



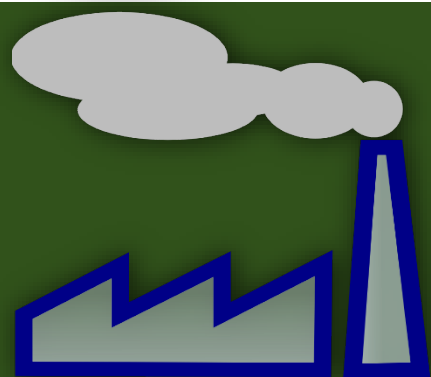
Greenhouse Gas Mitigation Options Database (GMOD) and Tool

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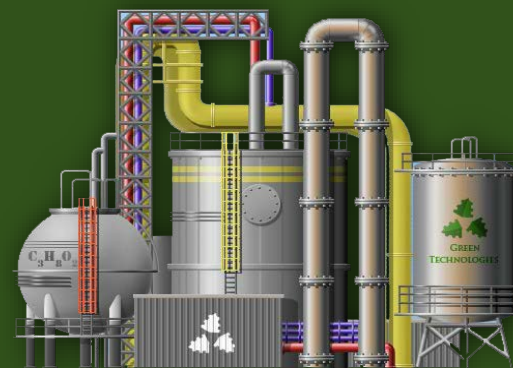
Power Sector



Cement Sector



Pulp & Paper Sector



Refinery Sector



Landfill Sector

Outline



-
- GMOD Introduction



-
- GMOD Framework
(Database & Tool)



-
- GMOD Usability, and
Credibility
 - Future Work

Outline

- A brief introduction to
 - Greenhouse Gas Mitigation options Database (GMOD)
 - GMOD availability and functionality
 - Users support (how the GMOD can satisfy the users' needs)
- Future research goal and summary

What is GMOD Database and Tool?

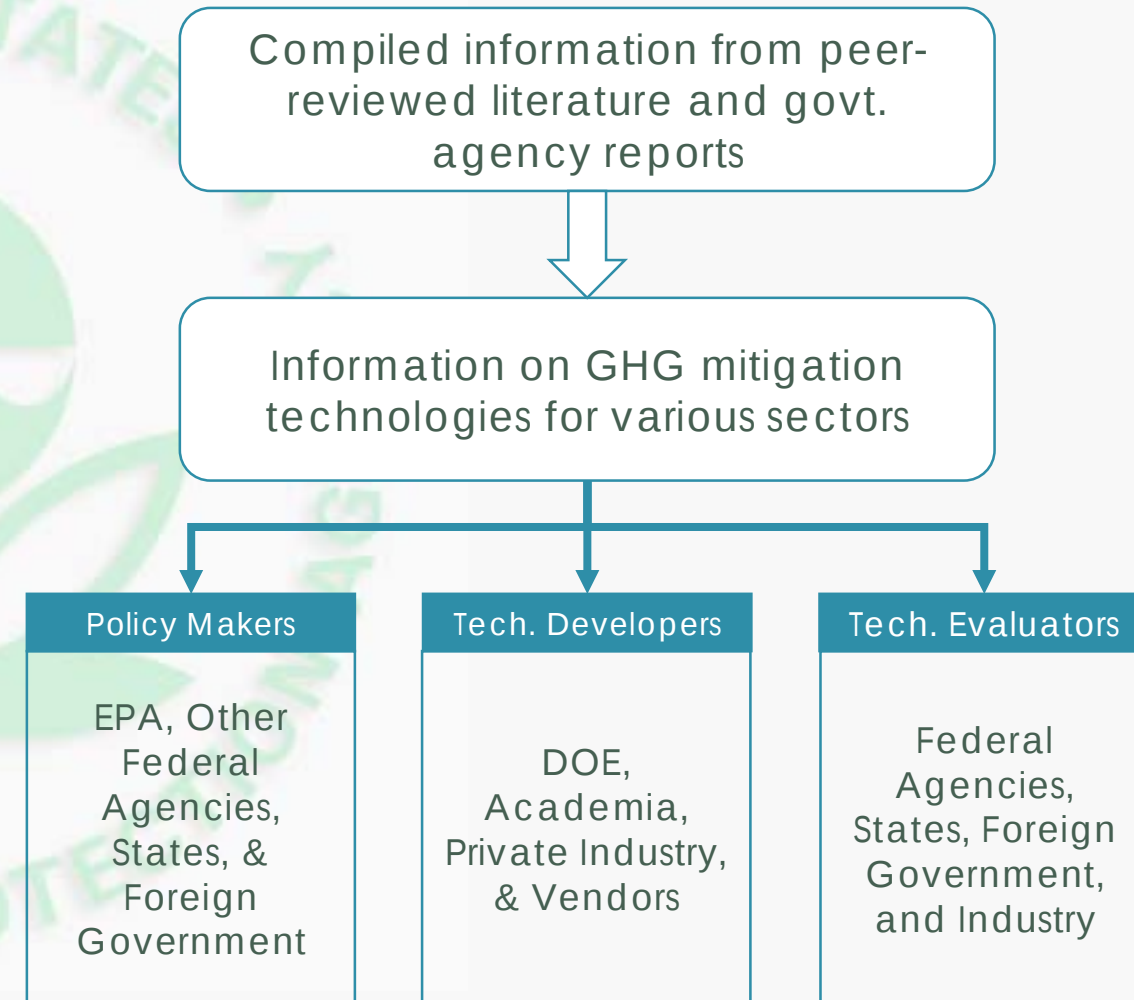
- Data repository of greenhouse gas (GHG) mitigation technologies (**new, existing & retrofit**) for the Power, Pulp & Paper, Cement (*peer reviewed*), Refineries, Landfill (*ready for external peer review*) and Iron & Steel sectors (*under development*)
- Collected from well-known data sources (publications, reports, databases etc.)
- Provides costs, emissions, performance, and availability information of the technology
- Includes default data and parameters defined for capital costs, lifetime economic and utilization rates
- Approx. 400 datasets for various sectors
- A user friendly interface

