Health and Ecological Assessment Task (HEAT) Group 2013 Review: Final Report

October 2014

Executive Summary

Under the *Emissions Management Framework for Alberta's Electricity Sector*, a review of the Framework is carried out every five years. As a part of each Five-Year Review, a Health and Ecological Assessment Task (HEAT) Group is formed. For the second Five-Year Review in 2013, the HEAT Group was charged with reviewing air emission substances emitted by the electricity sector that are subject to formal control, and reviewing and identifying any new and relevant information regarding potential environmental or health effects from air emissions from electricity generation.

The HEAT Group reviewed relevant work done by the 2003 Electricity Framework Project Team and the 2008 HEAT Group, and developed a process for achieving its mandate. The process included the following key components:

1. Health and Ecological Assessment to review recent literature on the health and ecological effects of air emissions from electricity generation.
2. Chemical Screening to identify all air emissions produced by electricity generation, and associated emission rates, toxicity, bioaccumulation, and persistence.
3. Air Emissions Substance Review to assess air emissions produced by electricity generation based on foregoing work, and create recommendations for further action.

Based on the results of these components, and previous relevant work, each air emission substance produced by electricity generation was organized into one of the following four categories:

1. Priority List
2. Management Actions need to be considered
3. Ongoing Surveillance Recommended
4. Insufficient Information

A rationale for categorization was created for each air emission substance, resulting in proposed recommendations for further action (see recommendations 1 and 2), to be reviewed by the 2013 Electricity Framework Review (EFR) Team.

Throughout the Five-Year Review, key learnings regarding the review process were identified. To assist with future Reviews, the group also created one general recommendation pertaining to the process (see recommendation 3).

Recommendations

These recommendations are given as advice to the project team and may or may not be included in the project team's final report which will be forwarded to CASA Board of Directors for their approval.

Draft Recommendation 1:

The Project Team should determine a mechanism that will, prior to commencement of the 2018 Electricity Framework Review, ensure that each substance listed in Category 2 (i.e. Management actions need to be considered) will be evaluated as described in Table 1 of this report.

Draft Recommendation 2:

The 2018 HEAT Group should explicitly include substances listed in Category 3 in the search terms of the health and ecological literature reviews.

Draft Recommendation 3:

CASA should form a standing Working Group to address the data gaps that were identified in the 2013 Review, and to ensure continuity between the reviews, in preparation for the 2018 air emission substance review (rec 72).

1. Introduction

The *Emissions Management Framework for Alberta's Electricity Sector* recommends that a formal review of the Framework be undertaken every five years. This review should use a consensus decision-making process, and include a multi-stakeholder group consisting of industry, government, non-government organizations, and communities with an interest in the electricity sector.

The intent of the Five-Year Review is to assess new emission control technologies, update emission limits for new generation units, determine if emission limits for new substances need to be developed, review implementation progress, and determine if the Framework is achieving its emission management objectives.

The first Five-Year Review occurred in 2008 and the second Five-Year Review commenced in 2013. As part of each Five-Year Review, a Health and Ecological Assessment Task (HEAT) Group is formed. The purpose of this report is to provide background to the historical work that has been completed and to outline the work that was undertaken by the 2013 Five-Year Review HEAT Group.

This report is organized as follows:

- Section 2: Background
- Section 3: 2013 HEAT Five-Year Review
- Section 4: Learnings for Future Reviews
- Section 5: Recommendations

2. Background

This section contains an overview of work that is relevant to the 2013 HEAT Group, which was completed as part of the original Electricity Management Framework in 2003, and the first Five-Year Review in 2008.

2.1 2003 Prioritization Subgroup

As part of the development of the Electricity Management Framework in 2003, the Electricity Project Team (EPT) recognized a need for a process to review air emissions of concern and establish priorities for their management. The EPT formed the Prioritization Subgroup (PSG) to:

> *Identify which air emissions from the electricity sector, in addition to mercury, are a priority to be addressed.*

In addition to developing screening and validation criteria in support of five Priority substances identified by the EPT (sulphur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), particulate matter (PM), and greenhouse gases (GHGs)), the PSG created a second list of substances ("List 2") for the purpose of evaluating co-benefits when reviewing management options for the Priority substances.

Based on the 2003 PSG and EPT minutes and reports, it would appear that the Priority and List 2 substances were determined by the following process:

In 2003, PSG created a "master list" by compiling a list of substances from: published information on the electricity sector; 10 existing processes used to identify substances; feedback from a public information session; and suggestions from the EPT. The master list was reduced and categorized as follows:

1. Priority substances
   While there was extensive discussion by the PSG and the EPT about developing criteria to screen for priority substances, no record was found of such a process being used to identify the final five Priority Substances. It appears that the EPT took into consideration all research done by the PSG, and reached consensus on the five Priority substances. Following this decision, efforts of the PSG focused on generating rationale for identifying the five Priority substances.

2. List 2 substances
   A table was generated based on expert opinion which indicated the level of control exerted on each substance through potential control technologies applicable to the Priority substances. Based on this table, the PSG members voted on which substances should be included in List 2. A screening statement indicated the main factors to be considered: toxicity, bioaccumulation, long-range transport, and predicted ambient air concentrations. No explicit definitions of these factors could be found in the PSG records. The PSG also took into consideration information from sources such as the US EPA and Environment Canada. A discussion of all these elements produced the final List 2 substances.

The Priority and List 2 substances formed the start point for the 2008 HEAT Group Five-Year Review.

2.2 2008 HEAT Group Five-Year Review

As part of the Five-Year Review in 2008, the first multi-stakeholder HEAT Group was established to:

- Assess information generated since 2003 related to possible new substances not yet regulated, but which should be considered based on potential environmental and/or health impacts;
- Compile and review any new or additional information that illustrates potential health effects associated with emissions from the electricity sector, and determine how any new information impacts the Framework; and
- Make recommendations for future Five-Year Reviews.

Consultants were hired by the HEAT Group to undertake a review of recent research or reports (published between 2002 and 2007), and report on any new information regarding the magnitude and/or nature of:

1. Direct and indirect health and environmental effects that could be associated with air emissions from fossil fuel fired electrical generation facilities.
2. New information related to emissions from fossil fuel fired electrical generation facilities.

Based on the outcomes of their work in 2008, HEAT concluded that: i) no new substances were identified that should be of concern to regulators; and ii) no new environmental and health effects information was identified to warrant a detailed review of the work. The Group recommended that for

future Five-Year Reviews, an independent peer review should be completed on the results of the work of HEAT Groups.

3. 2013 HEAT Group Five-Year Review

For the 2013 Review, the HEAT Group was given the following objectives by the EFR Team, as outlined in the 2013 Electricity Framework Review Project Charter:

1. Review air emissions substances emitted by the electricity sector that are subject to formal control, including List 2 substances and possible new substances. Identify further action if required.
2. Form a multi-stakeholder group with appropriate representation to oversee a review to identify any new and relevant studies or research findings regarding potential environmental or health effects from air emissions from electricity generation, including an independent peer review of the results.

