DEVELOPING AN AUDITABLE INVENTORY OF METHANE, NITROUS OXIDE AND CARBON DIOXIDE USING THE SANGEA™ ENERGY AND EMISSIONS ESTIMATING SYSTEM

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ABSTRACT

ChevronTexaco believes that global climate change is an important issue and is taking action to address it in a comprehensive way. We recently implemented a corporate-wide system for estimating greenhouse gas emissions and energy utilization.

The SANGEA™ Energy and Emissions Estimating System, developed by ChevronTexaco, is an automated, electronic data management information system that is designed to gather monthly energy and greenhouse gas emissions data from ChevronTexaco's worldwide exploration and production, refining and marketing, petrochemicals, transportation and coal activities. The system enables users to estimate emissions of methane, nitrous oxide and carbon dioxide. In order to promote standardization of methodologies and comparability of approaches, we are making the system available free of charge to potentially interested users.

ChevronTexaco Corporation and its Chevron, Texaco and Caltex facilities enter data to calculate greenhouse gas and criteria pollutant emissions, as well as energy utilization on a monthly basis. At the end of each quarter, energy and emission estimates are reported to ChevronTexaco Corporation.

This paper will provide a brief overview of the SANGEA™ system and highlight key innovations. It will also summarize lessons learned during system implementation, and outline how the system has been applied to a variety of business activities, including methane venting, coal mining and carbon dioxide utilization.

SANGEA™ helps ChevronTexaco's business by enabling each facility to efficiently measure and therefore manage energy utilization and greenhouse gas emissions. Minimizing energy utilization saves money and helps us operate more efficiently. Managing our greenhouse gas emissions helps us address the

important issue of global climate change in a verifiable and proactive manner, and demonstrates our commitment to deal with this issue.

INTRODUCTION

ChevronTexaco Corporation is a global company providing energy and chemical products and services vital to the growth of the world's economies. Our core values include a commitment to protecting the safety and health of people and the environment. This commitment is a critical component of the value we deliver to our stockholders, customers, government partners and employees.

ChevronTexaco Corporation is responding to the concern about climate change with a four-fold plan of action. We are:

- Reducing emissions of greenhouse gases and increasing energy efficiency
- Investing in research, development and improved technology
- Pursuing business opportunities in promising innovative energy technologies
- Supporting flexible and economically sound policies and mechanisms that protect the environment

ChevronTexaco's SANGEA™ Energy and Emissions Estimating System was designed to enable us to establish a reliable baseline and have a verifiable inventory of greenhouse gas emissions. This will enable us to pursue our goal of reducing emissions per unit output from our operations.

WHAT IS THE SANGEA™ SYSTEM?

The SANGEA™ Energy and Emissions Estimating System is an Excel-based auditable energy and greenhouse gas inventory system, with calculations driven by a Visual Basic add-in. It is a comprehensive management system that provides for data collection, data entry, computation, compilation, reporting, recordkeeping and data management in an Oracle data base at the corporate level.

ChevronTexaco Corporation developed the SANGEA™ system using our decision-driven project management process. Representatives from the major business units actively participated in developing the system. In addition, we hired external consultants to provide programming expertise and also gain perspective on greenhouse gas inventory issues and expertise in auditing.

The SANGEA™ system:

- Requires monthly data input
- Enables facilities to submit quarterly reports to the corporation
- Requires documentation of data sources so that the data is verifiable
- Provides for a consistent approach across all of ChevronTexaco

- Yields emissions and energy utilization information that can be reviewed and analyzed by the facilities in real-time, enabling each facility to manage its own emissions.
- Is highly automated, with the ability for transfer of input data from existing accounting systems into the spreadsheet, automatic quarterly reporting from facilities to the corporation and standard reports generated for each facility by the software.

Key innovations are:

- Combining greenhouse gas emissions and energy utilization estimates. Because the input data used to estimate energy utilization is a subset of data used to estimate greenhouse gas emissions, combining the estimates is more efficient for the user, eliminates rework, and ensures consistent energy utilization and greenhouse gas emission data for a given facility.
- Developing an enterprise-wide, complete process for data generation, calculation, analysis, reporting and management. The ability to comprehensively manage data with automatic reporting, downloading, and Oracle database loading and query at the corporate parent level were integral to the design for ChevronTexaco's system.
- The emissions and energy utilization estimation system is modular and Excel-based. The modules allow facilities to customize reports for their operations (e.g., downstream versus upstream). Use of Excel avoids the need for users to load and understand a new software environment.
- The system provides users with the optional ability to estimate criteria pollutant emissions (sulfur oxides, oxides of nitrogen, volatile organic compounds and particulate matter), as well as greenhouse gas emissions and energy utilization.
- The system uses the latest greenhouse gas estimating methodology provided in the *API Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Inventory (API Compendium)* [1].

