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| athena Institute |
| NREL US LCI Database – N.A. Electricity Generation by Fuel Type Update & Template Methodology |
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| **9/8/2010** |

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# Introduction

The purpose of this document is to provide a methodology for creating, populating and updating the North American Electricity Generation by Fuel Type data for the US LCI database. The database is formally named “USLCIDB\_Electricity\_Generation”.

From section 4.6 of the SOW, we have the following initial strategy outline:

**4.6: Electricity Energy Update Methodology**

A methodology needs to be developed to define how the electricity grid data modules for N. America can be managed and regularly updated (biannually) to reflect the changes in the fuel mix used to generate electricity at various regional scales. The modules need to reflect the different electricity grid fuel mixes as defined by eGRID and NERC.

Therefore, the Subcontractor shall develop updated electricity generation fuel mix information to cover both new and existing regional electricity grid LCI modules to be supported within the US LCI database.

The work plan calls for creating a linked Microsoft Excel based spreadsheet that will accept user input for region specific electricity generation by fuel type statistical information then determine the regional composite electricity generation percent breakdown by energy source (fuel type) for use by the US LCI database. The primary user of the spreadsheet will be the NREL staff.

The Excel workbook will consist of a number of linked worksheets, structured as follows:

1. One worksheet will be dedicated for user input of electricity fuel source data. A form will be created to handle user input data for one location (state, province, territory) at a time. The sources for this information will also be documented in the worksheet.
2. A summary worksheet will contain all the raw electricity generation data as input by the user.
3. Additional worksheets will contain mapping information, such as the following:
   1. Regions that compose larger regions
   2. Energy source to common energy source mapping
4. One summary worksheet will contain all the effective electricity generation data. This will be the final “composite” electricity generation mix for each regional definition, where any generation shortfalls are imported from the next Grid interconnect. It is planned that the “composite” electricity generation information will be available for eGRID sub-regions, NERC regions, major N. American Interconnects (East, West, and Texas), N. America Average, US Average and Canada Average.
5. A second summary worksheet will be calculated and contain all of the updated “Percent breakdown by fuel type” data for each region identified in step #4.

During development of the methodology, the following deviations from the proposed strategy evolved:

1. Multiple worksheets are necessary for users to input the electricity generation data. It was possible to use a single worksheet for capturing the regional electricity profile data (net generation, net inter-regional transfers, total international imports, total international exports, etc). However, the level of detail for the generation by energy source data differed widely for US, Canada and Mexico. Most notably, the US data was captured at the generating facility (plant) level, while Canadian data was captured at the province/territory level, and Mexican data was captured at the country level. Each country also uses different energy source nomenclature.
2. It was more feasible to keep the summary level data for “Raw Electricity Generation data by Energy Source and Generating Region” that has been neutralized into common EIA Energy Source buckets on individual worksheets for each country, for similar reasons as listed in point #1 above.
3. Lookup “tables” or Excel Regions are captured in a single “LOOKUPS” worksheet.
4. The “Composite Electricity Generation” profiles for each generating region (State, Province, Territory, and North American Grid Inter-tie) could not easily be contained in an Excel file without the use of VBA Macros. Since SQL databases are better suited to heavy data manipulation, procedure iteration and sanity checking, the decision was made to create a database for modelling the composite electricity generation profiles for each generating region, country, grid inter-tie, and macro (also called manufacturing) regions.
5. It was more feasible to keep the “Percent breakdown by Energy Source by Generating Region” on individual worksheets for each country, for similar reasons as listed in point #1 above. The “Composite Percent Breakdown by Energy Source by Region” is available as a query from the database.

# Scope

The scope of this document is constrained to providing the following:

* Details for the software and databases used to manage the database and for preparing the data for entry into the database;
* Decisions made concerning the gathering and processing of the data from a selection of US, Canadian and international sources;
* Procedures for creating and populating the database;
* Procedures for updating the database as new data becomes available;
* Procedures for running a short list of reports to extract meaningful data from the database; and finally
* An appendix containing a list of the data sources from which the statistical electricity generation data was gathered in addition to other relevant references.

# Software and Databases

The following is a list of software and databases that are employed throughout the execution the methodology.

* A PC or laptop running Windows XP, Windows Vista or better is required to install and run the software listed below.
* Microsoft Excel 2007 or better. Should work with Excel 2003, but conditional formatting and some formulae might not work as expected.
* Microsoft SQL Server Express 2005 (or better). Please note that minor SQL (Structured Query Language) syntax changes occur with each new version of Microsoft SQL Server which may need to be worked around if a newer version is used. A command line shell is the default user interface for managing the database.
* Microsoft SQL Server Management Studio Express. This software provides a graphical user interface that greatly simplifies managing the database when compared with the default command line user interface.
* A modern web browser (i.e., FireFox, Internet Explorer, Safari, etc.) will be used for gathering the statistical data from a select list of international sources. Use of a non-standards compliant web browser may hinder data collection efforts as some websites will not be properly displayed.

# SQL Database

Using Microsoft SQL Server 2005 Express, a database named “USLCIDB\_Electricity\_Generation” was created. The purpose of this database was to do the following:

1. Store raw and calculated regionally specific electricity data for each North American generating region of interest (states, provinces, territories, countries, NERC Regions, and eGRID Subregions).
2. Capture a list of North American Grid Inter-tie regions that are comprised of generating regions (states, provinces, territories, countries). For this project, these will be the NAT (North America Total), NAE (North America East), NAW (North America West) and Texas.
3. Capture a list of grid regions that are comprised of generating regions (states, provinces, territories, countries). This list is used as a filter for calculating the composite electricity generation profiles for generating regions. For this project, the grid regions will include countries (USA, Canada, and Mexico) the North American Grid Inter-tie regions, a NERC Regions grid region, an eGRID Subregions grid region, and one grid region for each generating region that is not connected to one of the North American grid inter-ties (e.g., Alaska, Yukon Territories, etc.).
4. Capture a list of macro regions that are comprised of generating regions (states, provinces, territories, countries). Throughout this document, the macro regions are referred to as either Macro or Manufacturing regions interchangeably. For this project, the macro regions will include countries (USA, Canada, and Mexico) and the North American Grid Inter-tie regions, a NERC Regions region, and an eGRID Subregions region. These regions are used for calculating both raw and composite electricity generation profile data for the macro regions using the corresponding electricity generation profiles for the generating regions that make up each macro region.
5. Calculate and store raw and calculated electricity data for the North American Grid Inter-ties.
6. Calculate and store composite electricity data for each region (state, province, territory) whereby any generation shortfall is met by importing electricity from the appropriate NA Grid Inter-tie. The NERC Regions and eGRID Subregions are assumed to be self-contained with no generation shortfall; consequently the corresponding composite data will be the same as the raw data.
7. Calculate and store composite electricity data for each macro region.
8. Generate unformatted reports that contain composite electricity generation data by energy source for generating regions, North American Grid Inter-tie regions, NERC regions, and eGRID Subregions.

# The North American Electricity Grid Inter-ties

The North American Electricity Grid consists of three inter-ties: North America East, North America West, and Texas. Within the NA Grid, there are 3 types of regions as follows.

**Type-A Region :: Province, State, NERC region, eGRID Subregion** :: e.g., Ontario, BC, Florida, WECC (NERC), CAMX (eGRID Subregion), etc.

**Type-B Region :: Macro Region** :: i.e., USA, Canada, North America East (NAE), North America West (NAW), North America Total (NAT), a NERC Regions region, and an eGRID Subregions region.

**Type-C Region :: Electricity Grid (Interconnections)** :: North America East (NAE), North America West (NAW), Texas, Canada, USA, a NERC Regions region, an eGRID Subregions region, and one grid region for each generating region that is not connected to one of the North American grid inter-ties (e.g., Alaska, Yukon Territories, etc.).

## Constraint:

We have constrained each Type-A region to belong to only one Type-C region.

In reality, some Type-A regions belong to 2 or 3 Type-C regions (for instance, Texas actually has different parts of it that are in NAE and NAW grid interconnection regions). Whichever Type-C region a Type-A region is mostly in is the one we chose for it to contribute to. We enforce this constraint to simplify the following situation: If a Type-A region is not self-sufficient from an electricity generation perspective, then its electricity generation by energy (fuel type) percentage breakdown is really a composite (hybrid) of what it generates and what it imports from the Type-C region.

## Type-A Regional Characteristics

Each Type-A region has a few regional characteristics as follow:

1. Net Electricity Generated GWh
2. Net Inter-Regional Trade (electricity traded with neighbouring Type-A regions. This actually goes to or comes from the Type-C region to which the Type-A region belongs)
3. Total International Exports (this really goes to the Type-C region)
4. Total International Imports (this really comes from the Type-C region)
5. Estimated Losses (line losses)
6. Regional Self Sufficiency Ratio = Total Generation / (Total Generation - Total International Exports + Total International Imports +/- Net Inter-Regional Trade). Canada and US/Mexico treat the Net Inter-Regional Trade with different signs (one is positive for export the other is negative for export). So the formula is country dependent.
7. Each Type-A region can belong to none, one, or multiple Type-B regions. Each Type-A region has numerous electricity generation facilities, not all of which necessarily contribute to the same Type-B region. To account for this, each Type-A region has a contribution factor that has a value between 0 and 1 that identifies how much of its electricity generation data (net generation, import, export, inter regional trade, line losses) contribute to each of the Type-B regions to which it belongs.
8. Each Type-A region can belong to only one Type-C region. In reality, some Type-A regions belong to 2 or 3 Type-C regions (for instance, Texas actually has different parts of it that are in NAE and NAW grid interconnection regions). Whichever Type-C region a Type-A region is mostly in is the one we chose for it to contribute to. We enforce this constraint because if a Type-A region is not self-sufficient from an electricity generation perspective, then its electricity generation by energy (fuel type) percentage breakdown is really a composite (hybrid) of what it generates and what it imports from the Type-C region.

## Type-A Energy Source Characteristics

Each Type-A region has energy source specific electricity generation characteristics as follows:

1. Energy Type (Bituminous Coal, Lignite Coal, Nuclear, Hydroelectric, Natural Gas, etc.)
2. Net Electricity Generation GWh per Energy Type
3. Net Generation Ratio per Energy Type = Net Electricity Generation for each Energy Type / Total Generation for all energy types for the region

## Type-B Regional Characteristics

Each Type-B region has a few regional characteristics as follow:

1. Net Electricity Generated GWh is the sum of the contribution from all constituent Type A regions.
2. Net Inter-Regional Trade is the sum of contribution from all constituent Type A regions.
3. Total International Exports is the sum of contribution from all constituent Type A regions.
4. Total International Imports is the sum of contribution from all constituent Type A regions.
5. Estimated Losses (line losses) is the sum of contribution from all constituent Type A regions.
6. Regional Self Sufficiency Ratio = Total Generation / (Total Generation - Total International Exports + Total International Imports +/- Net Inter-Regional Trade). Canada and US/Mexico treat the Net Inter-Regional Trade with different signs (one is positive for export the other is negative for export). So the formula is country dependent.
7. Each Type-B region is completely self-contained, and does not belong to any other Type A, Type B or Type C regions.