The HEAT Group convened in November 2013 to develop a work plan to carry out its mandate. A list of HEAT Group members can be found in Appendix A.

3.1 2013 HEAT Group Workplan

The following outlines the deliverables[1] of the 2013 HEAT Group workplan and the key tasks carried out to achieve them. It also contains details of how the work was conducted. The full workplan is appended in Appendix B, and a summary of timelines and associated costs can be found in Appendix C.

3.1.1 Deliverables

Deliverable 1: Health and Ecological Assessment

Identify any new and relevant studies or research findings regarding potential ecological (biotic and abiotic) or human health effects from air emissions from electricity generation.

Deliverable 2: Chemical Screening

Screen and identify chemical emissions associated with electrical generation facilities in Alberta.

Deliverable 3: Air Emission Substances Review

Review air emission substances emitted by electricity generation that are subject to formal control, including Priority substances and possible new substances. Identify if further action is required.

3.1.2 2008 HEAT Group Recommended Independent Review

Based on the recommendation from the 2008 Five-Year Review, the 2013 HEAT Group considered conducting an independent peer review of the results of their work. They determined that an

[1] Note: These “Deliverables” correspond to the “Objectives” in Appendix B: 2013 HEAT Group Workplan. The terminology was changed in the body of this report to prevent confusion between the objectives for HEAT provided by the 2013 EFR Team, and the pieces of work undertaken by the 2013 HEAT Group to achieve those objectives.

independent review had would have two basic purposes: 1. interpreting/drawing conclusions from the findings of the literature reviews; and 2. ensuring that the literature reviews are accurate and complete.

Based on the 2013 HEAT Group membership and associated constituencies, they agreed that there was sufficient expertise to draw conclusions from the literature reviews and communicate conclusions to non-expert readers.

As the HEAT Group is a multi-stakeholder group linked to a multi-stakeholder Project Team, operating on a consensus basis, the Group also agreed that there were sufficient checks and balances built into the process to ensure completeness, accuracy and transparency of the literature reviews.

3.2 Deliverable 1: Health and Ecological Assessment

In order to determine if further action would be needed for Priority or List 2 substances, and if action would be needed for new substances, the Group required an understanding of how the lists were originally generated. The group conducted a review of the process used by the 2002-03 Prioritization Subgroup (PSG) to assess its applicability for the current Five-Year Review.

Concurrent to the process review, HEAT initiated two literature reviews which were carried out by external consultants[2]. The original focus was on Priority and List 2 substances. The underlying assumption to this focus was that List 2 represented substances that are "of concern" or "to watch". Based on the findings of the process review, it became evident that the original purpose of List 2 was:

i. To recognize that other significant substances from electricity generation exist, and that management of the Priority substances may provide co-benefits of reducing these other substances.
ii. To help EPT understand the overall implications of management options for the five Priority substances.

As such, the HEAT Group adjusted the scope of the literature reviews to not focus only on Priority and List 2 substances. The Group developed a new process that reflected the new understanding of past work and created new categories to indicate varying levels of concern, in addition to the Priority category for substances. The process involved completion of health and ecological assessment literature reviews, focussed on: new information on the five Priority substances; new information since 2008 on any emissions from electricity generation; and information on mixtures since 2008. It was then determined if and how any new information might impact the Framework, and recommendations for next steps were made.

The following sections 3.2.1 and 3.2.2 are summaries of the ecological and health effects literature reviews[3] that were produced:

[2] A copy of the ecological effects and health effects literature reviews Statements of Work can be found in Appendices D and E, respectively.
[3] The reports summarized in sections 3.2.1 and 3.2.2 will be made available at www.casahome.org

3.2.1 Thermal electricity generation: Atmospheric emissions and associated health effects

This review presents a collection of recent white and grey literature abstracts (2008-2013) relating to the atmospheric emissions of thermal electricity generation and the associated health effects. The main objectives of this review, were to:

1. Identify new information (2008-2013) related to atmospheric emissions from thermal electricity generation and provide a list of abstracts;
2. Identify new information related to health effects associated with thermal electricity generation emissions and provide a list of abstracts; and
3. Critically evaluate and rank the health effects studies to provide an indication of the quality of the literature.

The focus was on emissions of the five Priority substances, as well as any other substances documented in recent literature. Fuel types of interest were those relevant to thermal electricity generation in Alberta: coal, oil, natural gas, shale, black liquor, biomass, municipal solid waste, refuse-derived fuel, sewage sludge, and recyclable waste.

For the health effects studies, articles considered relevant were original epidemiology, animal, or in vitro studies evaluating the health impacts of atmospheric emissions from power plants. The literature search produced 63 white literature articles and 8 grey literature documents. Each of the health effects studies underwent an assessment of technical quality; 23 were ranked as high quality, 35 as moderate quality, and 13 as low quality.

For atmospheric emissions, articles were considered relevant if they measured emissions directly from power plant stacks, measured ambient pollutant concentrations near power plants, or presented past/future emission inventories of existing power plants. The literature search produced approximately 400 relevant white literature and approximately 80 relevant grey literature articles related to emissions.

The report provides a summary of the main findings and key studies for each pollutant, and presents a list of all recent abstracts identified by the literature search. Pollutants are categorized as '5 Priority Substances'(Hg, NO_x, SO_2, PM, CO_2/GHG) and 'Non-Priority Substances'. The main non-priority substances captured by the literature search include PM components (elements, metals, ammonia, black carbon, elemental carbon, organic carbon, polycyclic aromatic hydrocarbons, sulphates, nitrates, and other ions), dioxins and furans, volatile organic compounds, acid gases, radionuclides, and amines/nitrosamines.

3.2.2 Identification of Ecological Effects of Air Emissions Associated with Electricity Generation: A Literature Search.

The objective of this review, was to provide a report of studies from white and grey literature regarding adverse ecological (includes biotic and abiotic) effects from substances known to be emitted to the air from electrical generation (i.e., power plants).

In order to meet this objective, the following pieces of work were developed:

1. Pollutant Inventory:
   An inventory of substances known to be emitted to air from power plants that generate electricity. This was used to evaluate whether or not pollutants identified in the studies were relevant to electrical power generation and air emissions.

2. Search Terms and Search Engines:
   An initial inventory of search terms used to search the white and grey literature. The literature search consisted of Internet and academic search engines.
3. Evaluation and Categorization:
   A series of terms developed by the consultant to categorize or qualify each relevant study. Qualitative criteria that were developed *a priori* and these qualifiers were worked into an electronic database[4].
4. Literature Search and Review:
   Based on the pollutant inventory, search terms, and evaluation criteria, a literature search was conducted and each relevant study was qualified. The literature search included a review of the abstract and title only. Studies were identified as relevant for entry into the database if the study focus was on substances included in the pollutant inventory, associated with electrical power generation or ecological effects from air emissions.