GMOD Data Elements (Criteria)

- Necessary data elements that need to be compiled
 - Year of availability
 - Stage of development
 - Characteristics of installation
 - Primary and secondary fuels
 - Process Energy Consumption (penalty etc.)
 - Cost of Electricity
 - Streams and Inlet flue gas concentrations
 - CO₂ removal efficiency and co-benefits (Removal of other air pollutants, if any)
 - Capital costs, fixed and variable operating and maintenance costs
 - Environmental impacts (CO₂, CH₄, biogenic CO₂, NO_x, Sulfur dioxide, Mercury etc.)
- All data need to be (technical elements)
 - Presented consistently with common unit (SI units)
 - Documented (references, quality, accessibility etc.)

How GMOD Supports

- GMOD is a **decision support** database and tool
- Serves as a **comprehensive source** for GHG control options for various sectors
- GMOD is designed to answer the following questions (but not limited to):
 - What is the best available technology for the situation?
 - What is the technology stage of development and availability?
 - What is the projected utilization cost?
 - What are the ancillary impacts of technology deployment?
 - What are the emission reduction costs?



GMOD Requirements & Availability

- An executable package that can operate on Microsoft and OS X operating systems:
 - Operating system: Microsoft windows 7, 8, 8.1, 10 or OS X 10.x,
 - Memory (RAM): 256 MB or higher
 - Processor: 800 MHz or higher
 - Hard drive space: 500 MB or higher, and
 - An internet connection is recommended
- The alternative goal is to download the exe. package from the EPA website (www.epa.gov/gmod - under construction)
- Current version will be available by email (bhander.gurbakhash@epa.gov)
- Terms of Use

"The user is responsible for understanding the implications of changing any variable default values. EPA is not responsible for erroneous output due to unrealistic changes the user makes to the default values in the program."





