Further Details on Recommended Tracking Framework

This Appendix provides additional details on several topics related to the recommended tracking framework:

- Assessment of emissions sources for inclusion in tracking framework;
- Emissions sources not included in the tracking framework;
- Treatment of pre-combustion emissions from fuel production and delivery;
- Data sources used to support the tracking framework;
- Preliminary Tracking Metrics for *Expanded:Production* and *Expanded:Consumption* Scopes.

Assessment of Emissions Sources for Inclusion in Tracking Framework

Table 1 presents further details on our assessment of emissions sources, as discussed in Box 4 in the main report text.

Table 1. Assessment of Policy Influence and Measurability for GHG Emissions Sources

Key to Ratings:	Policy Influence	Measurability
●	Direct & unique	High
◎	Mixed	Medium
○	Indirect &/or diffuse	Low

Sector	Subsector	Policy Influence (Levers)	Measurability (Data Sources)
Emissions Sources from *Geographic-plus Inventory*			
Transportation			
	Road	● Land use planning ● Road & transit infrastructure ● Parking and road pricing ● Trip reduction programs	● WSDOT vehicle counts (VMT) ◎ PSRC models (VMT) ◎ Dept. of Licensing (efficiency) ◎ Fuel sales
	Marine & Rail	◎ Port regulation	◎ Port of Seattle inventory
	Air	◎ Internet infrastructure to support video conferencing	● Port of Seattle fuel data ○ Passenger attribution to KC
Buildings			
	Res'l / Comm'l	● Building codes ● Energy supply	● Utility billing data (BTU, MWh) ◎ Fuel mix reports (tCO_2/MWh)
Industry			
	Energy / Process	● Electricity supply ○ Material / energy exchanges	● Utility billing data (BTU, MWh) ◎ PSCAA data ◎ Company-provided data
	Fugitive	◎ Regulation on some (e.g. HFC)	○ Scaled national data (HFC, SF6)
Waste			
	Landfills	● Waste infrastructure ● Landfill operation / contracts	● Utility data (tons) ◎ Gas capture (CH_4/ton)
	Wastewater	● Wastewater infrastructure	◎ Gas generation / capture
Agriculture			
	Livestock	◎ Incentives for digesters	◎ USDA animal counts
	Fertilizer Application	○ Outreach	○ Scaled national data (N_2O)
Land-use			
	Res'l Development	● Land use planning ● Building permitting	● KC Assessor (permit data) ● Satellite/field data (clearing)
***Consumption--based Inventory* Sources**			
Personal Transportation		(See *Transportation*, above)	
Home Operation		(See *Buildings: Residential*, above)	
Food		○ Education: diet / waste ◎ Government procurement	○ IMPLAN or CEX data & I-O ($) ◎ GHG Inventories & I-O (CO_2e/$)
Goods		○ Consumer education ◎ Government procurement	○ IMPLAN or CEX data & I-O ($) ◎ GHG Inventories & I-O (CO_2e/$)
Services[1]		○ Business education ◎ Government procurement	○ IMPLAN or CEX data & I-O ($) ◎ GHG Inventories & I-O (CO_2e/$)
Construction[2]		◎ Building and land use codes ◎ "Green building" incentives	○ IMPLAN or Census[3] data & I-O ($) ◎ GHG Inventories & I-O (CO_2e/$) ● Process LCAs ($CO_2e$/ton)
Other			
	Retail and wholesale	(Can be considered a subset of *Buildings: Commercial*, above, though limited ability to disaggregate into types of goods consumed.)	
	Other transport (long-distance freight)	◎ Road-to-rail infrastructure ○ Systems for local production	○ IMPLAN, CEX, or Census & I-O ($) ◎ GHG Inventories & I-O (CO_2e/$)

[1] Policy levers available to Buildings: Commercial could also reduce the embodied emissions of services to the extent that commercial building energy in King County is a significant fraction of these emissions. However, emissions associated with in-county operations of commercial buildings, at 4.0 $MTCO_2e$ (Table 2 of the main report) and not all of which are associated with in-county consumption, are less than half the entire embodied emissions associated with services consumed in King County, 9.7 $MTCO_2e$ (Table 8 of the main report, including restaurants). This suggests that in-county buildings represent at most about 40% of the embodied emissions associated with services.