The broad scope of the literature search resulted in the review of over 6,775 titles and abstracts, of which only 345 (5%) were determined to be of relevance. This literature search may be considered more of a triage tool to pull out the most relevant information pertaining to the ecological effects of air emissions associated with electricity generation from 2008 to 2013. Combined with the interactive database, this literature search outlines the most relevant research within the past five years.

As a consequence of the broad scope of the search terms, there was a broad spread of research topics that were reviewed and entered into the database. There were no obvious or prevalent trends in the research overall, with many articles reporting a wide range of receptors and endpoints. The literature search did highlight that the bulk of research pertaining to abiotic ecological effects of air emissions in the past five years has focused on air and soil for priority pollutants. In addition, biotic ecological effects have focused on plants for NO_x, SO_2, and mercury, while mammals were the most common receptors for PM. In terms of the priority pollutants, these two receptor groups (i.e., plants and mammals) were the most frequently mentioned and researched. Two new substances were reported (secondary aerosols and a Criegee intermediate) that had abiotic receptors with respect to increased atmospheric reactivity.

3.3 Deliverable 2: Chemical Screening

In order to conduct a thorough review of new substances, the 2013 HEAT Group decided that a comprehensive list of substances emitted by electricity generation was required. Therefore, chemical screening was needed to identify all emissions from electricity generation, and their associated emission rates, toxicity, bio-accumulation, and persistence. An external consultant was hired to carry out the chemical screening. The Statement of Work can be found in Appendix F.

[4] In support of the review, a database was created using Microsoft Access to log each of the relevant studies based on a review of the title and abstract. This database file will be made available for download at www.casahome.org. Each relevant study was logged into the database to document all the titles, abstracts and full reference information that was obtained based on specific search terms. With guidance from the HEAT Group, categories were developed to catalogue each study according to key areas of interest. The cataloging of each study into relevant groupings allows for a simple and straight-forward search of the database in order to retrieve articles of interest. This database may be a valuable resource for future HEAT reviews. In terms of the pollutant inventory, only the following categories were identified in the database: NO_x, SO_2, mercury, PM, inorganics, organics.

The report titled *Chemical Screening of Emissions Associated with Electrical Generation Facilities in Alberta* (CSEEG) was produced. The report includes an Appendix (D), which presents a summary of findings, incorporating the outcomes of the inhalation toxic potency screening, and the volatility, bio-accumulation, and persistence of chemicals in the emission profiles of electrical generation facilities in Alberta.

The assessment focused on electrical power generation facilities based on combustion of coal and natural gas. The assessment incorporated the following lines of evidence to identify priority chemicals in air emissions:

- Generated an inventory of chemicals and emission rates from electrical generation facilities in Alberta.
- Conducted a toxic potency screening for each facility selected for the assessment and presented the chemicals that contributed 99.9% of the relative potency from the emission profiles.
- Determined the bio-accumulation and persistence potential of chemicals emitted by electrical generation facilities.
- Summarized the findings of human health risk assessments of historical environmental impact assessments and community based bio-monitoring that was conducted in close proximity to electrical generation facilities.

3.4 Deliverable 3: Air Emissions Substance Review

The purpose of the Air Emission Substance Review was for the HEAT Group to review each substance identified in the chemical screening, consider information produced by the literature reviews, and categorize each substance to indicate if further action would be required. Throughout the review process, the group used the following documents that were prepared by or for CASA during the course of work on the Electricity Framework from 2003 to present:

- *Thermal electricity generation: Atmospheric emissions and associated health effects.* (2014)
- *Identification of Ecological Effects of Air Emissions Associated with Electricity Generation: A Literature Search.* (2014)
- *Chemical Screening of Emissions Associated with Electrical Generation Facilities in Alberta.* (2014)
- *Literature review on atmospheric emissions and associated environmental effects from conventional thermal electricity generation.* (2008)
- *Compilation of Recent Abstracts (2007-08) – Health Effects Associated with Thermal Electricity Generation.* (2008)
- *HEAT Recommendations to the Electricity Framework Review Project Team for their consideration.* (2008)
- *Report of the Prioritization Subgroup to the CASA Electricity Project Team*. (2003)

To carry out the review, the following steps were taken by the 2013 HEAT Group in this order:

1. The Group created categories for further action, including a description of each and additional considerations regarding the implications of using each.
2. Each Group member was tasked with working through the list of substances independently, choosing a category for each substance, and recording their rationale.
3. The Group convened for a two-day workshop to discuss and agree on categories for further action for each substance. As the workshop progressed, a more specific understanding began to develop in the Group of what further action was necessary for each substance. As a consequence, the Group chose to create the following revised categories:

3.4.1 Table 1: Final Air Emissions Substance Review Categories for Further Action

Category		**Description**
1	Priority List	Substances that are known to be an issue, and known ways of managing them exist and are being employed. (i.e., existing priority substances for which there is insufficient evidence for removal from the list.)
2	Management action needs to be considered	Substances that need to be evaluated by the Project Team for further management action. Considerations should include but are not limited to: • What is the state of science on this substance? • Can the substance be reduced? • What are management options for reduction? • What is the cost of reduction? • Are there co-benefits to management? • Is monitoring required?
3	Ongoing surveillance recommended	Substances that the 2018 HEAT group should include in the search terms of the health and ecological literature reviews, with the express purpose of watching for potential emissions trends over time, and identifying data gaps.
4	Insufficient information	Substances for which there is insufficient evidence to indicate that action is required.

Note: The 2018 HEAT Group should explicitly include substances listed in categories 1, 2 and 3 in the search terms of the ecological and health literature reviews.

During the categorization workshop, the group initially considered each substance individually. However some substances were grouped, as the evidence in support of their categorization was similar (e.g. PAHs). Ultimately the HEAT Group produced a list of categorized substances, along with rationale and considerations for each, which can be found in Appendix G. Certain substances which were discussed together share the same rationale. No new substances were added to the Priority list (i.e. Category 1), however List 2 substances were re-categorized along with additional substances into Categories 2, 3, and 4. As a consequence, the 2013 HEAT Group developed a new and more scientifically robust way to categorize and prioritize chemicals.

Note: A few items were identified on the list of substances from the chemical screening that were not useful for categorization, as they represented groupings of other chemicals that were also on the list and had been discussed individually. The Group therefore chose to remove the following from the list of substances to be categorized: total aldehydes; total ketones; and VOCs and Total VOCs.

4. Learnings for Future Reviews

The Group encountered a number of set-backs to designing an effective process and keeping on schedule. This was in part due to a lack of understanding of the work that had been done in previous years. A critical learning has been the importance of thorough and clear documentation of the process undertaken by each successive HEAT group, specifically with respect to recommendations for further action on substances. This will help subsequent groups avoid confusion and erroneous assumptions.

Information Limitations

The Group also identified certain limitations in available information, which challenged their ability to carry out their work. Specifically, the Group surmised that there are data gaps and a general lack of scientific information regarding:

- the effects of mixtures (i.e. effects that are not specific to only one chemical);
- the effects of low doses over long periods of time; and
- long- and short-range dispersion and deposition.