## Type-C Regional Characteristics

Each Type-C region has a few regional characteristics as follow:

1. Net Electricity Generated GWh is the sum for all constituent Type A regions.
2. Net Inter-Regional Trade is the sum for all constituent Type A regions.
3. Total International Exports is the sum for all constituent Type A regions.
4. Total International Imports is the sum for all constituent Type A regions.
5. Estimated Losses (line losses) is the sum for all constituent Type A regions.
6. Regional Self Sufficiency Ratio = Total Generation / (Total Generation - Total International Exports + Total International Imports +/- Net Inter-Regional Trade). Canada and US/Mexico treat the Net Inter-Regional Trade with different signs (one is positive for export the other is negative for export). So the formula is country dependent.
7. Each Type-C region is completely self-contained, and does not belong to any other Type A, Type B or Type C regions.

## Determining a Regions Composite (or Effective) Electricity Generation Ratio by Energy Source Breakdown

If a Type-A region has a Self Sufficiency Ratio >= 1, then the electricity by energy source values are being contributed 100% by the Type-A region for the Electricity Generation by Energy Source Percentage Breakdown.

If a Type-A region has a Self Sufficiency Ratio < 1, then the electricity by energy source values are being contributed by both the Type-A region and the Type-C region to which it belongs.

For the purposes of using North American electricity generation profiles, the "Composite Electricity Generation GWh by Energy Source by Region" and the "Composite Electricity Generation Ratio by Energy Source by Region" represent a more accurate and relevant electricity profile for electricity consumed within both a generating (Type-A) region and macro (Type-B) region than using the Raw data alone.

Both NERC Regions and eGRID Subregions are being treated as generating (Type-A) regions. Both NERC Regions and eGRID Subregions are considered to be self-sufficient which means that both the Raw and Composite profiles for these two types of regions are the same. Consequently, the “Raw Electricity Generation” profile data in the Excel file is sufficient for both the NERC Regions and eGRID Subregions.

# Electricity Data Decisions

This section provides details about decisions made that concern the refinement, allocation and quality of data as well as outlining calculations that are used to prepare the data for population or update of the database.

## Energy Sources

This section contains decisions made about the sources of energy. The term “Energy Sources” is used interchangeably with “Fuel Types” throughout this document and refers to the type of fuel or energy used in the generation of electricity.

### Energy Sources from US and Canadian Electricity Generation Data

The Electricity Generation data from Canadian, Mexican and US sources itemize the energy sources slightly differently. The details of the energy source itemization are listed below in Table 1.

Table Energy Sources from US and Canadian Electricity Generation Data

| **Energy Source** | **Notes** |
| --- | --- |
| **Bituminous**  **Coal** | Includes the following EIA energy sources descriptions:  **BIT** - Anthracite Coal, and Bituminous Coal.  **SC** - Coal Synfuel. Coal-based solid fuel that has been processed by a coal synfuel plant, and coal-based fuels such as briquettes, pellets, or extrusions, which are formed from fresh or recycled coal and binding materials.  **SGC** - Synthetic gas, derived from coal.  **WC** - Waste/Other Coal (Anthracite Culm, Bituminous Gob, Fine Coal, Lignite Waste, Waste Coal) .  For Canadian data, both Canadian and Imported Bituminous Coal are included.  For Mexican data, Coal is included. |
| **Subbituminous**  **Coal** | Includes the following EIA energy sources descriptions:  **SUB** – Subbituminous Coal  For Canadian data, both Canadian and Imported SubBituminous Coal are included.  For Mexican data, there is no explicit place holder for “Subbituminous Coal”. |
| **Lignite**  **Coal** | Includes the following EIA energy sources descriptions:  **LIG** – Lignite Coal  For Mexican data, there is no explicit place holder for “Lignite Coal”. |
| **Petroleum**  **(RFO)** | Includes the following EIA energy sources descriptions:  **RFO**  – Residual Fuel Oil (includes No. 5 and No. 6 Fuel Oils and Bunker C Fuel Oil)  For Canadian data, Petroleum (Heavy Fuel Oil) is included.  For Mexican data, there is no explicit place holder for “Petroleum (RFO)”. |
| **Petroleum**  **(DFO)** | Includes the following EIA energy sources descriptions:  **DFO**  – Distillate Fuel Oil (includes all Diesel and No. 1, No. 2, and No. 4 Fuel Oils)  **JF**  – Jet Fuel  **KER**  – Kerosene  For Canadian data, both Petroleum (Light Fuel Oil) and Petroleum (Diesel) are included.  For Mexican data, Oil is included. |
| **Petroleum**  **(Other Fossil)** | Includes the following EIA energy sources descriptions:  **PC**  – Petroleum Coke  **SG**  – Synthetic Gas, other than coal-derived  **WO**  – Waste/Other Oil (including Crude Oil, Liquid Butane, Liquid Propane, Oil Waste, Re-Refined Motor Oil, Sludge Oil, Tar Oil, or other petroleum-based liquid wastes)  For Canadian data, Other is included.  For Mexican data, Other is included. |
| **Hydroelectric** | Includes the following EIA energy sources descriptions:  **WAT**  – Water (Conventional, Pumped Storage)  For Canadian data, there is no distinction between conventional and pumped storage. Additionally, emissions from the flooding of land for hydro dams are not included.  For Mexican data, there is no distinction between conventional and pumped storage.  Note: The generation from a hydroelectric pumped storage facility is the net value of production minus the energy used for pumping. |
| **Solid**  **Renewable**  **Fuels**  **(Biomass)** | Includes the following EIA energy sources descriptions:  **AB** – Agriculture Crop By-products/Straw/Energy Crops  **MSB**  – Municipal Solid Waste – Biogenic Component  **MSW**  – Municipal Solid Waste  **OBS**  – Other Biomass Solid (Animal Manure and Waste, Solid By-products, and other solid biomass not specified)  **TDF**  – Tired (tire derived fuel)  **WDS** – Wood/Wood Waste Solids (Paper Pellets, Railroad Ties, Utility Poles, Wood Chips, and other wood solids)  For Canadian data: there is no explicit place holder for non-wood related “Solid Renewable Fuels (Biomass)”, rather all Biomass is grouped in the Wood category.  For Mexican data, Biomass and Waste are included. |
| **Liquid**  **Renewable**  **Fuels**  **(Biomass)** | Includes the following EIA energy sources descriptions:  **BLQ** – Black Liquor  **OBL**  – Other Biomass Liquid (Ethanol, Fish Oil, Liquid Acetonitrile Waste, Medical Waste, Tall Oil, Waste Alcohol, and other Biomass not specified)  **SLW** – Sludge Waste  **WDL** – Wood Waste Liquids (Red Liquor, Sludge Wood, Spent Sulfite Liquor, and other wood based liquids  For Canadian data: there is no explicit place holder for “Liquid Renewable Fuels (Biomass)”, rather all Biomass is grouped in the Wood category.  For Mexican data, there is no explicit place holder for “Liquid Renewable Fuels (Biomass)”. |
| **Gaseous**  **Renewable**  **Fuels**  **(Biomass)** | Includes the following EIA energy sources descriptions:  **LFG**  – Landfill Gas  **OBG**  – Other Biomass Gases (Digester Gas, Methane, and other biomass gases)  For Canadian data: there is no explicit place holder for “Gaseous Renewable Fuels (Biomass)”, rather all Biomass is grouped in the Wood category.  For Mexican data, there is no explicit place holder for “Gaseous Renewable Fuels (Biomass)”. |
| **Wind** | Includes the following EIA energy sources descriptions:  **WND** – Wind  For Canadian data, Wind and Tidal is included.  For Mexican data, Wind and Tide is included. |
| **Solar** | Includes the following EIA energy sources descriptions:  **SUN**  – Solar (Photovoltaic, Thermal)  For Canadian data, there is no explicit place holder for “Solar” |
| **Geothermal** | Includes the following EIA energy sources descriptions:  **GEO**  – Geothermal  For Canadian data, there is no explicit place holder for “Geothermal”. |
| **Natural Gas** | Includes the following EIA energy sources descriptions:  **NG** – Natural Gas |
| **Other Gases** | Includes the following EIA energy sources descriptions:  **BFG** – Blast Furnace Gas  **OG** – Other Gas (Butane, Coal Processes, Coke-Oven, Refinery, and other processes)  **PG** – Propane  For Canadian data: there is no explicit place holder for “Other Gases”.  For Mexican data, there is no explicit place holder for “Other Gases” |
| **Nuclear** | Includes the following EIA energy sources descriptions:  **NUC** – Nuclear (Uranium, Plutonium, Thorium) |
| **Other Fuels** | Includes the following EIA energy sources descriptions:  **OTH**  – Other (Batteries, Chemicals, Coke Breeze, Hydrogen, Pitch, Sulfur, Tar Coal, and miscellaneous technologies)  **MSN**  – Municipal Solid Waste – Non-biogenic components  **PUR**  – Purchased Steam  **WH**  – Waste heat not directly attributed to a fuel source. Note that WH should only be reported where the fuel source for the waste heat is undetermined, and for combined cycle steam turbines that are not supplementary fired  For Canadian data: there is no explicit place holder for “Other Fuels”.  For Mexican data, there is no explicit place holder for “Other fuels” |

## Calculations

### Self Sufficiency Ratio

A region’s self sufficiency ratio is calculated as the ratio of Production to Total Supply. The data sourced from the US and Canada differs slightly in how these two values are determined because each country calculates “inter-regional trade” slightly differently.

For Mexico, the self-sufficiency ratio is not considered since we are only interested in the electricity imported into the US from Mexico.

The following citations for Net Interstate Trade and Net Trade Index for the US data were obtained from Table 10 Supply and Disposition of Electricity, 1990, 1995, and 2001 through 2008 (Millions kilowatt hours) in the file located at the following URL:

<http://www.eia.doe.gov/cneaf/electricity/st_profiles/sep2008.pdf>

#### Net Interstate Trade

“Net Interstate Trade is the difference between Total Supply and Disposition.”

US - Net Interstate Trade represents the difference between the amount of electricity produced in the State and consumed in the State. Positive values indicate a State that is a net interstate exporter of electricity; negative values indicate a State that is a net interstate importer of electricity.

CAN - The reverse relationship is assumed to be true for Canadian provinces and territories, where a negative value indicates a region that is a net inter-region exporter of electricity; while a positive value indicates a region that is a net inter-region importer of electricity.

Consequently we have two slightly different country specific formulae for determining the Total Electricity Supply and hence the corresponding Self Sufficiency Ratio, as follows.

#### Net Trade Index

“Net Trade Index is the ratio of Total Supply to Total Disposition.”

The Net Trade Index represents a State’s electricity self-sufficiency. Values greater than 1 indicate that, on an annual net basis, the State supplied electricity consumed outside the State; values less than 1 indicate that, on an annual net basis, the State consumed electricity produced outside the State.”

#### Self Sufficiency Ratio Formulae

The following two formulae calculate a generating regions country-dependent self sufficiency ratio.

**US Self Sufficiency Ratio** = Production/Total Supply = Net Gen / (Net Gen - Total Exports + Total Imports – Inter Region Transfer)

**Canadian Self Sufficiency Ratio** = Production/Total Supply = Net Gen / (Net Gen - Total Exports + Total Imports + Inter Region Transfer)

### Total Electricity Supply

**Canadian Total Supply** = Net Generation – International Exports + International Imports + Net Inter-Regional Transfer

**US Total Supply** = Net Generation – International Exports + International Imports –Net Inter-Regional Transfer

## Inter-Regional Transfer Decisions

### Newfoundland & Labrador and Quebec

Churchill Falls is owned and operated by CFLCo, while Hydro Quebec holds about 33% of the shares. All electricity generated at the facility is hydroelectric in nature and is transmitted via Hydro Quebec infrastructure to end markets within QC, Labrador, the rest of Canada (Ontario), and exported to the US. The electricity generated at Churchill Falls facility represents the entirety of the NL “net\_inter\_regional\_trade\_gwh” value. Since it goes directly to QC, if we are to properly represent the fuel mix for electricity "generated" and consumed for QC, we must re-allocate the electricity from the Churchill Falls facility to QC. Failure to do so would result in a dirtier mix of fuels being used to meet the electricity imported into QC as it would naturally be assumed to be from the North American East grid inter-tie, which is NOT 100% Hydro.