- GMOD Introduction

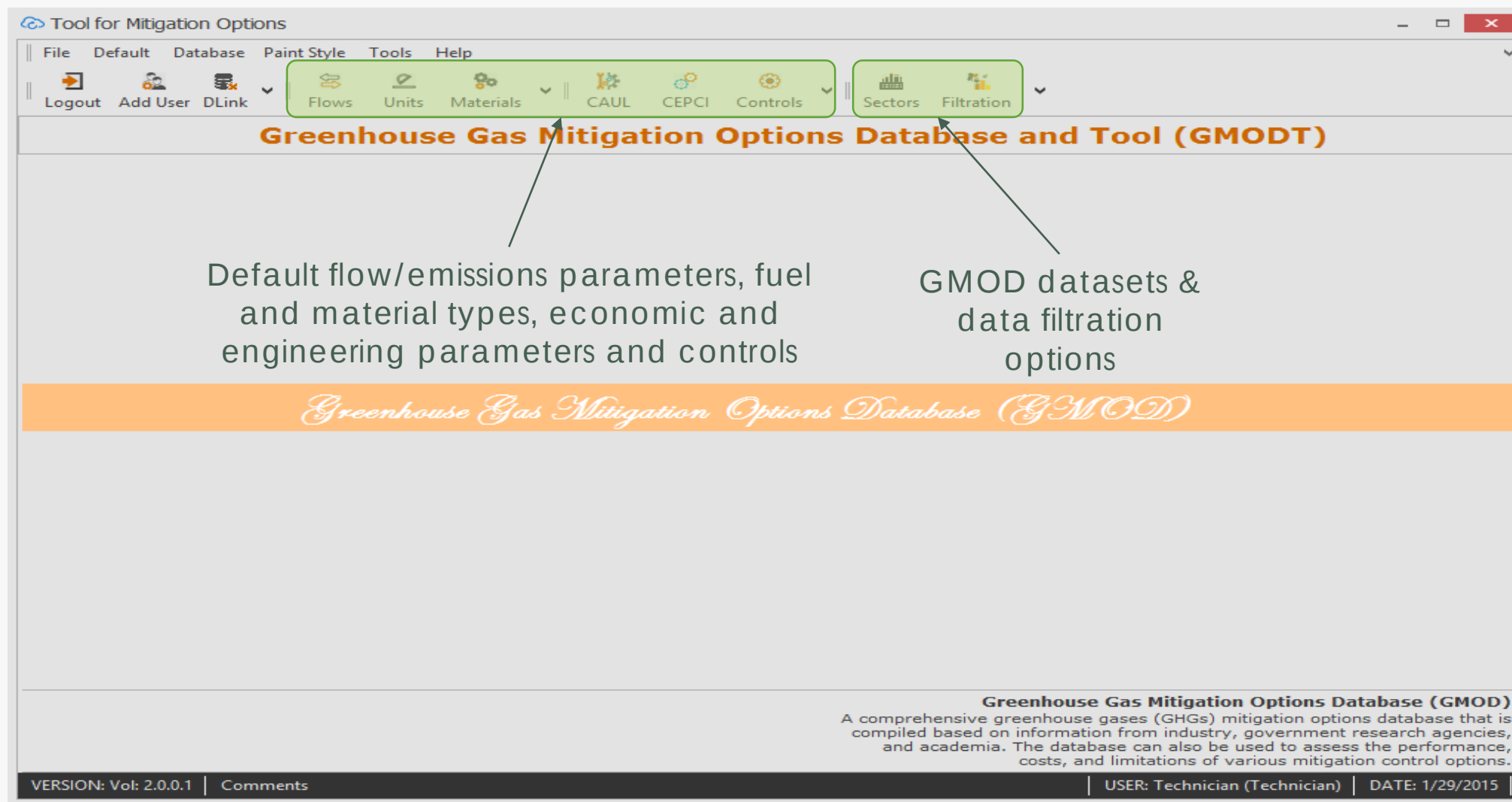


- GMOD Framework
(Database & Tool)