It was agreed that it would beyond the scope and expertise of the HEAT Group to recommend specific strategies to address these limitations. However, it's important to note that the outcomes of this Review highlight opportunities that agencies such as the Alberta Environmental Monitoring Evaluation Reporting Agency (AEMERA) could explore to improve understanding.

Process

The Group felt that it would be beneficial for future reviews to be conducted following a process similar to the one outlined in this report. As this was a new process however, a number of learnings emerged that may inform future groups, and help them to carry out their work more efficiently (outlined below).

Literature Reviews

For both the health and ecological literature reviews, the consultants were each asked to generate criteria to evaluate the quality of studies contained in their review. While this was feasible for the health literature review, it proved to be significantly more challenging in the timeframe and budget provided for the ecological literature review, which had a significantly broader scope and included many more studies. Future HEAT Groups should consider ways to manage this issue, potentially by prescribing in the Request for Proposal which evaluation criteria are to be used and establishing an appropriate timeline and budget.

The HEAT Group discussed the need for the literature reviews to not only depend on quantitative evidence, but also to take into consideration qualitative evidence. Also, a number of questions were raised by the consultants regarding scope of the reviews. In the future, HEAT Groups should specify the following up front:

- Included:

    - Information on mixtures
    - Biomass
    - Animal studies and in-vitro
    - Source apportionment
    - Studies evaluating co-firing coal with biomass or other products
- Excluded:
    - Studies evaluating different combustion conditions
    - Studies evaluating emission abatement technology
    - Cost-benefit analysis

Chemical screening

A number of limitations of the chemical screening became apparent as the Group began to conduct the air emissions substance review; future HEAT Group reviews may be more effective if the following additional information is included in the chemical screening:

- Exposure levels
- Deposition (relating to short- and long-range transport)
- Dispersion (relating to short- and long-range transport)

It was also noted that air modeling may be needed to determine emission levels where there are gaps in information and must consider the ambient air quality in a region.

The Group felt that the chemical screening process could have been improved and refined had it been designed after the literature reviews were complete. It would be advisable for the two deliverables not to overlap in the future, so that the outcomes of the literature reviews can inform the chemical screening.

In terms of the substance list produced by the chemical screening, it was discussed that new substances (e.g. synthetic) may emerge with potential mimicking effects to the substances listed in this report. The Group noted that in future Five-Year Reviews, this should be considered in determining whether to add a new substance to any category for further action.

5. Summary of Recommendations

Based on the outcomes of the 2013 HEAT Review, the Group has generated the following three recommendations for consideration by the EFR Team. Although the expectation is that the EFR Team will make a reasonable effort to implement these recommendations, the HEAT Group recognizes that the Team will use their discretion to make adjustments if needed. Specifically, the Group felt that the timing and parties responsible for implementing recommendations 1 and 3 may be adjusted by the Team, which has the benefit of a more comprehensive understanding of the entire Electricity Framework Review process.

These recommendations are given as advice to the project team and may or may not be included in the project team's final report which will be forwarded to CASA Board of Directors for their approval.

Draft Recommendation 1:

The Project Team should determine a mechanism that will, prior to commencement of the 2018 Electricity Framework Review, ensure each substance listed in Category 2 (i.e. Management action needs to be considered) will be evaluated as described in Table 1 of this report.

Draft Recommendation 2:

The 2018 HEAT Group should explicitly include substances listed in Category 3 in the search terms of the health and ecological literature reviews.

Draft Recommendation 3:

CASA to form a standing Working Group to address the data gaps that were identified in the 2013 Review, and to ensure continuity between the Reviews, in preparation for the 2018 air emission substance review (rec 72).

Appendix A: 2013 HEAT Group Membership

HEAT Group Members	**Stakeholder group**
Kristi Anderson	Mewassin Community Council
Debra Hopkins	Alberta Environment and Sustainable Resource Development
Colin L. Soskolne	Prairie Acid Rain Coalition
Merry Turtiak	Alberta Health
David Lawlor	Enmax
Robyn Jacobsen	CASA
Michelle Riopel	CASA
Alternate Members	**Stakeholder group**
Kaitlyn Wall	Alberta Environment and Sustainable Resource Development
Alison Anaka	Enmax
Colin Dumais	Enmax

Appendix B: 2013 HEAT Group Workplan

Health and Ecological Assessment Task Group

Draft Workplan, April 14, 2014

Background

In January 2002, Alberta Environment asked the Clean Air Strategic Alliance (CASA) to develop a new way to manage air emissions from electricity generation in Alberta. Using a multi-stakeholder collaborative approach, CASA developed innovative solutions in the form of 71 recommendations comprising a management framework and presented it to the Government of Alberta in November 2003. The report, *An Emissions Management Framework for the Alberta Electricity Sector*, was accepted by the Government of Alberta and implemented through regulations, standards and facility approvals (see Appendix I). The first emission standards were effective January 1, 2006.

To ensure continuous improvement and to keep the Framework timely and relevant, a formal review of the framework is to be undertaken every five years (Recommendation 29). This review should include a multi-stakeholder group consisting of industry, government, non-government organizations, and communities with an interest in electricity generation in Alberta. The intent of the Five Year Review is to assess new emission control technologies, update emission standards for new generation units, determine if emission standards for new substances need to be developed, review implementation progress, and determine if the Framework is achieving its emission management objectives.

The first five year review was initiated in 2008. As part of the second five year review, initiated in 2013, the Health and Ecological Assessment Task (HEAT) group was established to:

- Review air emissions substances emitted by the electricity sector that are subject to formal control, including List 2 substances and possible new substances. Identify further action if required.
- Form a multi-stakeholder group with appropriate representation to oversee a review to identify any new and relevant studies or research findings regarding potential environmental or health effects from air emissions from electricity generation, including an independent peer review of the results.

Based on this mandate from the 2013 Electricity Framework Review Project Team, the following work plan outlines the objectives and key tasks required to complete this work.

With regard to the recommended independent review, the independent review would have two basic objectives: 1. interpreting/drawing conclusions from the findings of the literature reviews, and 2. ensuring that the literature reviews are accurate and complete.

Based on the membership of the task group, expertise exists around the table to draw conclusions from the literature reviews and communicate conclusions to non-expert readers. Constituencies would be relied on to provide additional expertise.

Since the HEAT group is a multi-stakeholder group, linked to a multi-stakeholder project team, operating on a consensus basis, there are sufficient checks and balances built into the process to ensure completeness, accuracy and transparency of the literature reviews. Members' constituencies and the experts around the table constitute the "independent review". Alberta Health has indicated that they will conduct an independent internal audit of the work, and is willing to share the results with the group.

Objectives

Objective 1: Health and Ecological Assessment

Identify any new and relevant studies or research findings regarding potential ecological (biotic and abiotic) or human health effects from air emissions from electricity generation.

Objective 2: Chemical Screening

Screen and identify chemical emissions associated with electrical generation facilities in Alberta.