[2] The assessment of *Construction* here pertains to the embodied emissions in construction materials and therefore receives different ratings than the assessment for *Buildings*, which pertains to building energy use.

[3] Purchasing data for some materials not generally purchased directly by consumers (e.g., cement and other construction materials) is available from the Economic Census instead of the Consumer Expenditure Survey (CEX).

Emissions Sources Not Included in the Tracking Framework

The tracking framework focuses on a Core scope of emissions in the transportation, buildings, and waste sectors for which data are readily available. For the two additional scopes, *Expanded Production* and *Expanded Consumption*, the focus is on sectors or categories of emissions that, taken together, meet the criteria discussed in Table 9 in Box 4 of the main report. The tracking framework does not yet cover all sources included in the *Geographic-plus Inventory*, however. After considering data limitations and the relative magnitude of emissions, the sources in Table 2 in the recommended tracking framework are not included at this time. More work is needed to include these sources, which together comprise less than 10% of the *Geographic-plus Inventory*.

Table 2. Emissions Sources in the *Geographic-plus Inventory* Not Yet Included in the Tracking Framework

Sector	Source	Total Emissions, 2008 (Million $MTCO_2e$)	Reason Not Included in Tracking Framework at This Time
Transportation			
	Ferries	0.04	▪ Very small (<0.5%) share of *Geographic-plus Inventory*
	Cruise Ships	0.05	▪ Very small (<0.5%) share of *Geographic-plus Inventory*
	Marine pleasure craft	0.01	▪ Very small (<0.5%) share of *Geographic-plus Inventory*
	King County International Airport (Boeing Field)	0.13	▪ Small (<2%) share of *Geographic-plus Inventory* ▪ Little opportunity for local government policy influence ▪ Emissions largely associated with industrial activity (e.g., Boeing) satisfying demand outside King County
Buildings			
	Residential: lawn equipment	0.05	▪ Very small (<0.5%) share of *Geographic-plus Inventory* ▪ No locally specific data sources known
	Commercial: lawn and other mobile equipment	0.41	▪ Small (<2%) share of *Geographic-plus Inventory* ▪ No locally specific data sources known
Industry			
	Fugitive Gases (ODS substitutes and SF_6)	0.73	▪ No locally specific data sources known
	Industrial Equipment	0.78	▪ No locally specific data sources known
Waste			
	Wastewater Treatment	<0.01	▪ Very small (<0.5%) share of *Geographic-plus Inventory*
Agriculture			
	Fertilizer Application	<0.01	▪ Very small (<0.5%) share of *Geographic-plus Inventory* ▪ No locally specific data sources known
	Total *Geographic-plus* Sources Not Included at This Time:	**2.20**	

Each of these sources can continue to be assessed in the context of a regular GHG inventory (and each is currently included in the *Geographic-plus Inventory*).[4]

Treatment of Pre-combustion Emissions from Fuel Production and Delivery

The Core scope of the recommended tracking framework includes emissions associated with burning fuels for transportation and buildings in King County, regardless of whether those fuels are burned directly (e.g., in a vehicle or home) or instead indirectly to produce electricity used in vehicles and buildings.

[4] In addition, as described in the main body of this report, it is not recommended that emissions associated with the *use* and *disposal* phases of the Consumption-based inventory be included in the Expanded: Consumption tracking framework. These emissions are (for the most part) included within the Core scope.

Other emissions can also be associated with fuel use: emissions associated with producing and transporting the fuels themselves. For example, fossil fuels require extraction and processing equipment that in turn require energy and associated emissions. Producing biofuels, too, requires equipment for feedstock growth, harvest, and processing, and may require clearing of land to plant biofuel crops. Furthermore, even if land is not directly cleared to grow biofuel crops, growing these crops may induce land to be cleared elsewhere to make up for lost production of the prior crop. For example, if corn in the Midwestern U.S. is directed to biofuel production instead of to food (or feed) uses, other land may be cleared (even if in another part of the world) to make up for (all or a portion of) the corn diverted away from food production. This phenomenon is sometimes called indirect land use change and can comprise a substantial portion of the emissions associated with biofuel production.[5] Since most GHG inventories (including the US EPA's national inventory) count biofuel combustion as zero emissions, including pre-combustion emissions may have a greater impact on biofuel emissions accounting than for fossil fuels and therefore more significantly affect the relative emissions between biofuels and fossil fuels than among different types of fossil fuels.