- GMOD Usability, and
Credibility
- Future Work

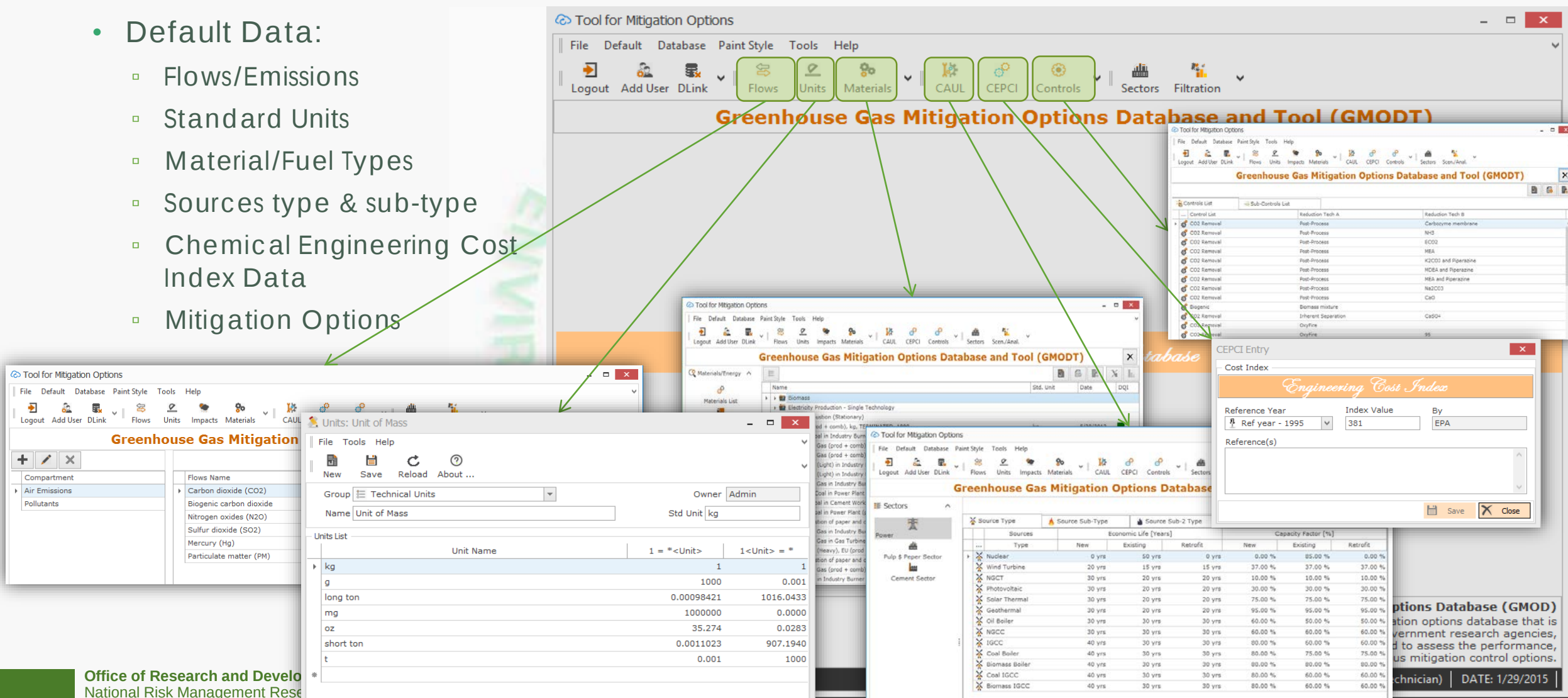
GMOD Database & Tool Structure



GMOD Tool (Interface) Structure

Default Data:

- Flows/Emissions
- Standard Units
- Material/Fuel Types
- Sources type & sub-type
- Chemical Engineering Cost Index Data
- Mitigation Options