Objective 3: Air Emission Substances Review

Review air emission substances emitted by electricity generation that are subject to formal control, including priority substances and possible new substances. Identify if further action is required.

Key Tasks

The task group discussed the following series of key tasks to address the HEAT objectives.

Objective 1: Health and Ecological Assessment

1. Complete health and ecological assessment literature reviews, focussed on:
    a. New information on the 5 Priority Substances,
        i. The task group will use this to make recommendations on the 5 Priority Substances
    b. New information since 2008 on any emissions from electricity generation.
    c. Information on mixtures since 2008.

2. Determine how any new information impacts the framework and make recommendations for next steps.

Objective 2: Chemical Screening

3. Conduct a chemical screening.
    a. Generate an inventory of chemicals emitted from electrical generation.
    b. Conduct a toxic potency assessment.
    c. Determine bioaccumulation and persistence potential for organic compounds.

d. Draft a report that documents the findings. This will help the group to determine if further action is required.

Objective 3: Air Emission Substances Review

4. Create a comprehensive list of substances based on:
    a. Health and ecological assessment literature reviews (Task 1).
    b. Chemical screening (Task 2).
    c. Report of the Prioritization Subgroup to the CASA Electricity Project Team. (2003)
    d. Literature review on atmospheric emissions and associated environmental effects from conventional thermal electricity generation. (2008)
    e. Compilation of Recent Abstracts (2002-2007) - Health Effects Associated with Thermal Electricity Generation (2008)
    f. HEAT Recommendations to the Electricity Framework Review Project Team for their consideration (2008)

5. Review the comprehensive list of substances from Task 4 and identify further action, if required.

Future Reviews

6. Contribute to improving future health and ecological assessments.
    i. Task group will clearly articulate and provide rationale for the new process that was undertaken in 2013/14.
    ii. Make recommendations for future five year reviews.

Consultants

The following key tasks will be addressed on an ongoing basis to provide clear direction to consultants and on-going guidance to resolve issues and exchange information:

- Develop Terms of Reference, including the scope of work, for consultants.
- Attend regular updates with consultants at specific milestones and provide feedback.
- Review draft consultant's reports and provide feedback.

Timelines

Activity	**Date**
Develop and finalize RFPs for health and ecological assessment literature review	January-February 2014
Source ecological assessment literature review	February-March 2014
Receive approval from team on new workplan	April 2014

Hire consultant to conduct chemical screening	April 2014
Literature reviews are completed	May 14 2014
Chemical screening completed	May 30 2014
Make recommendations on the 4 priority substances	Late May 2014
Create and evaluate comprehensive substances list.	Late May 2014
Recommend next steps for reviewed substances. Assess whether or not additional substances should be formally controlled based on new or emerging information.	June 2014
Create recommendations for improving future HEAT reviews	June 2014
Complete final report to the team	July 15, 2014

Membership

Membership of the task group should include all affected stakeholders.

The following are suggested task group members:

- Alberta Environment and Sustainable Resource Development
- Alberta Health
- Electricity Generators
    - Enmax
- Non-government organizations
    - Mewassin Community Council
    - Prairie Acid Rain Coalition

Budget

Item	**Estimated Cost**	**Allocated**	**Balance**
Task 1: Ecological Literature Review	$20,000	$20,000	$0
Task 1: Health Literature Review	In-kind ($20,000)	$20,000	$20,000
Task 2: Chemical Screening	$20,000	$0	[-$20,000]
Final Report: writing, printing	$3,000	$0	[-$3,000]
Totals	**$63,000**	**$40,000**	**[-$3,000]**

Appendix C: Summary of timelines and costs

Date	Milestone
November 2013	HEAT convenes and develops a workplan.
March to May 2014	Consultant is retained and completes work for the Ecological Literature Review. - Duration: 3 months - Cost: $24,000
January to May, 2014	Consultant is retained and completes work for the Health Literature Review. - Duration: 5 months - Cost: $20,000 (in-kind from Alberta Health)
April to July, 2014	Consultant is retained and completes work for the Chemical Screening. - Duration: 4 months - Cost: $23,000
October 2014	HEAT Final Report complete

Appendix D: Ecological Literature Review Statement of Work

SCHEDULE 'A' -

STATEMENT OF WORK

Objective and Scope

The Consultant will undertake research and provide a report pertaining to new information on the ecological effects of electrical generation to aid the five-year review of the 2003 *Emissions Management Framework for the Alberta Electricity Sector* (the Framework). Specifically, the consultant will survey and document any new information, studies, and reports related to:

- Substances known to be emitted into the air from electricity generation from power plants (not limited to stack emissions).

The term 'ecological' refers to both:

- Biota: the plant and animal life in an ecosystem; and
- Abiota: non-living chemical and physical factors in an ecosystem (examples include soil, water, air, temperature).

The literature review is to focus on new information, including white and grey literature, published between January 1, 2008 and December 31, 2013. The consultant will be asked to focus the search on:

- Priority Substances identified in the Framework.
- Any new information on substances known to be emitted by power plants as well as new substances that are not listed in the Framework. This will be a 'high level' review limited to a survey of new information.

Grey literature includes:

- Literature published by provincial and federal organizations (e.g. CASA, Ontario Clean Air Alliance, Alberta Environment and Sustainable Resource Development, PTAC, Environment Canada), as well as international organizations (e.g. USEPA, WHO).

The consultant will meet the objectives as described by completing the following tasks:

1. **Chemical Inventory:** Develop and inventory of substances known to be emitted to air from power plants that generate electricity.
2. **Search Terms and Search Engines:** Develop an initial inventory or matrix of search terms used to search the white and grey literature. The literature search will be clearly documented and consist of internet (e.g., Google) and academic search engines (e.g., Web of Science).
3. **Evaluation Criteria:** Develop a quality assurance system that is open and transparent and based on quantitative and qualitative criteria. The evaluation methodology will be integrated into a multifunctional electronic database using a Microsoft Access format. This criteria will be subject

to approval by the task group, and used by the consultant to provide an evaluation of quality for each study or report contained in the review.

4. **Literature Search and Review:** Based on the chemical inventory, search terms and evaluation criteria, develop the database and conduct the literature search and score each study.
5. **Draft Report:** Document the process used to identify the literature related to adverse ecological effects and report the findings.
6. **Final report:** Complete final report based on comments received by Health and Ecological Assessment Task Group.

In addition, the consultant will:

- Provide an abstract, reference and (if applicable) URL for each study or report.
- Not undertake any risk assessment of the substances or comparison against current standards or guidelines.
- Focus on fuel types relevant to Alberta including smaller emission sources e.g. recyclable waste, black liquor.

The Framework, the Report of the Priority Substances Subgroup and the 2008 Ecological Effects Report will be made available to the consultant.