For 2007 Canadian statistics, QC Net Generation from Stats Can is 181,099,757 MWh. QC Inter-regional transfer from Stats Can is 30,408,218 MWh. The Inter-regional transfer from NL to QC of 30,077,913 is from the Churchill Falls facility. Reallocating this amount from NL to QC affects the net generation values, the inter-regional transfer values, and the self-sufficiency ratios for both QC and NL. The excel file “USLCIDB\_Electricity\_Generation\_Tasks.xlsx” uses formulae to accommodate this special situation. Special care will need to be taken while entering data updates into the “CAN Generation Data” worksheet of this Excel file.

## Losses & Unaccounted For Energy

Losses and unaccounted for energy include:

1. Reporting by utilities and power marketers that represent losses incurred in transmission and distribution, as well as volumes unaccounted for in their own energy balance; and
2. Discrepancies among the differing categories upon balancing the table.

## Grid Decisions

### Alaska (AK)

Although there is some electricity exchange from BC to Alaska, Alaska is considered to be an electricity generation and consumption island. Therefore Alaska does not contribute to the NA West grid inter-tie. In order to ensure that AK has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Hawaii (HI)

Hawaii is an island and has zero import, zero export, and zero inter-regional transfer. Therefore, Hawaii is completely isolated from all NA Grids. In order to ensure that HI has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Mexico (MEX)

Mexico presented an interesting situation. Mexico exports electricity to all 4 US border -states: California, Arizona, New Mexico, and Texas. This means that Mexico is effectively interconnected to all three of the North American grid inter-ties. The vast majority of this electricity export flows to California. Consequently, we have chosen to constrain Mexico to being included in only the North America West grid inter-tie.

The data for Mexico comes from a mix of GWh and MWh values from two different sources. You need to ensure that the values are all converted to either GWh or MWh when updating the data.

### Newfoundland & Labrador (NL)

Newfoundland & Labrador (NL) are completely isolated in terms of being inter-connected to the North American East Grid. NL has zero imports, zero exports, and net zero inter-regional transfers since all of its inter-regional transfer is to Quebec from the Churchill Falls facility and has been completely reallocated to Quebec. Consequently, NL is not considered to be connected to the NA East Grid. In the coming years this situation will probably revert such that the electricity generated by the Churchill Falls facility will be allocated to NL instead of QC; this is presently (2010) in the courts at which time NL will contribute to the NA East Grid inter-tie.

In order to ensure that NL has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Northwest Territories

The Northwest Territories (NT) has zero import, zero export, and zero inter-regional transfer. Therefore, the Northwest Territories is isolated from the NA West Grid. In order to ensure that NT has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Nunavut

Nunavut (NU) has zero import, zero export, and zero inter-regional transfer. Therefore, Nunavut is isolated from the NA East Grid. In order to ensure that NU has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Yukon Territory

Yukon Territory (YT) has zero import, zero export, and zero inter-regional transfer. Therefore, the Yukon Territory is isolated from the NA West Grid. In order to ensure that YT has data in the CompositeElectricityGenerationByRegionByEnergySource table, a standalone record has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### Countries

In order to ensure that each of the country-level regions (USA, CAN, MEX) have data in the CompositeElectricityGenerationByRegionByEnergySource table, a record for each of the countries has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### North America Grid Inter-tie Regions

In order to ensure that each of the generating regions that constitute the North America Grid Inter-tie Regions (NAE, NAW, Texas) have data in the CompositeElectricityGenerationByRegionByEnergySource table, container records for each of the North America Grid Inter-tie Regions has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### NERC Regions

In order to ensure that each of the NERC Regions (ASCC, TRE, FRCC, HICC, MRO, NPCC, RFC, SERC, SPP, WECC) have data in the CompositeElectricityGenerationByRegionByEnergySource table, a container record named “NERC Regions” has been created in both the ElectricityGrid and ElectricityGridComposition tables.

### eGRID Subregions

In order to ensure that each of the eGRID Subregions (AKGD, AKMS, AZNM, CAMX, ERCT, FRCC, HIMS, HIOA, MROE, MROW, NEWE, NWPP, NYCW, NYLI, NYUP, RFCE, RFCM, RFCW, RMPA, SPNO, SPSO, SRMV, SRMW, SRSO, SRTV, SRVC) have data in the CompositeElectricityGenerationByRegionByEnergySource table, a container record named “eGRID Subregions” has been created in both the ElectricityGrid and ElectricityGridComposition tables.

## North American Grid Inter-tie Composition

There are 3 grid inter-ties within North America: East, West, and Texas. These are more commonly known as the Western Interconnection, the Eastern Interconnection (includes Quebec), and the Texas Interconnection. A map of the NERC (North American Electricity Reliability Corporation) is found below.

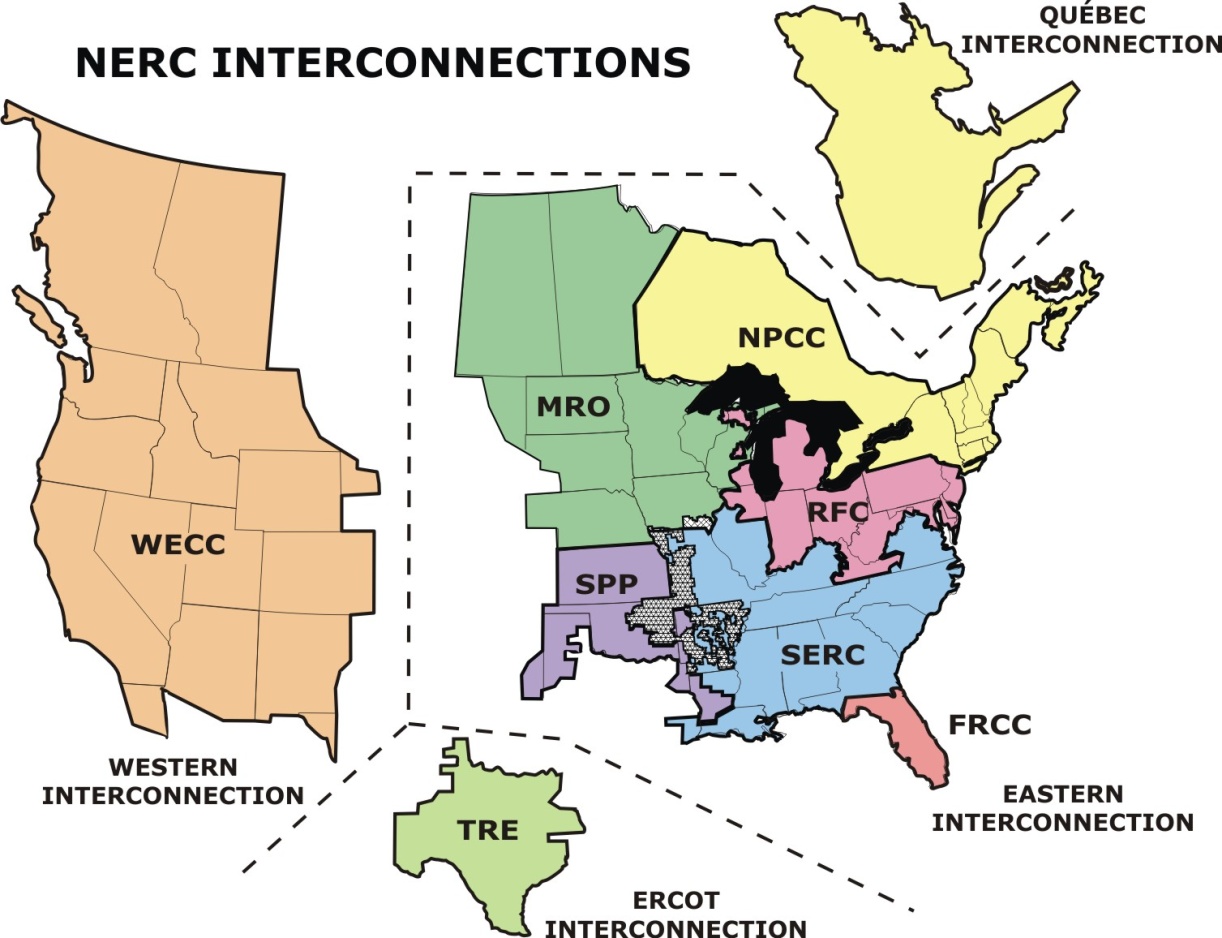


Figure NERC Interconnections

### NERC Regions

The following table contains the list of NERC regions.

|  |  |  |
| --- | --- | --- |
| **NERC Region Name** | **Full Name** | **Interconnection** |
| ASCC | Alaska Systems Coordinating Council | None |
| FRCC | Florida Reliability Coordinating Council | Eastern |
| HICC | Hawaiian Islands Coordinating Council | None |
| MRO | Midwest Reliability Organization | Eastern |
| NPCC | Northeast Power Coordinating Council | Eastern |
| RFC | Reliability First Corporation | Eastern |
| SERC | SERC Reliability Council | Eastern |
| SPP | Southwest Power Pool | Eastern |
| TRE | Texas Regional Entity | ERCOT |
| WECC | Western Electricity Coordinating Council | Western |

### NERC Region Composition by Generating Facility

Each US state has numerous electricity generating facilities that may contribute to different NERC regions. Fortunately, the US data is provided at the plant-level and each plant is associated with a single NERC region. As is the nature of statistics, a small percentage of facilities are missing their NERC region affiliation information so it is up to the person processing the data to manually assign an appropriate NERC region affiliation.

The following table contains the list of NERC regions to which each generating region contributes.

