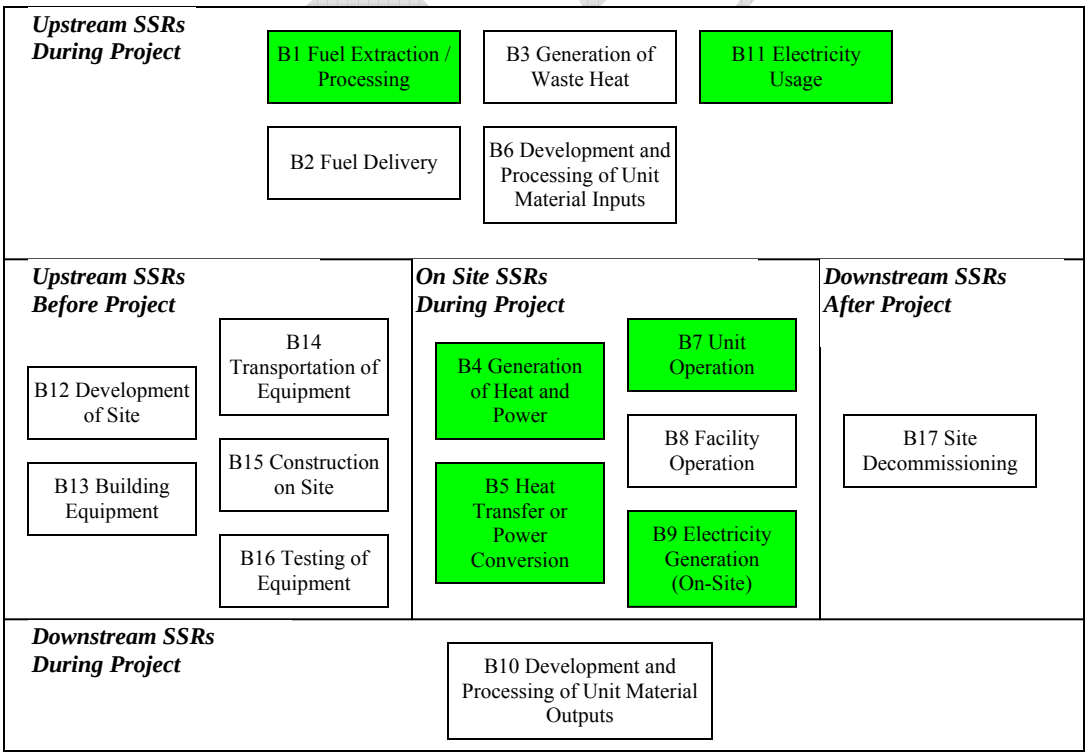


FIGURE 1.2: Baseline Element Life Cycle Chart



* Sources, sinks and reservoirs selected for measurement and monitoring under this protocol are highlighted.

Flexibility in applying the quantification protocol is provided to project developers in three ways:

1. The source of the waste heat may supplement their heat demand either to replace a component of the heat being transferred or to augment the heat exported, however, these emissions must be captured as supplementary heat and power under this protocol;
2. Waste heat recovery projects may occur within a single site or across multiple sites. Further, the defined unit impacted, both on the recovery and utilization of the waste heat, may include multiple processes, equipment, etc. Definition of the units impacted is to be justified by the project proponent;
3. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must be sufficiently robust as to ensure reasonable accuracy; and
4. Waste heat recovery projects may provide some or all of the heat requirements for the facility. Flexibility is provided in terms of allowing the broadening of the project scope to include existing, new, or retrofit supplementary heating both on and off site to meet the project energy load.

If applicable, the proponent must indicate and justify why flexibility provisions have been used.

2.0 Quantification of Identified Sources, Sinks and Reservoirs

Quantification of the reductions, removals and reversals of relevant SSRs for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\begin{aligned}\text{Emissions}_{\text{Baseline}} = {} & \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Gen Heat and Power}} \\ & + \text{Emissions}_{\text{Transfer / Conversion}} + \text{Emissions}_{\text{Unit Operation}} \\ & + \text{Emissions}_{\text{Electricity Generation}} + \text{Emissions}_{\text{Electricity Usage}}\end{aligned}$$

$$\begin{aligned}\text{Emissions}_{\text{Project}} = {} & \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Gen Sup Heat and Power}} \\ & + \text{Emissions}_{\text{Distribute Heat and Power}} + \text{Emissions}_{\text{Gen Heat and Power}} \\ & + \text{Emissions}_{\text{Transfer / Conversion}} + \text{Emissions}_{\text{Unit Operation}} \\ & + \text{Emissions}_{\text{Electricity Generation}}\end{aligned}$$