There is no well-established method of assessing the pre-combustion emissions associated with fuel production and delivery in a community's GHG inventory. One approach could be to estimate and include these emissions by developing corresponding emission factors (or multipliers) for each fuel used in the community.[6] However, one drawback of this approach is that it would introduce new uncertainties into otherwise well-established emission factors for fossil fuels and would rely on regular, detailed assessments of the processes used to produce the variety of fuels used.

An alternate approach could be to focus the assessment on biofuels (leaving treatment of fossil fuels unchanged), given the potential for biofuel emissions to be more substantially impacted by accounting for pre-combustion activities. For example, emissions from biofuels could be counted as a fraction of the standard, combustion emissions for a comparable petroleum-based fuel. The fraction could be determined as the ratio of the full life-cycle emissions of the two comparable fuels based on the best available life-cycle studies of the fuels. For example, the US EPA (2010) finds that life-cycle emissions of sugarcane-derived ethanol are about 40% of life-cycle emissions for gasoline per unit of energy. Accordingly, emissions from sugarcane-derived ethanol could be counted as 40% of the standard combustion (*tailpipe*) emissions for gasoline. While this method would slightly underestimate the full emissions associated with biofuels it would maintain consistency in accounting for petroleum fuels with most other GHG inventories, including the *Geographic-plus Inventory* calculated here. The benefits and drawbacks of the two approaches are summarized in Table 3.

[5] For a review of the issue, see Fargione, Plevin, and Hill (2010). For assessments of emissions associated with indirect land use change, see US EPA (2010) or CARB (2009).

[6] As of June 2011, such a method is being considered by ICLEI for their U.S. community GHG protocol.

Table 3. Benefits and Drawbacks of Alternate Methods of Accounting for Pre-Combustion Emissions from Fuel Production and Delivery

Approach	Benefits	Drawbacks	Additional Notes
Count (absolute) pre-combustion emissions associated with all fuels	▪ Most complete accounting for global emissions impacts of fuel use	▪ Introduces uncertainty into otherwise well-established practice of fossil fuel emissions accounting ▪ Could introduce annual variation into emissions estimates that may be unrelated to policy actions taken in the community and therefore reduce ability to track progress	▪ Because it is more complete, this method would better support assessment of the life-cycle emissions tradeoffs of replacing existing energy-using products with more efficient models[7]
Count emissions of biofuels as a ratio of their petroleum fuel equivalents	▪ Maintains simplicity and consistency with existing fossil fuel emissions accounting and most other GHG inventories ▪ Confines uncertainties associated with pre-combustion emissions to biofuel emissions	▪ Introduces a known inaccuracy, as it would report an underestimate of the full life-cycle emissions associated with the alternative fuel	▪ Could be adapted to assess alternative fossil fuels (e.g., liquid fuels derived from tar sands or coal) as a ratio of their "standard" petroleum fuel equivalents

Currently, liquid biofuels represent a very small fraction of fuels used in King County. However, the region has been cited has having the highest per-capita use of biodiesel in the country,[8] which (combined with federal incentives for biofuels) suggests that biofuel use may increase. Accordingly, accurately accounting for biofuel emissions will be increasingly important.

In the current *Geographic-plus Inventory* and Core tracking framework, we count biofuel GHG emissions as zero by default, following the practice of the US EPA's national inventory. National GHG inventories officially count biofuels as zero carbon, following IPCC guidance. This is largely reasonable since the national inventories also count net changes to biomass carbon stocks (e.g., in forests). If, as the result of land use change or wood harvesting, biofuel production results in changes to biological carbon stocks, then national inventories, in principle, should already capture these changes. Counting biofuel GHG emissions as zero makes less sense for community-scale inventories than it does for national inventories, since community-scale inventories generally cannot capture net changes in biomass carbon stocks where biomass energy is produced.[9]

Therefore, for future accounting of biofuels, pursuing one of the two methods discussed above is recommended. Once data sources are established to estimate the fraction of biofuel use in King County, this method could be introduced so that King County's tracking framework by default neither overcounts the climate benefit of biofuels nor includes a perverse incentive to use biofuels (or, for that matter, alternative fossil fuels) that may not provide net GHG benefits.