Table NERC Regions by Generating Region

| **Generating Region Name** | **Short Name** | **NERC Region** |
| --- | --- | --- |
| Alabama | AL | SERC |
| Alaska | AK | ASCC |
| Alberta | AB | WECC |
| Arizona | AZ | WECC |
| Arkansas | AR | SERC, SPP |
| British Columbia | BC | WECC |
| California | CA | WECC |
| Canada | CAN | MRO, NPCC, WECC |
| Colorado | CO | WECC |
| Connecticut | CT | NPCC |
| Delaware | DE | RFC |
| District of Columbia | DC | RFC |
| Florida | FL | FRCC, SERC |
| Georgia | GA | SERC |
| Hawaii | HI | HICC |
| Idaho | ID | WECC |
| Illinois | IL | MRO, RFC, SERC |
| Indiana | IN | RFC |
| Iowa | IA | MRO, SERC |
| Kansas | KS | SPP |
| Kentucky | KY | RFC, SERC |
| Louisiana | LA | SERC, SPP |
| Maine | ME | NPCC |
| Manitoba | MB | MRO |
| Maryland | MD | RFC |
| Massachusetts | MA | NPCC |
| Mexico | MEX | WECC |
| Michigan | MI | MRO, RFC |
| Minnesota | MN | MRO |
| Mississippi | MS | SERC |
| Missouri | MO | SERC, SPP |
| Montana | MT | MRO, WECC |
| Nebraska | NE | MRO |
| Nevada | NV | WECC |
| New Brunswick | NB | NPCC |
| New Hampshire | NH | NPCC |
| New Jersey | NJ | RFC |
| New Mexico | NM | SPP, WECC |
| New York | NY | NPCC |
| Newfoundland and Labrador | NL | NONE |
| North Carolina | NC | SERC |
| North Dakota | ND | MRO |
| Northwest Territories | NT | NONE |
| Nova Scotia | NS | NPCC |
| Nunavut | NU | NONE |
| Ohio | OH | RFC |
| Oklahoma | OK | SPP |
| Ontario | ON | NPCC |
| Oregon | OR | WECC |
| Pennsylvania | PA | RFC |
| Prince Edward Island | PE | NPCC |
| Quebec | QC | NPCC |
| Rhode Island | RI | NPCC |
| Saskatchewan | SK | MRO |
| South Carolina | SC | SERC |
| South Dakota | SD | MRO, WECC |
| Tennessee | TN | RFC, SERC |
| Texas | TX | TRE, SERC, SPP, WECC |
| United States | USA | WECC, TRE, SPP, MRO, SERC, RFC, FRCC, NPCC |
| Utah | UT | WECC |
| Vermont | VT | NPCC |
| Virginia | VA | RFC, SERC |
| Washington | WA | WECC |
| West Virginia | WV | RFC |
| Wisconsin | WI | MRO, RFC |
| Wyoming | WY | WECC |
| Yukon Territory | YT | NONE |

### Electricity Generating Islands

The following regions are considered to be isolated from the North American grid inter-tie regions:

Table Electricity Generating Islands

|  |  |
| --- | --- |
| **Country** | **Region** |
| CAN | Newfoundland and Labrador |
| CAN | Northwest Territories |
| CAN | Nunavut |
| CAN | Yukon Territory |
| USA | Alaska |
| USA | Hawaii |

### Regions Belonging to Multiple North America Grid Inter-ties

The following regions have interconnections with two or more of the North America Grid Inter-ties:

Table Regions with Multiple Grid Inter-ties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Country** | **Region** | **North American East** | **North American West** | **Texas** |
| USA | Montana | TRUE | TRUE | FALSE |
| USA | Nebraska | TRUE | TRUE | FALSE |
| USA | New Mexico | TRUE | TRUE | FALSE |
| USA | South Dakota | TRUE | TRUE | FALSE |
| USA | Texas | TRUE | TRUE | TRUE |
| Mexico | Mexico | FALSE | TRUE | TRUE |

An increased level of complexity is introduced due to the nature of having fractional inclusion in multiple grid inter-ties. In an attempt to simplify the breakdown of electricity generation by fuel type for each region, we have chosen constrain each region to belong to a single grid inter-tie. The constrained grid inter-tie inclusion is noted in the following table, with the changed inclusion highlighted in red.

Table Constrained Regions with Multiple Grid Inter-ties

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Country** | **Region** | **North American East** | **North American West** | **Texas** |
| USA | Montana | FALSE | TRUE | FALSE |
| USA | Nebraska | TRUE | FALSE | FALSE |
| USA | New Mexico | FALSE | TRUE | FALSE |
| USA | South Dakota | TRUE | FALSE | FALSE |
| USA | Texas | FALSE | FALSE | TRUE |
| Mexico | Mexico | FALSE | TRUE | FALSE |

### North America West Grid Inter-tie Composition

The following table contains the generating regions that contribute to the North America West Grid Inter-tie. In order to comply with the constraint that each generating region only contribute to a single North America Grid Inter-tie and to conform with any assumptions made regarding whether a generating region is isolated, generating regions that have been “removed” from the grid inter-tie are highlighted in red.

Table North America West Grid Inter-tie Composition

| **Electricity Grid Name** | **Region**  **Short Name** | **Region Name** | **Country** |
| --- | --- | --- | --- |
| North America West | AK | Alaska | USA |
| North America West | AB | Alberta | CAN |
| North America West | AZ | Arizona | USA |
| North America West | BC | British Columbia | CAN |
| North America West | CA | California | USA |
| North America West | CO | Colorado | USA |
| North America West | ID | Idaho | USA |
| North America West | MT | Montana | USA |
| North America West | NE | Nebraska | USA |
| North America West | NM | New Mexico | USA |
| North America West | NV | Nevada | USA |
| North America West | OR | Oregon | USA |
| North America West | SD | South Dakota | USA |
| North America West | TX | Texas | USA |
| North America West | UT | Utah | USA |
| North America West | WA | Washington | USA |
| North America West | WY | Wyoming | USA |
| North America West | MEX | Mexico | MEX |

### Texas Grid Inter-tie Composition

The following table contains the generating regions that contribute to the Texas Grid Inter-tie. In order to comply with the constraint that each generating region only contribute to a single North America Grid Inter-tie and to conform with any assumptions made regarding whether a generating region is isolated, generating regions that have been “removed” from the grid inter-tie are highlighted in red.

Table Texas Grid Inter-tie Composition

|  |  |  |  |
| --- | --- | --- | --- |
| **Electricity Grid Name** | **Region**  **Name Short** | **Region Name** | **Country** |
| Texas | TX | Texas | USA |
| Texas | MEX | Mexico | MEX |

### North America East Grid Inter-tie Composition

The following table contains the generating regions that contribute to the North America East Grid Inter-tie. In order to comply with the constraint that each generating region only contribute to a single North America Grid Inter-tie and to conform with any assumptions made regarding whether a generating region is isolated, generating regions that have been “removed” from the grid inter-tie are highlighted in red.

Table North America East Grid Inter-tie Composition

| **Electricity Grid Name** | **Region**  **Short Name** | **Region Name** | **Country** |
| --- | --- | --- | --- |
| North America East | AL | Alabama | USA |
| North America East | AR | Arkansas | USA |
| North America East | CT | Connecticut | USA |
| North America East | DC | District of Columbia | USA |
| North America East | DE | Delaware | USA |
| North America East | FL | Florida | USA |
| North America East | GA | Georgia | USA |
| North America East | IA | Iowa | USA |
| North America East | IL | Illinois | USA |
| North America East | IN | Indiana | USA |
| North America East | KS | Kansas | USA |
| North America East | KY | Kentucky | USA |
| North America East | LA | Louisiana | USA |
| North America East | MA | Massachusetts | USA |
| North America East | MB | Manitoba | CAN |
| North America East | MD | Maryland | USA |
| North America East | ME | Maine | USA |
| North America East | MI | Michigan | USA |
| North America East | MN | Minnesota | USA |
| North America East | MO | Missouri | USA |
| North America East | MS | Mississippi | USA |
| North America East | MT | Montana | USA |
| North America East | NB | New Brunswick | CAN |
| North America East | NL | Newfoundland and Labrador | CAN |
| North America East | NC | North Carolina | USA |
| North America East | ND | North Dakota | USA |
| North America East | NE | Nebraska | USA |
| North America East | NH | New Hampshire | USA |
| North America East | NJ | New Jersey | USA |
| North America East | NM | New Mexico | USA |
| North America East | NS | Nova Scotia | CAN |
| North America East | NY | New York | USA |
| North America East | OH | Ohio | USA |
| North America East | OK | Oklahoma | USA |
| North America East | ON | Ontario | CAN |
| North America East | PA | Pennsylvania | USA |
| North America East | PE | Prince Edward Island | CAN |
| North America East | QC | Quebec | CAN |
| North America East | RI | Rhode Island | USA |
| North America East | SC | South Carolina | USA |
| North America East | SD | South Dakota | USA |
| North America East | SK | Saskatchewan | CAN |
| North America East | TN | Tennessee | USA |
| North America East | TX | Texas | USA |
| North America East | VA | Virginia | USA |
| North America East | VT | Vermont | USA |
| North America East | WI | Wisconsin | USA |
| North America East | WV | West Virginia | USA |
| North America East | MEX | Mexico | MEX |

## Self Sufficiency

Raw data is available for each generating region from the sources listed in the “” section of this document. Each region has a Self Sufficiency Ratio that depends on the net electricity generation by that region, the net inter-regional electricity trade, and the international electricity imports and exports.

Each region may have electricity flows into and/or out of the region in the form of International Exports, International Imports, and Inter-Regional Transfers. A region’s Self Sufficiency Ratio is calculated as the ratio of Production to Total Supply. See “” for more details about calculating the country-dependent regional self sufficiency ratios.

If a generating region (see “” for more detail) has a Self Sufficiency Ratio that is greater than or equal to one, then the electricity consumed within that region are being contributed 100% by the generating region.

If a generating (Type-A) region has a Self Sufficiency Ratio that is less than one, then the electricity consumed within that region are being contributed by both the generating (Type-A) region and the grid inter-tie (Type-C) region to which it belongs.

For example, if a region has a self-sufficiency ratio of 0.94 (or 94%), then 94 percent of the electricity consumed within that region is generated by facilities within that region while the remaining shortfall of 6 percent is imported from the grid inter-tie to which that region belongs.

For the purposes of using North American electricity generation profiles, the "Composite Electricity Generation GWh by Energy Source by Region" and the "Composite Electricity Generation Ratio by Energy Source by Region" represent a more accurate and relevant electricity profile for electricity consumed within both a generating (Type-A) region and macro (Type-B) region than using the Raw data alone.

As mentioned above in “”, both NERC Regions and eGRID Subregions are being treated as generating (Type-A) regions. Both NERC Regions and eGRID Subregions are considered to be self-sufficient which means that both the Raw and Composite profiles for these two types of regions are the same. Consequently, the “Raw Electricity Generation” profile data in the Excel file is sufficient for both the NERC Regions and eGRID Subregions.

### Self Sufficiency Summary

#### Self Sufficiency Ratio >= 1.00

The electricity consumed within the region is assumed to be 100% generated within the region. The grid inter-tie does not contribute to the electricity being consumed within the region.

#### Self Sufficiency Ratio < 1.00

The electricity consumed within the region is a hybrid of electricity generated within the region and that imported from the grid inter-tie to which the region belongs.

# Database Setup

This section contains details on setting up the SQL Server Express database on a Windows PC or laptop, running Windows XP or better. Explicit hard drive paths will be stated and assumed to be the same on your computer. If you decide to use different paths and file or folder names, it is recommended that you also update this document to reflect the changes.

### Download & Install Database Software

The download site for Microsoft SQL Server Express edition is found at the following URL:

<http://www.microsoft.com/sqlserver/2005/en/us/express.aspx>

1. Click on the link above to open the SQL Server 2005 Express Edition web page in your default browser.
2. Click one of the download links to go to the “Downloading and Installing SQL Server 2005 Express” page at the following URL:   
   <http://www.microsoft.com/Sqlserver/2005/en/us/express-down.aspx>
3. Under the “Install Microsoft SQL Server 2005 Express Edition” group, click the “Download” link and save the installation package to your hard drive.
4. Launch Windows Explorer and navigate to the folder where you downloaded the installation package (likely either SQLEXPR32.EXE or SQLEXPR\_ADV.EXE).
5. Double click on the installation package and follow the prompts to install the database on your computer.

### Download & Install Database Management Software

The download site for Microsoft SQL Server Management Studio Express edition is found at the following URL:

<http://www.microsoft.com/Sqlserver/2005/en/us/express-down.aspx>

1. Under the “SQL Server Management Studio Express” group, click the “Download” link and save the installation package to your hard drive.
2. Launch Windows Explorer and navigate to the folder where you downloaded the installation package (likely named “SQLServer2005\_SSMSEE.msi”).
3. Double click on the installation package and follow the prompts to install the database on your computer.