Deliverables and Timelines:

The consultant will be expected to provide the following deliverables:

1. A 2 hour kick-off meeting with the task group, in Calgary on the morning of **March 31, 2014**. Supporting documents for the meeting (ie. criteria for evaluating studies) will be provided to the task group by March 28th.
2. A discussion or question/answer session with the task group to improve coordination. Are there any substances with new information of relevance to the task group (in the initial information gathering)? This discussion will take place **mid-April.**
3. A draft literature review to the task group by **April 21, 2014.** The task group will review the draft and provide comments by **May 7, 2014.**
4. A final literature review for the task group by **May 21, 2014.**

The task group may request one or two teleconferences with the consultant over the course of the work. The task group may require a presentation from the consultant upon completion of the work and/or the opportunity to ask any questions. A more detailed timeline of deliverables is outlined in Table 1.

Table 1: Deliverables and Timeline

Deliverable	Timeline	Payment Schedule
1. Develop chemical emission inventory, search terms and evaluation criteria.	March 21 – March 28	-
2. Provide evaluation criteria to task group	March 28	-

3. Meeting with task group to present results of Deliverable 1, and for Q&A.	March 31 (AM)	-
4. Task group provides final approval for chemical emission inventory, search terms, and evaluation criteria.	April 3	-
5. Database development, preliminary literature search and review.	April 3 – April 11	-
6. Discuss initial findings with the task group via teleconference and/or Webinar.	Mid-April (Tentatively April 14)	-
7. Continue literature search and review and submit draft report	April 21	-
8. Receive and incorporate comments	May 7	-
9. Final report and delivery of quality assurance system	May 21	**Max. $24, 003.00**

The draft report, final report, and any appended studies should be provided electronically to Michelle Riopel at mriopel@casahome.org.

Appendix E: Health Literature Review Statement of Work

SCHEDULE 'A' -

TERMS OF REFERENCE

Objective and Scope

The Consultant will undertake research and provide a report pertaining to new information on the human health effects of electrical generation to aid the five-year review of the 2003 *Emissions Management Framework for the Alberta Electricity Sector* (the Framework). Specifically, the consultant will survey and document any new information, studies, and reports related to:

- Any substances known to be emitted into the air from electricity generation (not limited to stack emissions); and,
- Public health impacts associated with these substances, in particular when emitted by, coal-fired and gas fired power plants.

The literature review is to focus on new information since 2008, including white and grey literature, published between January 1, 2008 and December 31, 2013. The consultant will be asked to focus the search on:

- Priority Substances identified in the Framework.
- Any new information on substances known to be emitted by power plants as well as new substances that are not listed in the Framework. This will be a 'high level' review limited to a survey of new information since 2008.

Grey literature includes:

- Literature published by provincial and federal organizations (e.g. CASA, Ontario Clean Air Alliance, Alberta Health, Environment Canada), as well as international organizations (e.g. USEPA, WHO).

The consultant will:

- Develop evaluation criteria for indicating the quality of literature included in the review. This criteria will be subject to approval by the task group, and used by the consultant to provide an evaluation of quality for each study or report contained in the review.
- Provide an abstract, reference and (if applicable) URL for each study or report.
- Not undertake any risk assessment of the substances or comparison against current standards or guidelines.
- Focus on fuel types relevant to Alberta including smaller emission sources e.g. recyclable waste, black liquor.

The Framework, the Report of the Priority Substances Subgroup and the 2008 Health Effects Report will be made available to the consultant.

Deliverables:

The consultant will provide the following deliverables:

5. A discussion or question/answer session with the task group to improve coordination. Are there any substances with new information of relevance to the task group (in the initial information gathering)? This discussion will take place at the **end of March.**
6. A draft literature review to the task group by **Mid-May, 2014.** The task group will review the draft and provide comments by **end of May.**
7. A final literature review for the task group by **May 30, 2014.**

The task group may request one or two teleconferences with the consultant over the course of the work. The task group may require a presentation from the consultant upon completion of the work and/or the opportunity to ask any questions.

The primary point of contact for the consultant will be Merry Turtiak. All interim reports, final reports, and any appended studies will be submitted provided electronically to Michelle Riopel at mriopel@casahome.org.

Table 1: Timeline

Task	*Timeline*
Begin literature search on priority substances and any new information on substances known to be emitted by power plants	Mid-January 2014
Develop criteria for evaluating studies	By end of February
Task group provides final approval of criteria	Week of March 17
Discuss initial findings with task group	End March - TBA
Provide draft literature review to task group	Mid-May
Receive and incorporate comments	End of May
Revise and submit literature review	**Early June**

Appendix F: Chemical Screening Statement of Work

SCHEDULE 'A' -

STATEMENT OF WORK

Objective and Scope

The objective of the project will be to generate an inventory of chemicals and emission rates from electrical generation, and provide information on toxicity potency, bioaccumulation, and persistence potential.

Assumptions:

- The chemical list will be restricted to electrical generation by the following fuel types: 1) coal; 2) natural gas; and 3) biomass as it relates to persistence, bioaccumulation and toxicity potency.
- Other fuel sources used in Alberta (e.g., wind and hydro) to generate electrical power would not be included as part of this work.

The consultant will complete the following tasks to achieve the objective:

1. Generate an inventory of chemicals and emission rates from electrical generation based on the following sources of information:
    a. Previous regulatory applications for power generation (e.g., Epcor, TransAlta, Fording Coal, Mustus Energy, etc.) in Alberta.
    b. National Pollutant Release Inventory (NPRI) for electrical generation facilities in Alberta.
    c. Wabamun Genesee Biomonitoring Program and community health assessment.
2. Conduct a toxic potency assessment based on the following:
    a. Emission estimates (this will be based on previous information and databases).
    b. Acute and chronic toxicity.
    c. Carcinogenic and non-carcinogenic effects.
3. Determine bioaccumulation and persistence potential for organics, and evaluate inorganics.
    a. Determine bioaccumulation and persistence potential for organic compounds based on the following:
        i. Physical and chemical properties (e.g., Log Kow, Henry's Law Constant, vapour pressure, etc.).
        ii. Level III fugacity modelling.
    b. Evaluate inorganics based on previous environmental assessments and available scientific evidence.
4. Provide a draft report that documents the findings. The report will identify chemicals, and provide information on toxicity potency, bioaccumulation, and persistence potential.
5. Incorporate feedback from task group on draft report, and provide final report.

Emission rates (as mass of chemical / time (e.g., kg/day)) will be based on emission inventories available from various sources within Alberta. The following database inventories will be reviewed:

- NPRI provides facility specific emission rates for a few chemicals in Alberta.

- Environmental Impact Assessments (EIAs) from previous applications (e.g., Epcor, TransAlta, Fording Coal, Mustus Energy, Enmax, etc.) will provide emission rates by facility and will provide the most comprehensive dataset (assuming the project-specific emission rates are publicly available).

Emission rates can be obtained from other sources such as annual Environmental Protection and Enhancement Act (EPEA) approval reports, continuous emission monitoring system (CEMS) reporting, or regional modelling inventories. However, these datasets are not comprehensive as they may only focus on a limited number of chemicals or particular sources. In addition, these databases are often based on existing inventories (i.e. NPRI or EIAs). Therefore, the Consultant will choose not to obtain emission rates from these databases.