Lastly, similar questions may need to be addressed for solid biomass used for electricity and heat production, especially in the case of woody biomass fuels. Either the absolute or the ratio approach discussed above could also be adapted to consideration of solid biomass (or other alternative fuel sources) used in electricity or heat production.

[7] For example, accurate assessments of the embodied emissions in a vehicle, building, or appliance relative to the emissions associated with *using* that product would need to consider not only the combustion emissions but also the pre-combustion emissions associated with the fuel used.

[8] http://www.harvestcleanenergy.org/biofuel/index.html

[9] For more on this, see Searchinger et al. (2009).

Further Details on Data Sources for Core Metrics

Table 4 lists particular data sources used to assemble the Core tracking metrics in Table 12 of the main report. For further details on many of these data sources, see Appendix B.

Table 4. Data Sources Used for Core Tracking Framework

Emissions Source	Activity Data	Intensity Data	Issues or Challenges
Core			
Transportation: Road			
Passenger (Light duty vehicles)	▪ PSRC (VMT model results) ▪ WA DOT (HPMS VMT data for scaling across years)	▪ Federal Bureau of Transportation Statistics (BTS)	▪ Using national intensity data does not capture changes in local vehicle or fuel mix, suggesting opportunity for data development ▪ WA DOT's HPMS method changed in 2010, so a means to compare pre-2010 data will need to be developed
Passenger (Bus)	▪ King County Metro and Federal Transit Administration's National Transit Database	▪ King County Metro	▪ Existing King County Metro and Sound Transit data not easily organized in the origin-destination pair approach used for other vehicle travel ▪ Improvements in PSRC models may enable bus VMT to be assessed together with other vehicles, as above
Medium / heavy duty vehicles	▪ PSRC (VMT model results) ▪ WA DOT (HPMS VMT data for scaling across years)	▪ US DOT Federal Highway Administration's Highway Statistics	▪ Same as above for passenger vehicles
Buildings: Residential & Commercial			
Natural gas	▪ PSE (sales in therms)	▪ US EPA (GHGs per therm)	Unclear how natural gas purchased direct from wholesalers and only delivered by PSE (e.g., to Seattle Steam) is counted in PSE statistics
Electricity	▪ PSE and SCL (sales in kwh)	▪ Washington Department of Commerce (GHGs per kwh delivered)	
Oil	▪ Federal Energy Information Administration (EIA) State Energy Data System (SEDS) ▪ Census Bureau, for scaling factors (employment, # homes with oil heat)	▪ US EPA (GHGs per BTU of oil)	▪ Scaling of state totals is insufficient method, particularly for commercial oil use, suggesting opportunity for data development (e.g., with local heating oil suppliers) ▪ Future of EIA SEDS data is in question given federal budget.
Steam	▪ PSCAA data (natural gas consumption at Seattle Steam and University of Washington steam plants)	▪ US EPA (GHGs per therm)	▪ May require collaboration with Seattle Steam in the future, given recent switch to biomass as partial feedstock and development of emissions factor for their biomass use
Waste: Landfills			
King County's waste (currently Cedar Hills)	▪ King County Solid Waste Division	▪ US EPA (WARM tool) and King County Solid Waste Division (Landfill gas capture rate)	
Seattle's waste (currently Arlington)	▪ Seattle Public Utilities	▪ US EPA (WARM tool)	▪ Landfill gas capture rate at Arlington landfill is unknown. EPA WARM's (prior) 75% default used. May want to update to WARM version 11 default (90%).

Preliminary Tracking Metrics for *Expanded: Production* and *Expanded: Consumption* Scopes

Table 5 provides preliminary baseline tracking metrics for the expanded scopes for 2003 and 2008. Although data for these scopes are limited, we assemble preliminary, example metrics here to demonstrate possible metrics and to provide comparison between sources. Ultimately, developing a robust tracking framework for many of these sources (especially those in italics) may require focusing instead on specific emissions sources where policy influence is more direct or unique and/or where data availability is greater, such as the production metrics of land use or in-region landfills or the consumption metric of air travel.[10] Regardless, improved data collection systems are needed to enable tracking of these metrics over time and could be the subject of additional research.