INVENTORY SCOPE AND BOUNDARIES

The scope and boundaries of a greenhouse gas inventory depend on the purpose of the inventory, and may be driven by business needs (e.g., forecasting), industry standards (benchmarking) or government requirements. The ChevronTexaco greenhouse gas inventory scope and boundaries were discussed in a previous paper [2]. Because the inventory was expected to have several purposes, the scope and boundaries were initially designed based on the principles of completeness, credibility and control.

ChevronTexaco is currently a member of the four-person Drafting Committee that is developing global guidelines for petroleum industry greenhouse gas inventories. When these guidelines are complete, they will provide a common basis for emissions estimating in the oil and gas industry worldwide.

GASES INCLUDED

The SANGEA™ system includes three of the six greenhouse gases listed in the Kyoto Protocol. Carbon dioxide and methane were included because they are expected to be emitted from our operations in significant quantities. Nitrous oxide was also included in the inventory because it can be a minor byproduct of combustion. The other three Kyoto gases were not included in our inventory because they are not expected to be emitted in significant quantities from our operations.

IMPLEMENTING A GREENHOUSE GAS INVENTORY--LESSONS LEARNED

ChevronTexaco implemented the SANGEA™ software in three phases. The first phase of implementation consisted of pilot tests at worldwide upstream and U.S. downstream locations. As a result of these tests, we made changes to the SANGEA™ system to make it more user-friendly, and to improve the flow of information.

The second phase of implementation took place in July 2001, before the Chevron Texaco merger. Initial deployment of the software was done during a training class that was attended by representatives of all Chevron business units. After the training session, SANGEA™ software users were given two months to configure the software for their business units and to enter data for the first nine months of the year. The first reports were to be submitted by mid-October, 2001, and the final year-end report was due in mid-January 2002. The report was to contain full year data for 2001 for each facility.

In addition to the training session, help desk services were available to SANGEA™ software users as they configured their systems, entered data and produced reports. The majority of the users were able to use the SANGEA™ system with little difficulty, and the majority of the reports were delivered on time. Users learned that it was best to have a good understanding of greenhouse gas emission sources, equity shares of operations, and location of facilities. With this information, users could draft a configuration plan before using the software. Although configuration can be changed at any time, it is easier and more efficient to complete the configuration with a minimum of revisions. Also, a comprehensive understanding of the operation is necessary to ensure a complete inventory.

The main problems occurred at facilities that did not have ChevronTexaco's common operating environment software. Because the SANGEA™ software was designed to be used with Windows NT and Excel 97, it did not always function properly with other combinations of operating systems and versions of

Excel. In particular, facilities that had non-English versions of Excel typically encountered difficulties.

Starting in October, 2001, the SANGEA™ system was revised to incorporate learnings from the first phase of implementation, and to be compatible with a planned upgrade of ChevronTexaco's common operating environment from Windows NT/Excel 1997 to Windows XP/Excel 2000.

The SANGEA™ 1.1 system was issued in early 2002, and used in the third phase of implementation by all ChevronTexaco business units.

The SANGEA™ software is designed so that existing users can transfer configuration and input information from existing files to the new software, with little or no rework. This is a significant benefit, because some facilities have implemented highly detailed inventory systems, listing each emissions source individually. It would have taken a great deal of effort to re-enter all of that information. Also, retaining the configuration makes it easier to compare data from year to year.

The third phase of implementation took place in March 2002, after the ChevronTexaco merger. The software deployment incorporated lessons learned from the first and second phases of implementation.

We continue to provide help desk support, and note a high level of activity every three months when the quarterly reports are due. With roughly 70 users, we receive many suggestions for improvements, and plan to incorporate as many as possible into the next version of SANGEA™, which we expect to issue at the end of this year.

THE SANGEA™ SYSTEM AND NON-CO_2 GREENHOUSE GASES

Although carbon dioxide is the most significant greenhouse gas emitted from oil and gas industry operations, the SANGEA™ software also includes methodologies for estimating emissions of methane and nitrous oxide. Details of how these gases are handled in the various modules of the SANGEA™ software and examples of how the software can be used are provided below.

METHANE VENTING

The SANGEA™ software includes a module to characterize the various sources of methane emissions, including

- Gas-operated devices, such as gas-operated valves, actuators, controllers, etc. in gas production, processing or transmission service

- Gas-driven chemical injection pumps, including piston, diaphragm and other types of pumps
- Compressor seal leaks for compressors in natural gas service
- Vessel leaks for vessels and natural gas service
- Oil well workovers
- Gas well workovers and Low Pressure Gas well cleaning
- Pressure relief valves
- Well blowouts
- User-defined methane vents

The SANGEA™ software uses a conservative default emission factor for each of the above categories. The default emission factors are taken from the *API Compendium*; users are encouraged to customize the emission factor if local data is available.