Bioaccumulation and persistence potential would be assessed based on criteria established by regulatory authorities such as Environment Canada and US Environmental Protection Agency. In order to assess chemical persistence, it will be necessary to identify those chemicals that would be expected to persist or accumulate in the environment in sufficient quantities for people to be exposed via soil, food and water pathways. The purpose is to identify the chemicals emitted to air through stacks that are non-volatile and thus have the potential to accumulate in environmental media other than air. A chemical will be characterized as non-volatile based on the following criteria from the US EPA (2003):

- molecular weight ≥ 200 g/mol (or 2.0E+02 g/mol);
- Henry's Law Constant ≤ 0.00001 atm m^3/mol (or 1.0E 05 atm m^3/mol); and
- vapour pressure ≤ 0.001 mmHg (or 1.0E 03 mmHg).

Bioaccumulative chemicals have the potential to accumulate in living organisms and will be characterized in accordance with the following criterion from Environment Canada (2007):

- octanol water partitioning coefficient (Log Kow) ≥5.

Physical chemical properties (i.e., molecular weight, Henry's Law Constant, vapour pressure, and octanol water partitioning coefficient) will be obtained from Syracuse Research Corp. (SRC 2011) or, if a property is not available from SRC 2011, the EPI Suite program developed by US EPA (2011) will be searched.

Fugacity modeling will be completed to determine the potential relative apportionment of the chemicals in environmental media (i.e., air, soil, water and sediment) based on emission rates. Chemicals have the potential to migrate from one environmental compartment to another and fugacity models are used to study and predict the behaviour of chemicals in these compartments. Fugacity models are restricted to organic compounds and cannot be used with inorganic compounds. Fugacity model results will be based on the "Level III" fugacity model developed by US EPA (2011) that adheres to methods developed by MacKay et al. (1992; 1993). If a chemical is found to partition in soil, water or sediment more than 5%, there may be a "realistic presence" of the chemical in environmental media other than air (Boethling et al. 2009; Environment Canada 2003). The premise of this model is that if a chemical emitted to the air does not meet any of these criteria, the potential for the chemical to deposit in the environment and persist or accumulate in the environment is negligible and limited only to air.

Deliverables:

The consultant will provide the following deliverables:

- Draft report in electronic copy
- Final report in electronic and hard copy

Budget and Timelines:

CASA will pay the Consultant as follows: $21,000.00 including GST on submission of an approved invoice for the completion of all tasks as outlined in Schedule "A".

The cost break-down and timeline is summarized in Table 1 according to task, assuming that the project starts April 28th 2014.

Table 1 Timelines and cost for the chemical screening report

Task	Description	Start Date	End Date	Cost
1	Generate chemical inventory and emission rates	April 28th	May 9th	
2	Conduct toxic potency screen	May 12th	May 16th	
3	Determine bioaccumulation and persistence potential for organics, evaluate inorganics	May 19th	May 23rd	
4	Draft report	May 26th	May 30th	
5	Incorporate feedback from task group and produce final report	June 9th	June 13th	
Final report submitted			**June 13th 2014**	**$21,000**

The draft and final reports and any appended studies are to be delivered to the Clean Air Strategic Alliance, c/o Michelle Riopel at:

10035 108 st NW Flr 10

Edmonton AB T5J 3E1

mriopel@casahome.org.

Appendix G: Categorized Substance List with Rationale and Considerations

The following categorization of substances is the result of the Air Emissions Substance Review.

Note: In this table, the 2013 report titled *Chemical Screening of Emissions Associated with Electrical Generation Facilities in Alberta* has been abbreviated to "CSEEG".

Substance	**Category 1: Priority List** **Rationale and Considerations**
Total Particulate Matter (includes PM 2.5, PM 10, and TSP)	These are priority substances from the electricity sector that require management, as identified by the 2003 PSG: SO_2, NO_x, Mercury, PM, and GHGs. HEAT did not find sufficient information to remove them from the priority list.
Mercury	
SO_2	• There is extensive literature to show the health effects. • Constitutes a high proportion of emissions from electricity generation (especially coal).
NO_2	• NOx is emitted in all forms of electricity generation combustion (mostly NO plus smaller amounts of NO2 and N2O). • Note: the focus is on NO_2 as a Priority List substance rather than NO_x because only NO_2 has an ambient objective within Alberta based on the potential for respiratory effects.
GHGs	• Management is covered by Alberta's 2008 Climate Change Strategy[5].
Substance	**Category 2: Management Actions Need to be considered** **Rationale and Considerations**
Antimony	Metals identified as of potential concern as they have multiple pathways (see CSEEG section 6.6: Summary of Regulatory Applications)
Arsenic	
Barium	
Cadmium	
Cobalt	
Lead	
Manganese	
Selenium	
Chromium (i.e. Chromium III and Chromium VI for HEAT purposes)	• Metals identified as of potential concern as they have multiple pathways (see CSEEG section 6.6: Summary of Regulatory Applications • Chromium VI was ranked in the top 5 chemicals to contribute more than 5% of toxic potential (CSEEG section 3.3.3: Chronic Inhalation (carcinogens)). • The group agreed that although Chromium III was not listed in the top 5% of toxic potential for chronic inhalation, it would be

[5] http://esrd.alberta.ca/focus/alberta-and-climate-change/climate-change-strategy/documents/AlbertaClimateChangeStrategy-2008.pdf

	included in Category 2 because the risk is unknown from a multiple pathways perspective.
Formaldehyde	• CSEEG Table 4 shows that it contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency. • CSEEG Table 6 shows that it contributes more than 0.1% to carcinogenic toxic potency. • New information has very recently emerged from the EPA.
Benzene	• It is a known carcinogen • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency • There is a public perception of risk • CSEEG Tables 4, 6, and D-1 show that it is emitted from coal combustion and natural gas, and contributes more than 0.1% to acute and carcinogenic toxic potency.
Hydrogen fluoride	• Historically it has been a priority for GoA. • CSEEG Tables 4 and 5 show that it is a chemical that contributes to more than 0.1% of acute and chronic toxic potency. • It is predicted to exceed Toxicity Reference Values based on predicted air concentrations on an acute basis. (CSEEG section 6.6: Summary of Regulatory Applications). • The point was made that because emissions are related to coal, the categorization of this substance may change as coal is phased out.
Substance	**Category 3: Ongoing Surveillance Rationale and Considerations**
Boron	Metals listed in CSEEG Table 12, indicating that they are bio-accumulative, persistent, and non-volatile.
Calcium	
Chlorine	
Copper	
Iron	
Magnesium	
Molybdenum	
Potassium	
Rubidium	
Silicon	
Silver	
Sodium	
Strontium	
Thallium	
Thorium	
Titanium	
Uranium	
Zinc	