### Database Name:

The database is named “USLCIDB\_Electricity\_Generation”. If the database name is to be changed, all stored procedures, functions, and scripts will need to be updated to reflect the database name change. Numerous SQL statement generation formulae will also need to be updated within the Excel file “USLCIDB\_Electricity\_Generation.xlsx”. This is a time consuming manual process to verify that the database being referenced in all SQL scripts is correct.

### Database Data Files:

The database data files are assumed to be stored in the following folder:

Folder: C:\Data\Database\mssql\data\USLCIDB\_Electricity\_Generation\

The database data files have the following names:

Data File: USLCIDB\_Electricity\_Generation.mdf

Log File: USLCIDB\_Electricity\_Generation\_log.mdf

### Database Backup Files

The database backup files are assumed to be stored in the following folders:

Folder: C:\Data\Database\mssql\backup\USLCIDB\_Electricity\_Generation\

Note that “SQL Server Management Studio Express” has the following default location for saving backup files

Folder: C:\Program Files\Microsoft SQL Server\MSSQL.2\MSSQL\Backup\

Since this default path is tied to the software and database version and might require UAC authentication for Windows Vista (or better), we chose to use a custom folder.

### SQL Server Project Files:

The SQL script files associated with the “USLCIDB\_Electricity\_Generation” database are assumed to be stored in the following folders:

Folder: C:\Users\cgoemans\Documents\SQL Server Management Studio Express\Projects\USLCIDB\_Electricity\_Generation

There are a number of types of script, each having its own sub-folder as follows:

|  |  |
| --- | --- |
| **Script Type** | **Sub-Folder** |
| Functions | Functions |
| Query Results | Results |
| Create | ScriptsCreate |
| Data Retrieval | ScriptsGetData |
| Data Insert | ScriptsInsertData |
| Data Update | ScriptsUpdateData |
| Sanity Check Reports | ScriptsSanityCheck |
| Stored Procedures | StoredProcedures |

### Create New Database

This section contains details on creating a new SQL Server Express database using the Microsoft SQL Server Management Studio Express application.

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “Databases” collection.
4. Click “New Database” to open the “New Database” form. Ensure the following form input field values:
   1. The “Use full-text indexing” checkbox is enabled (checked),
   2. Database Name = “USLCIDB\_Electricity\_Generation”,
   3. Data file Name= “USLCIDB\_Electricity\_Generation” (default after enter database name),
   4. Data file Path=”C:\Data\Database\mssql\data”,
   5. Log file Name= “USLCIDB\_Electricity\_Generation\_log” (default after enter database name),
   6. Log file Path=”C:\Data\Database\mssql\data”
   7. Click the “OK” button to create the new database.
5. The new database will now appear in the “Database” collection.
6. Backup the new database (see below for instructions).

### Restore Database

This section contains details on restoring a SQL Server Express database to a previous state using the Microsoft SQL Server Management Studio Express application and a backup file.

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Click Tasks -> “Restore” -> “Database” to launch the “Restore Database” form.
5. Click the “From device” button.
6. Click the “...” button to the far right of the “From device” button to launch the “Specify Backup” form.
7. Click the “Add” button to launch the “Locate Backup File” form.
8. Navigate to the backup file folder and pick a backup file.
9. Back in the “Specify Backup” form; click the “OK” button.
10. Back in the “Restore Database” form, do the following:
    1. Click the checkbox beside the selected backup file,
    2. Click on the “Options”,
    3. Click the “Overwrite” checkbox,
    4. Ensure the paths to the “Restore As” file names and paths are correct,
    5. Check the “Leave the database ready to use ... ” radio button,
    6. Click the “OK” button to commence the database restore.

### Backup Database

This section contains details on backing up a SQL Server Express database using the Microsoft SQL Server Management Studio Express application.

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”
3. Right-click on the “USLCIDB\_Electricity\_Generation” database
4. Click Tasks -> “Back Up” to launch the “Back Up Database” form.
5. Click the “Remove” button to ensure that you do not append the current data to the most recent backup file.
6. Click the “Add” button to launch the “Select Backup Destination” form.
7. Navigate to the backup folder, e.g., “C:\Data\Database\mssql\backup\USLCIDB\_Electricity\_Generation\” then enter a meaningful file name.
8. Click the “OK” button on the three open forms and wait for the backup to complete.

# Data Gathering & Preparation

## USA

Electricity generation and consumption statistics in United States are available primarily via the US Energy Information Administration (EIA) and the Environmental Protection Agency (EPA) federal governmental organizations.

### EIA – U.S. Energy Information Administration

The U.S. Energy Information Administration (EIA) collects electric power data on survey instruments. Data collection is mandated by Congress to promote sound policymaking, efficient markets, and public understanding.

### EPA – U.S. Environmental Protection Agency

The Environmental Protection Agency publishes EGRID as part of its “Clean Energy” initiative. The eGRID data contains plant level electricity generation information for nearly all electric power plants and consumption information all states in the United States.

To visit the eGRID website, open a web browser and enter the following URL:

<http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>

The EIA data is the source of the eGRID data and the eGRID data consistently lags the vintage of EIA data, by 2 or more years.

Consequently for raw electricity generation data, we have chosen to go right to the source in order to obtain the most recent and relevant data. However one area that does require us to use the eGRID data is for eGRID Subregion mapping to electricity generating facilities (via U.S. zip codes) since this is not available in the source EIA data. As is the nature of statistics, a small percentage of facilities are missing their eGRID Subregion affiliation information so it is up to the person processing the data to manually assign an appropriate eGRID Subregion affiliation.

### Electricity Supply and Disposition

The EIA – U.S. Energy Information Administration is the source of data for this section.

Open a web browser and enter the following URL:

<http://www.eia.gov/fuelelectric.html>

Under the “Analyses” group, click on the “State Electricity Profiles” link to open the “State Electricity Profiles” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html>

Under the “Entire Reports, U.S. Summaries, and Individual State Electric Profiles” group on the right hand side of the web page, click on the most recent “YYYY Entire Report” to download the PDF version of the report. At the time of writing, the most recent report was “2008 Entire Report”. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/st_profiles/sep2008.pdf>

Once the PDF file has been downloaded and saved to your hard drive, double click on it to launch Acrobat Reader, and then navigate to Table 10 “Supply and Disposition of Electricity” for each state.

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “Regional Electricity Profiles” worksheet. Using the data in Table 10 “Supply and Disposition of Electricity”, update the US information in the pale yellow cells in the “Regional Electricity Profiles” worksheet.

Note that this will be a time consuming process and is potentially error prone as individual values are copied from the PDF file and pasted into the Excel file.

### Electricity Generation by Fuel Type

#### Plant Level Electricity Generation by Fuel Type (State and NERC Region)

The EIA – U.S. Energy Information Administration is the source of data for this section.

The EIA Plant Level data contains an abundance of data that will be the source of data for the “US Generation Data”, “NERC Region Generation Data”, and “eGRID Subregion Generation Data” worksheets.

Open a web browser and enter the following URL:

<http://www.eia.gov/fuelelectric.html>

Under the “Electricity Databases” group, click on the “more ...” link to navigate to the “Electricity Data Files” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/page/data.html>

Scroll down to “EIA-906 and EIA-920 and EIA-923” in the “Survey Form” column. Click on the link in the “Get the Data” column to navigate to the “Form EIA-906, EIA-920, and EIA-923 Databases” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html>

On the right hand side of this page you will see a table titled “Downloads”. In the “Year” column, find the most recent year that contains Finalized annual data, noted by a string similar to the “EIA-923 January – December Final, Nonutility Energy Balance and Annual Environmental Information Data, Excel format”. Note that this is one of the reports that the EPA uses for compiling its eGRID reports. In the “Format” column, click on the link named “ZIP” to download a ZIP package. When prompted, save the ZIP package to your hard disk. The ZIP file will be named similar to “f906920\_YYYY.zip” where YYYY is the year. The file that contains the plant level data is in an excel file named:

“f906920\_YYYY.xls”

Open the “f9067920\_YYYY.xls” file in Microsoft Excel, click on the worksheet named “Page 1 Generation and Fuel Data” to access the plant level data. You will be copying information from select columns.

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “EIA 906920” worksheet. Using the data in the source file “f906920\_YYYY.xls”, update the information in the “EIA 906920” worksheet.

The information contained in the “EIA 906920” worksheet will automatically update corresponding data in the “US Generation Data”, “NERC Region Generation Data”, “eGRID Subregion Generation Data” worksheets which will be used to determine raw data electricity generation by energy source profiles for each generating region, NERC Region, and eGRID Subregion. This information will also be used to generate SQL Statements for updating the database. Additionally, the raw data will be used to update data in the “NERC Region Composition” and “eGRID Subregion Composition” worksheets.

#### NERC Region Mapping to Facilities

While examining the EIA data in “f906920\_2008.xls” file (Form EIA-906, EIA-920, and EIA-923 Databases), some rows were missing NERC Region identifiers. For such data inconsistencies, we assumed a value of the NERC region to which the majority of generating plants within each state contribute. You will need to manually update the “NERC Region” column and optionally add a comment in the “Reserved” column on the “EIA 906920” worksheet.

#### State Level Electricity Generation by Fuel Type:

The data contained in the State Level report contains insufficient energy source (fuel type) species for use as a source for the US LCI Database Electricity data. This sub-section is included for reference purposes only.

Open a web browser and enter the following URL:

<http://www.eia.gov/fuelelectric.html>

Under the “Electricity Databases” group, click on the “State-level Spreadsheets” link to download the “generation\_states.xls” Excel spreadsheet. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/epa/generation_state.xls>

## CANADA

Electricity generation and consumption statistics in Canada are made available through Statistics Canada (StatsCan). StatsCan publishes numerous statistical reports in both HTML and PDF formats. It is worth noting that StatsCan updates the web pages more frequently than the corresponding PDF files. We have therefore chosen to use the web pages as the data source for the Canadian electricity generation and disposition data.

### Churchill Falls

Special attention must be paid to the hydroelectric data for Newfoundland and Labrador (NL) and Quebec (QC). The Churchill Falls facility is physically located within the NL provincial boundary and is owned and operated by a crown corporation named CFLCo that is registered in NL. Hydro Quebec holds about 33% of the shares of CFLCo. All electricity generated at the facility is hydroelectric in nature and is transmitted via Hydro Quebec infrastructure to end markets within QC, Labrador, the rest of Canada, and exported to the US. The electricity generated at Churchill Falls facility represents the entirety of the NL “net\_inter\_regional\_trade\_gwh” value. Since it goes directly to QC, if we are to properly represent the fuel mix for electricity "generated" and “consumed” for QC, we must re-allocate the electricity from the Churchill Falls facility to QC. Failure to do so would result in a dirtier mix of fuels being used to meet the demand for electricity imported into QC as it would naturally be assumed to be from the North American East grid inter-tie, which is not 100% hydroelectric.

### StatsCan – Statistics Canada

Open a web browser and enter the following URL to open the Statistics Canada search page:

<http://www.statcan.gc.ca/search-recherche/index-eng.htm>

Enter either “57-202-x” or “Electric Power Generation, Transmission, and Distribution” into the search form and press the “Search” button. You are looking for a link to a publication titled “Electric Power Generation, Transmission and Distribution”.

At the time of writing, the most recent release of this publication was found at the following URL:

<http://www.statcan.gc.ca/pub/57-202-x/2007000/t002-eng.htm>

The tables of interest for reporting year 2007 are:

* Table 2 “Generation of Electricity, 2007”   
  URL: <http://www.statcan.gc.ca/pub/57-202-x/2007000/t002-eng.htm>,
* Table 3 “Supply and disposition of electric energy, electric utilities and industry, 2007“  
  URL: <http://www.statcan.gc.ca/pub/57-202-x/2007000/t003-eng.htm>, and
* Table 6-2 “Electric utility thermal plants – Electric power generation, 2007”  
  URL: <http://www.statcan.gc.ca/pub/57-202-x/2007000/t007-eng.htm> .