[10] For a source-by-source assessment of policy influence (levers) and measurability (data sources), see Table 1.

Table 5. Preliminary Baseline Expanded GHG Tracking Metrics for King County: 2003 and 2008
(Parentheses indicate emissions avoided, sequestered, or stored)

Emissions Source		2003	2008
Expanded: Production[11]			
Cement	$MTCO_2e$ /tonne clinker produced	n/a	*0.99*
Steel	$MTCO_2e$ /tonne steel produced	n/a	*0.20*
Glass	$MTCO_2e$ /tonne glass produced	n/a	*0.36*
Other Industry	Emissions per value added (kg CO_2e / $)	n/a	*0.06*
Agriculture	$MTCO_2e$ / tonne of animal	*7.9*	*7.7*
Port of Seattle	$MTCO_2e$ / ton throughput	0.012	0.011
Land Use[12]			
	Emissions (Million $MTCO_2e$)	n/a	(0.4)
	Total Forest Cover (Acres)	n/a	860,000
	Annual Change in Forest Cover (Acres)	n/a	(4,400)
In-region Landfills[13]			
	Emissions (Million $MTCO_2e$)	0.21	0.21
	Energy generated at landfill (MBTU)	0	0
	Emissions avoided due to energy generation	0	0
Expanded: Consumption			
Embodied Emissions in Goods, Food, and Services[14]			
	Emissions (Million $MTCO_2e$)	n/a	*24.0*
	Emissions per person ($MTCO_2e$ /resident)	n/a	*12.8*
Embodied Emissions in Construction			
	Residential (Million $MTCO_2e$)	n/a	*2.5*
	Non-residential (Million $MTCO_2e$)	n/a	*1.7*
	Residential per person ($MTCO_2e$ /resident)	n/a	*1.3*
	Non-residential per person ($MTCO_2e$ /resident)	n/a	*0.9*
Recycling and Composting[15]			
	Diversion (recycling + composting) rate (%)	36%	48%
	Recycling relative to national average (t / resident)	0.09	0.15
	Composting relative to national average (t /resident)	0.05	0.07
	Avoided emissions due to recycling (Million $MTCO_2e$)	(0.5)	(0.8)
	Avoided emissions due to recycling ($MTCO_2e$ /resident)	(0.3)	(0.4)
	Emissions storage due to composting (Million $MTCO_2e$)	(0.01)	(0.02)
	Emissions storage due to composting ($MTCO_2e$ /resident)	(0.20)	(0.20)
Air travel			
	Emissions (Million $MTCO_2e$)	1.7	2.0
	Emissions per person ($MTCO_2e$ /resident)	1.0	1.1

[11] The estimates here of cement, steel, and glass emissions intensity rely on measurements made in 2006 by the Puget Sound Clean Air Agency (PSCAA). Better and more complete reporting of fuel use for these sectors (beyond what currently tracked by PSCAA) would be needed to update these metrics on a regular basis. Emissions intensity of "other industry" is approximate, based on value added in 2007 (2008 data not available) and includes value added by cement, steel, and glass in the denominator due to insufficient data to exclude these sectors.
[12] Metrics for emissions and annual change in forest cover reported here for 2008 are based on average rates of change between 1996 and 2006 as reported by the USFS and discussed in Appendix C. The metric of total forest cover is the USFS estimate for 2006.
[13] Since 2008, King County Solid Waste Division has since installed a landfill gas processing facility to generate electricity from methane collected at the Cedar Hills landfill, so future updates to metrics for energy generation at landfills and associated emissions benefits will be non-zero.
[14] The metric listed here includes embodied emissions in cars and trucks, home appliances, food, other goods, and services as in Table 8 of the main report. Ultimately, developing tracking metrics such as consumption of different types of food, goods, or services is recommended (ideally as measured by a functional unit, such as a kg of food), as called for in Table 11 of the main report.
[15] The assessment of recycling benefits is focused on the avoided manufacturing emissions due to use of recycled feedstock, not on avoided landfilling or transportation emissions (if any), any change in those emissions will be picked up in the Core tracking framework.