TABLE 2.1: Quantification Procedures

1. Project / Baseline SSR	2. Parameter / Variable	3. Unit
Project SSRs		
P1 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e
	Volume of Fuel Combusted for P4 and P6 / Vol. Fuel	L, m^3 or other
	CO_2 Emissions Factor for Fuel Including Production and Processing / $EF\ Fuel_{CO2}$	kg CO_2 per L, m^3 or other
	CH_4 Emissions Factor for Fuel Including Production and Processing / $EF\ Fuel_{CH4}$	kg CH_4 per L, m^3 or other
	N_20 Emissions Factor for Fuel Including Production and Processing / $EF\ Fuel_{N2O}$	kg N2O per L, m^3 or other
P4 Generation of Supplementary Heat and Power	$Emissions_{Gen\ Sup\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Gen\ Sup\ Heat\ and\ Power}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel Consumed to Generate Supplementary Heat and Power / $Vol.\ Fuel_i$	L, m^3 or other
	CO_2 Emissions Factor for Combustion of Each Type of Fuel / $EF\ Fuel_{i\ CO2}$	kg CO_2 per L, m^3 or other
	CH_4 Emissions Factor for Combustion of Each Type of Fuel / $EF\ Fuel_{i\ CH4}$	kg CH_4 per L, m^3 or other
	N_20 Emissions Factor for Combustion of Each Type of Fuel / $EF\ Fuel_{i\ N2O}$	kg N2O per L, m^3 or other
P5 Distribution of Waste Heat and Power	$Emissions_{Distribute\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Distribute\ Heat\ and\ Power}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel Combusted for the Distribution of Waste Heat and Power / $Vol.\ Fuel_i$	L, m^3 or other
P6 Generation of Heat and Power	$Emissions_{Gen\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Gen\ Heat\ and\ Power}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel Consumed to Generate Heat and Power / $Vol.\ Fuel_i$	L, m^3 or other
P7 Heat Transfer or Power Conversion	$Emissions_{Transfer\ /\ Conversion} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Transfer\ /\ Conversion}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel Consumed for Heat Transfer or Power Conversion / $Vol.\ Fuel_i$	L, m^3 or other
P9 Unit Operation	$Emissions_{Unit\ Operation} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Unit\ Operation}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel for Unit Operation / $Vol.\ Fuel_i$	L, m^3 or other
P11 Electricity Generation	$Emissions_{Elec\ Gen} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Elec\ Gen}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel for Electricity Generation / $Vol.\ Fuel_i$	L, m^3 or other
Baseline SSRs		
B1 Fuel Extraction and Processing	$Emissions_{Fuel\ Extraction\ /\ Processing} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$	
	$Emissions_{Fuel\ Extraction\ /\ Processing}$	kg of CO2e
	Volume of Fuel Combusted for B4 / Vol. Fuel	L, m^3 or other
B4 Generation of Heat and Power	$Emissions_{Gen\ Heat\ and\ Power} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2}); \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4}) ; \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N20})$	
	$Emissions_{Gen\ Heat\ and\ Power}$	kg of CO_2 ; CH_4 ; N_2O

	Volume of Each Type of Fuel Consumed to Generate Heat and Power / Vol. Fuel $_i$	L, m^3 or other
B5 Heat Transfer or Power Conversion	Emissions $_{Transfer / Conversion}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$); ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N20}$)	
	Emissions $_{Transfer / Conversion}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel Consumed for Heat Transfer or Power Conversion / Vol. Fuel $_i$	L, m^3 or other
B7 Unit Operation	Emissions $_{Unit\ Operation}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$); ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N20}$)	
	Emissions $_{Unit\ Operation}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel for Unit Operation / Vol. Fuel $_i$	L, m^3 or other
B9 Electricity Generation	Emissions $_{Elec\ Gen}$ = ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CO2}$); ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ CH4}$) ; ∑ (Vol. Fuel $_i$ * EF Fuel $_{i\ N20}$)	
	Emissions $_{Elec\ Gen}$	kg of CO_2 ; CH_4 ; N_2O
	Volume of Each Type of Fuel for Electricity Generation / Vol. Fuel $_i$	L, m^3 or other
B11 Electricity Usage	Emissions $_{Electricity}$ = Electricity * EF $_{Elec}$	
	Emissions $_{Electricity}$	kg of CO2e
	Incremental Electricity Exported from the Site / Electricity	kWh
	Emissions Factor for Electricity / EF $_{Elec}$	kg of CO2e per kWh

APPENDIX A: Glossary of New Terms

Supplemental Heat and Power	Any heat and power generated to supplement the heat collected from the waste recovery source(s). This includes heat used to replace the heat and power requirements that may be impacted by the project implementation, to augment the supply of heat and power and to cover times when the systems from which the waste heat is generated would not be able to provide the heat and power (shut-downs, turn-arounds, etc.).
Unit	The project unit is defined as the equipment, processes and facilities impacted who are being serviced and impacted by the waste heat recovery project. The project unit must be clearly defined and justified by the project proponent.