### Electricity Supply and Disposition

Statistics Canada is the source of data for this section.

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “Regional Electricity Profiles” worksheet. Using the data in Table 3 “Supply and disposition of electric energy, electric utilities and industry”, update the Canadian information in the pale yellow cells in the “Regional Electricity Profiles” worksheet. Pay special attention to QC and NL as some of the values need to be adjusted to account for the net effects of Churchill Falls on each province, you will need to fill in cells in columns V “Original net\_generation\_gwh) and W “Original net\_inter\_regional\_trade\_gwh” but only for NL and QC.

Note that this will be a time consuming process and is potentially error prone as individual values are copied from the web page and pasted into the Excel file. The special situation with QC and NL presents an additional opportunity for errors.

### Electricity Generation by Fuel Type

Statistics Canada is the source of data for this section.

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “CAN Generation Data” worksheet. Using the data in Table 2 “Generation of Electricity”, update the “Hydro” and “Wind and Tidal” information in the “CAN Generation Data” worksheet. Using the data in Table 6-2 “Electric utility thermal plants – Electric power generation”, update the information in the remaining pale yellow cells in the “CAN Generation Data” worksheet. Due to Churchill Falls, you will need to fill in cells E23 and E24 “Original Hydro MWH” for both QC and NL so that the corrected Hydro values can be calculated using the “Original net\_inter\_regional\_trade\_gwh” for NL from the “Regional Electricity Profiles” worksheet.

Note that this will be a time consuming process and is potentially error prone as individual values are copied from the web page and pasted into the Excel file. The special situation with QC and NL presents an additional opportunity for errors.

## MEXICO

Mexico presents an interesting situation. Unlike for the US and Canada, no raw data was readily available for Electricity Generation by Fuel Type for Mexico. Instead, summary data was obtained from the EIA – US Energy Information Administration and from IEA – International Energy Agency. The electricity generation data for Mexico was sourced from the EIA - U.S. Energy Information Administration and from the IEA – International Energy Agency.

Additionally, Mexico exports electricity to all 4 US border -states: California, Arizona, New Mexico, and Texas. This means that Mexico is effectively interconnected to all three of the North American grid inter-ties. The vast majority of this electricity export flows to California (approximately 92% of the total amount reportedly imported into the US from Mexico in 2008). Consequently, we chose to constrain Mexico to being included in only the Western Interconnection (what we are referring to as the North America West grid inter-tie).

### Electricity Supply and Disposition

The EIA – U.S. Energy Information Administration is the source of data for this section.

Open a web browser and enter the following URL:

<http://www.eia.gov/fuelelectric.html>

Under the “Reports” group, click the “Electric Power Annual” link to open the “Electric Power Annual” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html>

Under the “Tables by Chapter” group on the right hand side of the web page, click the Chapter 6 “Trade” link for Table 6.3 “U.S. Electricity Imports from and Electricity Exports to Canada and Mexico”. The table is available in HTML, XLS and PDF form. The explicit URLs for these links are:

<http://www.eia.doe.gov/cneaf/electricity/epa/epat6p3.html>

<http://www.eia.doe.gov/cneaf/electricity/epa/epaxlfile6_3.xls>

<http://www.eia.doe.gov/cneaf/electricity/epa/epaxlfile6_3.pdf>

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “Regional Electricity Profiles” worksheet. Using the data in Table 6.3 “Electric Power Industry - U.S. Electricity Imports from and Electricity Exports to Canada and Mexico”, update the MEX information in the pale yellow cells in the “Regional Electricity Profiles” worksheet.

Note that the “net\_generation\_gwh” value is calculated from the MEX data on the “MEX Generation Data” worksheet and that care must be taken to ensure the units of measure consistency for Mexico since the sources of data use both MWh and GWh.

Note that this step is potentially error prone as individual values are copied from the PDF file and pasted into the Excel file and referenced from other worksheets that may have different units of measure. You may need to manually edit the formula for “net\_generation\_gwh” but just for the MEX data.

### Electricity Generation by Fuel Type

The IEA – International Energy Agency is the source of data for this section.

Open a web browser and enter the following URL to open the IEA home page:

<http://www.iea.org>

Under the “Quick Menu” group, click the “Statistics & Balances” link to open the “Statistics” web page. The explicit URL for this page is:

<http://www.iea.org/stats/index.asp>

Under the “Statistics by Product” group, click the “Electricity/Heat” link to open the “Electricity/Heat” web page. The explicit URL for this page is:

<http://www.iea.org/stats/prodresult.asp?PRODUCT=Electricity/Heat>

Set “OECD Member Countries” to “Mexico” to open the “Electricity/Heat in Mexico” web page. The explicit URL for this page is:

<http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=MX>

This page includes electricity generation by fuel type as well as generation and disposition information.

Open the “USLCID\_Electricity\_Generation.xlsx” workbook, click on the “MEX Generation Data” worksheet. Using the data in “Electricity/Heat in Mexico” web page, update the information in the pale yellow cells in the “MEX Generation Data” worksheet.

The “TOTAL GWh” field is a summation of the electricity generated by the individual fuel types and is referenced by the “net\_generation\_gwh” field on the “Regional Electricity Profiles” for MEX.

Note that the unit of measure for electricity generation in Mexico from the IEA is GWh while the summary import/export data from the EIA is reported in MWh.

#### Coal Production

The electricity generation by fuel type data is presented in a manner that makes it difficult to affiliate data values into appropriate “Energy Source” buckets. For instance, the value of electricity generated by “Coal” does not offer any useful information about the specific species of coal used for the task. To overcome this shortcoming and the lack of available raw data the “Coal Production” data for Mexico was used.

Open a web browser and enter the following URL to open the EIA home page:

<http://www.eia.doe.gov/>

Under the “Geography” group, click the “International” link to open the “International Data” web page. The explicit URL for this page is:

<http://www.eia.doe.gov/emeu/international/contents.html>

Under the “Coal” group, click the “Production“ link to open the “International Energy Statistics” web page. The explicit URL for this page is:

<http://tonto.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=1&pid=7&aid=1>

This is a dynamic page that presents a user interface form. Make sure that both “Coal” and “Production” tabs are selected. Change the following input fields: “Country” to “Mexico”, “Product” to “All Products, “Single Year” to the year of interest (i.e., 2007), then click the “Update” button.

Coal production for 2007 in Mexico was 100% Bituminous coal, with no breakdown for Sub-Bituminous Coal. Consequently, the electricity generated by coal in Mexico was 100% allocated to the Bituminous Coal fuel type.

## eGRID Subregion Mapping

The grid is really one big mixing pot of electricity from all interconnected generating facilities across North America. EPA eGRID Subregions are traditionally associated with US electricity generating facilities. For the US States, it is relatively straight forward to identify how much generated electricity contributes to each eGRID Subregion since each facility can easily be associated with one eGRID Subregion.

Integrating the Canadian regional contributions into eGRID Subregion electricity generation profiles is essential to ensure that the electricity profile is more representative of the electricity mix that is actually consumed within the eGRID Subregions. Since eGRID Subregions are representative of US specific electricity generation and consumption areas, it was decided that Canadian contributions to eGRID Subregions would consist of the internationally exported values instead of the net generation values for interconnected Canadian generating regions. To achieve this, the raw net electricity generation by energy source values from are multiplied by a factor equal to Total International Exports / Total Net Generation for each interconnected Canadian generating region.

As previously mentioned, the Mexican raw electricity generation data is constrained to consist of just the GWh imported into the USA. Consequently, the Mexican electricity generation data being integrated into the eGRID Subregions can be integrated without further manipulation.

The following map identifies the eGRID Subregions for the United States was obtained from the following URL:

<http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007_eGRID_subregions.jpg>

### eGRID2007_eGRID_subregions.jpgeGRID Subregion Mapping to Canadian and Mexican Generating Regions

Figure Map of eGRID Subregions

Mexico and Canadian generating regions can easily mapped to eGRID Subregions based on which NERC Region each generating region belongs to in addition to their physical proximity to eGRID Subregions.

Table CAN and MEX Region to eGRID Subregion Mapping

| **Region** | **eGRID Subregion** |
| --- | --- |
| AB | NWPP |
| BC | NWPP |
| MB | MROW |
| MEX | CAMX |
| NB | NEWE |
| NL | #N/A |
| NS | NEWE |
| NT | #N/A |
| NU | #N/A |
| ON | NYUP |
| PE | NEWE |
| QC | NYUP |
| SK | MROW |
| YT | #N/A |

For Mexico, we are allocating 100% of its exported to US electricity to North America West intertie (and hence WECC and CAMX) since most of it goes to California.

Mapping values of “#N/A” means that the region does not contribute to any eGRID Subregions.

In the “USLCIDB\_Electricity\_Generation.xlsx” file, click on the “LOOKUPS” worksheet and scroll to the right until coming to an area titled “CAN and MEX Region to eGRID Subregion Mapping”. If there are any changes to how Canada and Mexico are mapped to eGRID Subregions, they should be entered here.

### eGRID Subregion Mapping to U.S. Facilities

The EIA – U.S. Energy Information Administration and EPA – Environmental Protection Agency are the sources of the data for this section.

The eGRID Subregions can be mapped to the EIA US generating facilities using the facility zip codes and the EPA Power Profiler tool.

#### Step 1 – EIA Plant Data

Open a web browser and enter the following URL:

<http://www.eia.gov/fuelelectric.html>

Under the “Electricity Databases” group, click on the “more ...” link to navigate to the “Electricity Data Files” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/page/data.html>

Scroll down to “EIA-860” in the “Survey Form” column. Click on the link in the “Get the Data” column to navigate to the “Form EIA-860 Database” web page. The explicit URL for this link is:

<http://www.eia.doe.gov/cneaf/electricity/page/eia860.html>

On the right hand side of this page you will see a table titled “Downloads”. In the “Year” column, find the most recent year that contains Finalized annual data. Note that this is one of the reports that the EPA uses for compiling its eGRID reports for mapping generating facilities to eGRID Subregions. In the “Format” column, click on the link named “ZIP” to download a ZIP package. When prompted, save the ZIP package to your hard disk. The ZIP file will be named similar to “f860yYY.zip” where YY is the year, e.g., “f860y08.xls” was the most recent file at the time of writing this document. The file that contains the plant data is in an excel file named:

“PlantYYY.xls” (e.g., “PlantY08.xls”)

Open the “PlantYYY.xls” file in Microsoft Excel, click on the worksheet named “PlantYYY” to access the plant data. Select and copy columns named “UTILCODE”, “PLNTCODE”, “PLNTNAME”, “MAIL\_STREET\_ADDRESS”, “MAIL\_CITY”, “COUNTY”, “STATE”, “ZIP5”, NAME\_OF\_WATER\_SOURCE”, “NERC”.

In the “USLCIDB\_Electricity\_Generation.xlsx” file, click the “EIA Facility to eGRID Subregion” worksheet tab. Paste the information into Column A.

In either file, select and copy all values in the “ZIP5” column. You will be pasting this into the EPA Power Profiler tool to map US zip codes to eGRID Subregions.