Zirconium	
5–methylchrysene	
7, 12 dimethylbenz(a)anthracene	
2-Chloroacetophenone	
Aluminum	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 5 shows that aluminum contributes more than 0.1% to chronic toxic potency. • It is ranked in the top five chemicals to contribute more than 5% of toxic potential (CSEEG section 3.3.2: Chronic Inhalation (non-carcinogens)).
Beryllium	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency. • CSEEG Table 6 shows that it contributes more than 0.1% to carcinogenic toxic potency.
Bromine	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 4 shows that bromine contributes more than 0.1% to acute toxic potency.
Nickel	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 4 shows that Nickel contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency.
Phosphorous	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 4 shows that phosphorous contributes more than 0.1% to acute toxic potency.
Vanadium	• A metal listed in CSEEG Table 12, indicating that it is bio-accumulative, persistent, and non-volatile. • CSEEG Table 4 shows that vanadium contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it also contributes more than 0.1% to chronic toxic potency.
2, 3, 7, 8 TCDD and 2, 3, 7, 8 TCDF	Although not shown to contribute to toxic potency, these should be under surveillance because: • There a high level of public perception of risk. • Health Canada considers them to be highly toxic and priority. • The National Pollutant Inventory shows that coal-fired electricity was responsible for 35 % of dioxin and furan emissions in Alberta

	in 2010 (a total of 1.5903g)[6] and 34% of dioxin and furan emissions in Alberta in 2011 (a total of 1.298g)[7]. • CSEEG Table D-1 shows them to be non-volatile, bio-accumulative, and persistent.
Hydrogen chloride	• It is ranked in the top five chemicals to contribute more than 5% of toxic potential (CSEEG section 3.3.2: Chronic Inhalation (non-carcinogens)). • It is coal-specific and will not be an issue once phased out. • Although we know it is emitted, it seems to be in low amounts and there is very little data.
2, 4 dinitrotoluene	CSEEG Table 12 shows it as persistent, bio-accumulative, and non-volatile.
3-methylcholanthrene	CSEEG Table 12 shows it as persistent, bio-accumulative, and non-volatile.
Acetaldehyde	• There is a public perception of risk to human health. • CSEEG Table 4 shows that it contributes more than 0.1% to acute toxic potency. • CSEEG Table 6 shows that it also contributes more than 0.1% to carcinogenic toxic potency.
Acrolein	• From 2006-2010, acrolein came up often in Environmental Impact Assessments. Health Canada changed the exposure limit to be less conservative and it stopped appearing often. The issue was raised by the Alberta Air Quality Objectives group, and currently there is an Alberta Air Quality Objective being developed for it • CSEEG Table 4 shows that it also contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency.
Benzyl Chloride	• Table 5 of chemical screening shows that it also contributes more than 0.1% to chronic toxic potency. • Table 6 of chemical screening shows that it also contributes more than 0.1% to carcinogenic toxic potency. • Has not been assessed for persistence and bioaccumulation.
Bis(2-ethylhexyl)phthalate	CSEEG Table 12 shows it as persistent, bio-accumulative, and non-volatile.
Ethylbenzene	CSEEG Table 6 shows that it also contributes more than 0.1% to carcinogenic toxic potency.
Hexachlorobenzene	• CSEEG Table 6 shows it's an emitted substance.

[6] 2010 Total Air Pollutants Emissions for Alberta, Environment Canada, Pollutant Inventories and Reporting Division, 2012. https://www.ec.gc.ca/inrpi-npri/

[7] 2011 Total Air Pollutants Emissions for Alberta, Environment Canada, Pollutant Inventories and Reporting Division, 2013. https://www.ec.gc.ca/inrp-npri/

	• In Alberta, coal-fired electricity emitted 1679.887g of hexachlorobenzene in 2010[8], and 1481.114g of hexachlorobenzene in 2011[9].
Propylene Oxide	CSEEG Table 6 shows that it also contributes more than 0.1% to carcinogenic toxic potency.
NH_3	• CSEEG Table 4 shows that it contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it contributes more than 0.1% to chronic toxic potency. • It is ranked in the top five chemicals to contribute more than 5% of toxic potential (CSEEG section 3.3.2: Chronic Inhalation (non-carcinogens)). • It was noted that this could be from ammonia slip from the Selective Catalytic Reduction put in place to control NO_x. There is a need to consider that restrictions on NH_3 production could result in removing control technology.
Sulphuric Acid	• CSEEG Table 4 shows that it also contributes more than 0.1% to acute toxic potency. • CSEEG Table 5 shows that it also contributes more than 0.1% to chronic toxic potency.
PAHs (Includes alkylated PAHs: 2-methylfluorene and 2-methylnaphthalene; and chlorinated PAH: 2 chloronaphthalene)	• Although there are a number of substances listed under PAHs, it is difficult to look at them individually or as mixtures because most research uses an indicator substance (commonly benzo(a)pyrene) as a proxy for the whole group. • For future literature reviews, all substances in this category should be used as key search words, but for the categorization purposes HEAT will treat them as a group.
Substance	**Category 4: Insufficient Information** **Rationale and Considerations**
1, 1, 1 Trichloroethane	Can be toxic in high enough doses, and potentially in low doses over extended periods of time. However this information in not known.
Chlorobenzene	Identified by Health Canada as non-toxic under Section 11 of the Canadian Environmental Protection Act.
Dichlorobenzene	Information from Health Canada shows that the amount in the environment is 9000 times less than the threshold estimated for the most sensitive aquatic species.
CO	• CSEEG Table 4 shows that it contributes more than 0.1% to acute toxic potency. • There is a known health impact but CO concentrations from stack emissions are a measure of inefficiency of burning fossil fuel and can be very difficult to detect. In general, CO from electricity

[8] 2010 Total Air Pollutants Emissions for Alberta, Environment Canada, Pollutant Inventories and Reporting Division, 2013 www.ec.gc.ca/inrp-npri

[9] 2011 Total Air Pollutants Emissions for Alberta, Environment Canada, Pollutant Inventories and Reporting Division, 2013 www.ec.gc.ca/inrp-npri

	generation is not considered a major contributor to ambient air quality.
1,3 Butadiene	There is insufficient evidence to indicate that action is required on these substances (See CSEEG Table D-1)
Acetophenone	
Benzaldehyde	
Bromoform	
Carbon Disulphide	
Chloroform	
Cyanide	
Dimethyl Sulphate	
Ethyl Chloride	
Ethyl Dibromide	
Ethylene Dichloride	
HCFC-22	
Hexane	
Isophorone	
Isopropylbenzene	
Methyl Bromide	
Methyl Chloride	
Methyl Ethyl Ketone	
Methyl Hydrazine	
Methyl Methacrylate	
Methyl tert-butyl ether	
Methylene chloride	
Pentane	
Phenol	
Propane	
Propionaldehyde	
Propylene	
Styrene	
Tetrachloroethylene	
Toluene	
Vinyl Acetate	
Xylenes	
Hydrochloric Acid	
Radionuclides	