As its name implies, the User-defined methane vent category can be used to incorporate emissions from sources not included in the SANGEA™ software. Users can calculate methane emissions and enter the results directly on the inventory spreadsheet, or link the SANGEA™ input cells to an appropriate calculational spreadsheet. For example, emissions from methane-blanketed tanks are typically estimated based on tank movements. The results of tank movement calculations are entered as a user-defined methane vent in the SANGEA™ system.

METHANE FLASHING

Methane venting can also occur when crude oil or other hydrocarbon liquids move from a vessel with elevated pressure to a vessel at atmospheric pressure. This type of methane emission is called flashing. Methane flashing losses can be estimated using the Flashing module of the SANGEA™ software. Users must enter the initial pressure and temperature of the liquid as well as the final temperature (because gases are flashed to the atmosphere, the final pressure is assumed to be atmospheric). Default values, which can be customized by the user, are provided for the specific gravity of the flash gas, the API gravity of the liquid and the fraction of methane in the flash gas. Flashing losses are estimated using the Vasquez-Beggs equation, as described in the *API Compendium*.

FUGITIVE METHANE EMISSIONS

The SANGEA™ system can be used to evaluate fugitive emissions of methane from upstream and downstream oil and gas industry operations, as well as during gas storage, transmission and distribution. The term 'Fugitive Emissions', as applied here refers to emissions that occur as a result of leaks of liquids or gases from such equipment as valves, flanges, connectors, open-ended lines, pump

seals and compressor seals, as well as pipelines. The SANGEA™ software includes default emission factors based on correlations for the various categories of fugitive leaks and default gas composition data. If users have source specific emission information, the default emission factors can be substituted with source specific emission information, or the methane emission can be estimated and incorporated into the inventory using the User-defined vent category described above.

As an alternative to using the correlation data, fugitive emissions can be estimated based on actual or estimated component counts and either default or user-specified emission factors if such information is available. For petroleum industry operations, fugitive methane emissions are such a small portion of the total greenhouse gas emissions that this level of detail is not necessary.

NITROUS OXIDE

Default emission factors for nitrous oxide are included in the Combustion module of the SANGEA™ system. There is a conservative default emission factor which can be applied to all types of combustion equipment, as well as equipment-specific default factors for major types of combustion equipment, such as turbines, boilers and engines. A conservative default emission factor is sufficient to provide an order of magnitude estimate of nitrous oxide emissions from combustion. This type of estimate demonstrates that even when adjusted for the Global Warming Potential, nitrous oxide emissions from combustion are insignificant compared to carbon dioxide emissions. If a more rigorous evaluation of nitrous oxide emissions from combustion is desired, the user must obtain equipment-specific emission factors. Each type of equipment can be specified separately in the SANGEA™ system, along with the appropriate emission factors.

The SANGEA™ system includes conservative default emission factors for nitrous oxide emissions from flaring and from imported electricity. As in the Combustion module, users can enter site-specific data if available. Emission factors for nitrous oxide emissions from imported electricity are provided for each state in the United States based on recent data from the U. S. Department of Energy[3].

COAL MINING--CASE STUDY

The Pittsburg and Midway Coal Company (P&M Coal), a ChevronTexaco Company, is a good example of a non-petroleum company that uses the SANGEA™ system to manage energy utilization and greenhouse gas emissions from its coal mines in North America. Using the Combustion, Indirect and User-defined Venting modules, emissions of methane, nitrous oxide and carbon dioxide from mine operations, including explosives and mine sweeping, are

estimated. For surface mines, the majority of emissions are from fuel combustion and electricity utilization. For subsurface mines, mine ventilation methane emissions dominate the inventory. The SANGEA™ system enables P&M Coal to have a consistent, auditable data set to manage energy and greenhouse gas emissions from its operations, and is linked to a common set of mine ventilation data that is used for reporting to the U.S. Mine Safety and Health Administration (MSHA).

CONCLUSIONS

Implementation of a companywide software system for consistent estimation of energy, greenhouse gas and criteria pollutant emissions yields numerous benefits. User involvement in development and ongoing improvement of the software is key to successful implementation. Ongoing, centralized support is necessary to keep the system up to date as greenhouse gas emission estimating methodologies and software environments continue to evolve. A modular approach to the inclusion of methane and nitrous oxide improves the efficiency of the Emissions Estimating system, and enables users to more easily analyze the data and managed emissions.

By implementing the SANGEA™ system worldwide at ChevronTexaco's businesses and offering the software free of charge to any interested company or person, ChevronTexaco is promoting the standardization of greenhouse gas emissions estimating methodologies based on the API Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry. Susann Nordrum (email: SBNordrum@chevrontexaco.com) or Arthur Lee (email: RLAS@chevrontexaco.com) can be contacted for details about obtaining this software.

REFERENCES

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