#### Step 2 – EPA Power Profiler

Open a web browser and enter the following URL:

<http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html>

Scroll to the bottom of the page and click on the link titled “Power Profiler eGRID Subregion and GHG emissions finder tool (XLS)” to download an Excel file named “Power\_Profiler\_Zipcode\_Tool\_v1-0.xls” (or similar). The explicit URL for this link is:

<http://www.epa.gov/cleanenergy/documents/egridzips/Power_Profiler_Zipcode_Tool_v1-0.xls>

Save the file to your local hard drive. Double-click the file “Power\_Profiler\_Zipcode\_Tool\_v1-0.xls” to launch Excel and open the file. Click on the “Data Entry” worksheet to open the “Data Entry” worksheet.

In the “ZIP CODE” column paste the zip codes you copied from the “ZIP5” column of either the “PlantYYY.xls” file or the “USLCIDB\_Electricity\_Generation.xlsx” file.

Select and copy the contents of the columns containing the zip codes and the Primary, Secondary & Tertiary eGRID Subregion mapping.

In the “USLCIDB\_Electricity\_Generation.xlsx” file, click on the “LOOKUPS” worksheet then scroll to the right until you see an area titled “eGRID Subregion to 5-DIGIT ZIP CODE MAPPING”. Paste the zip code to eGRID Subregion mapping data from the EPA Power Profiler here. Be sure to sort by “5-DIGIT US ZIP CODE”.

The data here is used to automatically update the “EIA Facility to eGRID Subregion”, “EIA 906920”, “eGRID Subregion Generation Data” and “eGRID Subregion Composition” worksheets.

#### Step 3 – Facility to eGRID Subregion Mapping Corrections

In the “USLCIDB\_Electricity\_Generation.xlsx” file, click on the “EIA Facility to eGRID Subregion” worksheet, it will now contain an incomplete mapping of EIA facilities to eGRID Subregions, some facility data is incomplete or inaccurate and the EPA Power Profiler zip code to eGRID Subregion mapping tool is only as up to date as the latest eGRID version. Check column “K” titled “eGRID Primary Subregion” for errors. You will need to manually associate an eGRID Subregion to facilities that do not map cleanly to eGRID Subregions based on the 5 digit zip code. Do this in Columns “L” titled "Corrected Orphans". Capture any remarks in column “N” titled “Remarks” to identify how you resolved each mapping error.

The following list contains examples for correcting mapping errors that were applied to the 2008 vintage of US data.

* Applied same subregion as other facilities in same county.
* Applied same subregion as other facilities in surrounding zip codes.
* Applied same subregion as majority of other facilities in same state.
* Applied same subregion as majority of other facilities in same state and same NERC region.
* Plant code missing, added from EIA 906920. Applied same subregion as majority of other facilities in same state and same NERC region.
* Plant code missing, added from EIA 906920. Applied same subregion as majority of other facilities in same state.
* Original ZIP code 62525 is for Decatur IL not FL. Using 32525 as correct ZIP code for FL, applied same subregion as other facilities in surrounding zip codes.

# Database Population & Update

This section contains an overview of the database core tables, sanity check reports, and details for populating and updating the database tables.

This section can be considered optional if the end user is not interested in modelling North American Electricity Generation by Energy Source profiles. In particular, as mentioned above, if only the NERC Region and eGRID Subregion profiles are of interest, then the data contained with the excel file “USLCIDB\_Electricity\_Generation.xlsx” in the “NERC Region Generation Data” and “eGRID Subregion Generation Data” worksheets will be sufficient.

## Core Tables

The following is a list of the core database tables:

* CompositeElectricityGenerationByRegionByEnergySource,
* ElectricityGenerationByRegionByEnergySource,
* ElectricityGrid, ElectricityGridComposition,
* EnergySource,
* ManufacturingRegion,
* ManufacturingRegionComposition, and
* Region

All of these tables are all pre-populated with 2008 (USA) and 2007 (CAN, MEX) data. Of these, the following tables will periodically need to be updated when new Electricity Generation raw data becomes available while the other tables are not expected to require periodic updates.

* Region and
* ElectricityGenerationByRegionByEnergySource

After the raw data is updated, a stored procedure will need to be executed to further update the following tables:

* Region,
* ElectricityGenerationByRegionByEnergySource, and
* ElectricityGenerationByRegionByEnergySource tables.

## Sanity Check Reports

As you proceed with inserting or updating data in one or more tables, it is strongly advised to run one or more of the Sanity Check reports that are located in the “ScriptsSanityCheck” sub folder. In particular, the “SanityCheck.RawDataChecks.sql” sanity check report should be run after any raw data inserts or updates.

The list of Sanity Check Reports includes the following:

1. SanityCheck.RawDataChecks.sql - run this report constantly as data is entered or updated.
2. SanityCheck.SummationErrors.sql - run this report after the data has been updated for either of the following tables:
   1. ElectricityGenerationByRegionByEnergySource
   2. CompositeElectricityGenerationByRegionByEnergySource

The following are instructions for executing the “SanityCheck.RawDataChecks.sql” sanity check report.

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Click the “Open” button to launch the “Open File” form.
5. Navigate to the “ScriptsSanityCheck” sub-folder.
6. Click on “SanityCheck.RawDataChecks.sql”.
7. Click the “Execute” button to run the sanity check.

## Step 1 - EnergySource

The EnergySource table is the first table to be populated. This table is pre-populated and should not require being repopulated. The following is included for reference purposes.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “EnergySource” worksheet. After changing the information in the Excel file, the corresponding data in the “EnergySource” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.EnergySource.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “EnergySource” worksheet.
11. Select the contents of column “E” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

## Step 2 - Region

The Region table is the second table to be populated. This table is pre-populated and should not require being repopulated; it will however need to be updated when new electricity generation statistics become available. . There are two cases for which this table will need population or updating.

* CASE 1 :: Initial population (or table recreation).
* CASE 2 :: Updating the region level data.

### CASE 1 - Initial population (or table recreation)

The following is included for reference purposes.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “Region” worksheet. After changing the information in the Excel file, the corresponding data in the “Region” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.Region.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the dependent data as well as the old data in the Region table. Don’t worry, the dependent data will be repopulated.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “Region” worksheet.
11. Select the contents of column “T” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

### CASE 2 - Updating Region records

When new electricity generation statistics become available, you will use the gathered generating region level (State, Province, and Territory) raw data to update the corresponding data in the Region table. The fields that will be updated include the following list:

* year,
* net\_generation\_gwh,
* total\_international\_exports\_gwh,
* total\_international\_imports\_gwh,
* net\_inter\_regional\_trade\_gwh,
* net\_trade\_index\_ratio,
* estimated\_losses\_gwh,
* estimated\_losses\_to\_total\_supply\_ratio,
* source

The information used for updating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “Regional Electricity Profiles” worksheet. After updating the information in the Excel file, the corresponding data in the “Region” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsUpdateData” sub-folder.
7. Click on “Update.Region\_RegionalElectricityProfiles.yyyymmdd.sql”.
8. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “Regional Electricity Profiles” worksheet.
9. Select the contents of column “Y” labelled “SQL UPDATE STATEMENTS for the Region table” that contain UPDATE scripts.
10. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
11. Click the “Execute” button to insert the new data.
12. Backup the database.

## Step 3 - ElectricityGrid

The ElectricityGrid table is the third table to be populated. This table is pre-populated and should not require being repopulated. The following is included for reference purposes.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “ElectricityGrid” worksheet. After changing the information in the Excel file, the corresponding data in the “ElectricityGrid” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.ElectricityGrid.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data from the ElectricityGrid table.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “ElectricityGrid” worksheet.
11. Select the contents of column “G” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

## Step 4 - ElectricityGridComposition

The ElectricityGridComposition table is the fourth table to be populated. This table is pre-populated and should not require being repopulated. The following is included for reference purposes.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “ElectricityGridComposition” worksheet. After changing the information in the Excel file, the corresponding data in the “ElectricityGridComposition” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.ElectricityGridComposition.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data from the ElectricityGridComposition table.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “ElectricityGridComposition” worksheet.
11. Select the contents of column “G” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

## Step 5 - ManufacturingRegion

The ManufacturingRegion table is the fifth table to be populated. This table is pre-populated and should not require being repopulated. The following is included for reference purposes.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “ManufacturingRegion” worksheet. After changing the information in the Excel file, the corresponding data in the “ManufacturingRegion” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.ManufacturingRegion.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data from the ManufacturingRegion table.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “ManufacturingRegion” worksheet.
11. Select the contents of column “G” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

## Step 6 - ManufacturingRegionComposition

The ManufacturingRegionComposition table is the sixth table to be populated. This table is pre-populated and should not require being repopulated. The following is included for reference purposes.

The field named “contribution\_factor” was added to the ManufacturingRegionComposition table so that generating regions (i.e., states, provinces, and territories) could contribute to one or more Manufacturing Regions. At present (August 2010) all records have “contribution\_factor” equal to 1..

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook on the “ManufacturingRegionComposition” worksheet. After changing the information in the Excel file, the corresponding data in the “ManufacturingRegionComposition” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.ManufacturingRegionComposition.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data from the ManufacturingRegionComposition table.
10. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “ManufacturingRegionComposition” worksheet.
11. Select the contents of column “L” labelled “SQL INSERT STATEMENTS” that contain INSERT scripts.
12. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE ----------".
13. Click the “Execute” button to insert the new data.
14. Backup the database.

## Step 7 - ElectricityGenerationByRegionAndEnergySource

The ElectricityGenerationByRegionByEnergySource table is the seventh (and last) table to be manually populated. This table is pre-populated but will require updating when new electricity generation statistics are available.

The information used for populating this table is found in the “USLCIDB\_Electricity\_Generation.xlsx” workbook across multiple worksheets. After changing the information in the Excel file, the corresponding data in the “ElectricityGenerationByRegionByEnergySource” table can be updated by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Click the “Open” button to launch the “Open File” form.
6. Navigate to the “ScriptsInsertData” sub-folder.
7. Click on “Insert.ElectricityGenerationByRegionByEnergySource.yyyymmdd.sql”.
8. Enable the deletion scripts in Step #1
9. Click the “Execute” button to delete the old data from the ElectricityGenerationByRegionByEnergySource and CompositeElectricityGenerationByRegionByEnergySource tables.
10. US DATA
    1. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “US Generation Data” worksheet.
    2. Select the contents of columns “CE through CW” labelled “SQL INSERT records into ElectricityGenerationByRegionByEnergySource” that contain INSERT scripts.
    3. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE – USA DATA ---------".
11. CAN DATA
    1. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “CAN Generation Data” worksheet.
    2. Select the contents of columns “BI through CA” labelled “SQL INSERT records into ElectricityGenerationByRegionByEnergySource” that contain INSERT scripts.
    3. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE – CAN DATA ---------".
12. MEX DATA
    1. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “MEX Generation Data” worksheet.
    2. Select the contents of columns “BI through CA” labelled “SQL INSERT records into ElectricityGenerationByRegionByEnergySource” that contain INSERT scripts.
    3. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE – MEX DATA ---------" in STEP #2.
13. NERC Region DATA
    1. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “NERC Region Generation Data” worksheet.
    2. Select the contents of columns “CG through CY” labelled “SQL INSERT records into ElectricityGenerationByRegionByEnergySource” that contain INSERT scripts.
    3. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE – NERC Region DATA ---------".
14. eGRID Subregion DATA
    1. Open the Excel workbook “USLCIDB\_Electricity\_Generation.xlsx” workbook and click the “eGRID Subregion Generation Data” worksheet.
    2. Select the contents of columns “CG through CY” labelled “SQL INSERT records into ElectricityGenerationByRegionByEnergySource” that contain INSERT scripts.
    3. Paste the info into the Insertion area denoted by "-- ---------- PASTE HERE – eGRID Subregion DATA ---------".
15. Click the “Execute” button to insert the new data.
16. Backup the database.

Note that steps 10, 11, and 12 are error prone since they involve numerous columns of data being individually copied and pasted. You need to be diligent to ensure that data for each energy source is copied and pasted so that the data is complete.

## Step 8 - CompositeElectricityGenerationByRegionAndEnergySource

When new electricity generation statistics become available and after updating the raw data in the Region and ElectricityGenerationByregionAndEnergySource tables, you will need to execute a single “control” stored procedure named “sp\_Update\_RunAllElectricityDataUpdateStoredProcedures”.

In general, the stored procedure will do the following:

* Correct for data discrepancies.
* Determine and populate the Region and ElectricityGenerationByregionAndEnergySource tables for all Grid regions and Macro (Manufacturing) regions.
* Determine and populate the CompositeElectricityGenerationByRegionAndEnergySource table for all Generating regions that belong to Grid Inter-ties and for the Macro (Manufacturing) regions.

Execute the stored procedure by following these steps:

1. Launch Microsoft SQL Server Management Studio Express.
2. Expand the “Databases” collection in the “Object Explorer”.
3. Right-click on the “USLCIDB\_Electricity\_Generation” database.
4. Backup the database.
5. Expand the “Programmability” collection.
6. Expand the “Stored Procedures” collection.
7. Right-Click the “sp\_Update\_RunAllElectricityDataUpdateStoredProcedures” stored procedure and select “Script Stored Procedure As” then select the “Execute To” then select the “New Query Editor Window”.
8. Right-Click the “sp\_Update\_RunAllElectricityDataUpdateStoredProcedures” stored procedure and select “Modify” then select the “Execute To” then select the “New Query Editor Window”.
   1. Enable each section that you intend to execute. I recommend executing each step individually and in sequence (i.e., 1, 2, 3 ... 11) to avoid data inter-dependency issues and to simplify trouble-shooting any errors that may occur.
   2. Click the “Execute” button to commit the changes to the database. NOTE: Clicking “Execute” here does not cause the stored procedure to execute, rather it simply commits (stores) the changes you just made to the database.
   3. Switch back to the Query Window that you opened in step #7 when you first right-clicked the “sp\_Update\_RunAllElectricityDataUpdateStoredProcedures” stored procedure. Click the “Execute” button to execute the stored procedure.
   4. Comment out the recently executed step
   5. Continue until all steps are executed.
9. Backup the database.

To simplify identification and troubleshooting any data errors, we recommend running the “SanityCheck.RawDataChecks.sql” sanity check report after completion of each step of this stored procedure. It is also advisable to run the “SanityCheck.SummationErrors.sql” sanity check report after all steps have been completed.

While executing, the stored procedure “sp\_Update\_RunAllElectricityDataUpdateStoredProcedures” carries out the following detailed actions:

1. Insert missing energy source records for each generating region into the Electricity Generation By Region By Energy Source table. This is done to facilitate the determination of the consolidated Electricity Generation By Region By Energy Source.
2. Zero the net\_generation\_ratio\_by\_region and net\_generation\_gwh values in the Electricity Generation By Region By Energy Source table for all records where the energy\_source is “Total”. These values included rounding errors and will be calculated in a subsequent step.
3. Insert or Update Electricity Generation By Region by Energy Source for all manufacturing (macro) regions. Values being updated are net\_generation\_gwh and net\_generation\_ratio\_by\_region.
4. Update the Region table for each manufacturing (macro) region. Values updated include net\_generation\_gwh, total\_internatioal\_exports\_gwh, total\_internatioal\_imports\_gwh, net\_inter\_regional\_trade\_gwh, estimated\_losses\_gwh, net\_trade\_index\_ratio, and source.
5. Update the value for Electricity Generation By Region By EnergySource net\_generation\_ratio\_by\_region for all regions.
6. Update the Region net\_trade\_index\_ratio for all regions.
7. Update Region fields for North American Grid Inter-tie regions (NAE, NAW). Texas is standalone and is already done via raw data and executed Stored Procedures. NAT will be calculated based on NAE, NAW and Texas. Values updated include net\_generation\_gwh, total\_internatioal\_exports\_gwh, total\_internatioal\_imports\_gwh, net\_inter\_regional\_trade\_gwh, estimated\_losses\_gwh, net\_trade\_index\_ratio, and source.
8. Update Region estimated\_losses\_to\_total\_supply\_ratio data for all regions
9. Update the Electricity Generation By Region By Energy Source table for North American Grid Inter-tie regions (NAE, NAW). Texas is standalone and is already done via raw data and executed Stored Procedures. NAT will be calculated based on NAE, NAW and Texas. Updated fields include net\_generation\_gwh, source, and net\_generation\_ratio\_by\_region.
10. Insert records into the Composite Electricity Generation by Region by Energy Source table for all generating regions.
11. Insert records into the Composite Electricity Generation by Region by Energy Source table for all manufacturing (macro) regions.

## Step 9 - Generate USLCI Database Reports

There are a number of stored procedures (having names with a “sp\_Get” prefix) and standalone queries that have been created for extracting data from the database.

Additional standalone queries can be found in the “ScriptsGetData” sub-folder of the following parent folder:

“C:\Users\cgoemans\Documents\SQL Server Management Studio Express\Projects\USLCIDB\_Electricity\_Generation\”

The CompositeElectricityGenerationByRegionByEnergySource table contains the final state of the electricity for all generating (Type-A) regions, macro/manufacturing (Type-B) regions, and grid inter-tie (Type-C) regions. The query that extracts detailed information from this table is probably the one that is of most interest. This report is named:

“CompositeElectricityGenerationByRegionByEnergySource.Details.sql”

# APPENDIX 1 - Data Sources and References

## NERC References

**2010 Data Update:**

* North American Electric Reliability Corporation (NERC) :: <http://www.nerc.com/>

## eGRID References

**2010 Data Update:**

* EPA – eGRID :: <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>

## Canadian References

**2010 Data Update:**

* Statistics Canada :: Electric Power Generation, Transmission and Distribution :: <http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=57-202-XWE&lang=eng> , data vintage is 2007 as of 09 August 2010. PDF file link is :: <http://www.statcan.gc.ca/pub/57-202-x/57-202-x2007000-eng.pdf>
* Statistics Canada :: Report on Energy Supply and Demand in Canada :: <http://www.statcan.gc.ca/pub/57-003-x/57-003-x2008000-eng.htm>
* CANSIM tables used for Stats Can Report on Energy Supply and Demand in Canada :: <http://cansim2.statcan.ca/cgi-win/CNSMCGI.PGM?Lang=E&ArrayId=131-0002,129-0001,129-0002,129-0003,129-0004,128-0010,127-0001,128-0012,134-0001,128-0013,128-0005,126-0001,134-0002,128-0014,128-0006,134-0003,133-0001,128-0015,134-0004,133-0002,133-0003,128-0009,303-0016,133-0004,133-0005,131-0001&Array_Pick=1&Detail=1&ResultTemplate=CII/CII___&RootDir=CII/&TblDetail=1> (not free)

**2008 Data Update:**

* <http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/tdm-toc_eng.cfm>
* Fuel consumption data are available from the RESD (Statistics Canada, #57-003-XIB) :: <http://www.statcan.ca/bsolc/english/bsolc?catno=57-003-X>
* Electric Power Generation, Transmission and Distribution (EPGTD) publication (Statistics Canada, #57-202-XIB). :: <http://www.statcan.ca/bsolc/english/bsolc?catno=57-202-X>
* <http://www.canelect.ca/en/electricityincanada/electricity_in_canada_links_other.html>
* Energy Statistics Handbook :: <http://www.statcan.ca/bsolc/english/bsolc?catno=57-601-XWE>

## US References

**2010 Data Update:**

* EPA – eGRID :: <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>
* EPA – Power Profiler home page :: <http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html>
* EIA – Electricity Data home page :: <http://www.eia.gov/fuelelectric.html>
* EIA –Electricity Data Tables :: <http://www.eia.doe.gov/cneaf/electricity/page/data.html>
* EIA –State Data Tables :: <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html>
* EIA - Electric Power Annual summary :: <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html>
* EIA – State Energy Profiles :: <http://tonto.eia.doe.gov/state/>
* EIA – State Electricity Profiles :: <http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html>
* EIA – State Electricity Profile PDF Report (2008) :: <http://www.eia.doe.gov/cneaf/electricity/st_profiles/sep2008.pdf>

**2008 Data Update:**

* Annual Energy Review :: <http://www.eia.doe.gov/emeu/aer/contents.html>
* Electrical Power Summary :: <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html>
* Notes :: <http://www.eia.doe.gov/emeu/iea/Notes%20for%20Table%201_5.html>
* Glossary of Terms :: <http://www.eia.doe.gov/emeu/iea/glossary.htm>
* Country and Region Definitions :: <http://www.eia.doe.gov/emeu/iea/geograph2005.html>
* Sources :: <http://www.eia.doe.gov/emeu/iea/6source.html>
* <http://www.eia.doe.gov/cneaf/electricity/epa/epates2.html> :: Losses and Unaccounted For include: (1) reporting by utilities and power marketers that represent losses incurred in transmission and distribution, as well as volumes unaccounted for in their own energy balance; and (2) discrepancies among the differing categories upon balancing the table.

## Mexican references

**2010 Data Update:**

* International Energy Agency (IEA): <http://www.iea.org>
* US DOE :: U.S. Electricity Imports from and Electricity Exports to Canada and Mexico ::<http://www.eia.doe.gov/cneaf/electricity/epa/epat6p3.html>
* International Energy Agency (IEA) :: IEA Statistics for Electricity/Heat in Mexico in 2005 :: <http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=MX>

**2008 Data Update:**

* International Energy Agency (IEA): <http://www.iea.org>
* North American Electricity Reliability Corporation : <http://www.nerc.com>
* US DOE :: U.S. Electricity Imports from and Electricity Exports to Canada and Mexico ::<http://www.eia.doe.gov/cneaf/electricity/epa/epat6p3.html>
* International Energy Agency (IEA) :: IEA Statistics for Electricity/Heat in Mexico in 2005 :: <http://www.iea.org/Textbase/stats/electricitydata.asp?COUNTRY_CODE=MX>
* US DOE :: Country Energy Balance – Mexico :: <http://www.eia.doe.gov/emeu/world/country/cntry_MX.html>

## MAPS

**2010 Data Update:**

* No new references used for this data update.

**2008 Data Update:**

* Atlas of Canada - Map of Electricity Generation by Fuel Type (1997) :: <http://atlas.nrcan.gc.ca/site.english/english/maps/economic/generatingstations/allbyfuel>
* Map of Canadian Electricity Grid :: <http://www.geni.org/globalenergy/library/national_energy_grid/canada/canadiannationalelectricitygrid.shtml>
* NERC Map of Western, Eastern and Texas Interconnections :: <http://www.nerc.com/fileUploads/File/AboutNERC/maps/NERC_Interconnections_color.jpg>
* Map of US eGRID Subregions :: <http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2007_eGRID_subregions.jpg>
* Atlas of Canada - Map of Electricity Transmission Lines (1987) :: <http://atlas.nrcan.gc.ca/site/english/maps/archives/5thedition/economic/resourceindustries/mcr4144?maxwidth=1200&maxheight=1000&mode=navigator&upperleftx=2096&upperlefty=1856&lowerrightx=5296&lowerrighty=4704&mag=0.125>