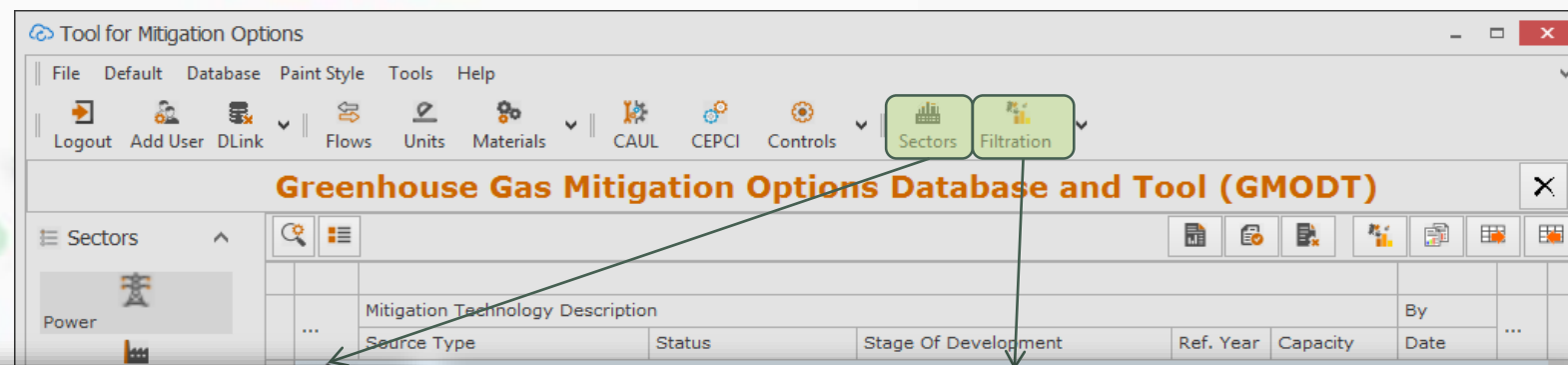


The screenshot displays the GMOD Tool interface, which includes several windows and panels:

- Main Window:** Features a menu bar (File, Default, Database, Paint Style, Tools, Help) and a toolbar with icons for Logout, Add User, DLink, Flows, Units, Materials, CAUL, CEPCI, Controls, Sectors, and Filtration. The title bar reads "Tool for Mitigation Options".
- Flows/Emissions Window:** Shows a list of flows with columns for Flows Name, Compartment, and Pollutants. The title bar reads "Greenhouse Gas Mitigation Options Database and Tool (GMODT)".
- Units: Unit of Mass Window:** Displays a table of units and their conversion factors. The title bar reads "Units: Unit of Mass".
- Materials Window:** Shows a list of materials with columns for Name, Std. Unit, Date, and DQI. The title bar reads "Greenhouse Gas Mitigation Options Database and Tool (GMODT)".
- CAUL Window:** Displays a list of controls with columns for Control List, Reduction Tech A, and Reduction Tech B. The title bar reads "Greenhouse Gas Mitigation Options Database and Tool (GMODT)".
- CEPCI Window:** Shows a table of cost index data with columns for Reference Year, Index Value, and By. The title bar reads "CEPCI Entry".
- Sectors Window:** Displays a table of sources with columns for Source Type, Source Sub-Type, Source Sub-2 Type, Economic Life [Years], and Capacity Factor [%]. The title bar reads "Greenhouse Gas Mitigation Options Database and Tool (GMODT)".

GMOD Interface – Technologies Data

- Technologies data:
 - Sectors data
 - Data filtration options



Technology: New 379 MW PC Boiler (Super) w/ Post Comb-Econ FG Plus, 90% CO2 Removal

File Tools Help

New Open Save Save As... Reload General Info. LCI Results Report Help

Technology: New 379 MW PC Boiler (Super) w/ Post Comb-Econ FG Plus, 90% CO2 Removal Availability Year: 2015 By: EPA

Description: Retrofitted with Econamine Flue Gas (FG) Plus Carbon Capture and Storage (CCS) at 90% CO2 Removal - low output. Base Year: 2007 Date: 7/1/2011

DataSet Type: Undefined

Summary Costs and Others Emissions Resources Documentation

General Summary

Facility Status: New Facility Type: New W/Controls Net Output [MW]: 379.00 Net HR Before, [mmBtu/MWh]: 0

Stage of Development: Demonstration Aux. Power [kWh/MWh]: 2.29 Net HR After, [mmBtu/MWh]: 12.66

Technology Location: Greenfield, Midwestern US (Generic site) Technology Vendor: [Blank]

Reduction Technology

Source Type: Coal Boiler Source Sub-Type: Supercritical Economic Life [yrs]: 40.00 Capacity Factor [%]: 0.80

Reduction Tech. 1: [Blank] Reduction Tech. 2: [Blank]

Sub-reduction Tech.: [Blank] Sub-reduction Tech2.: [Blank]

Sub2-reduction Tech.: MEA Sub2-reduction Tech2.: Select...

VERSION: Vol: 2.0.0.1 Comments

Close Scenario >> Take Average >> Compare >>

Technologies List

Name	Development Stage	Sub-source Type	Red. Technology	Sub-red. Technology	Capacity
New 379 MW PC Boiler (Super) w/ Po...	Demonstration	PC Boiler			
New 546 MW PC Boiler (Super) w/ Po...	Demonstration	PC Boiler			
New 135 MW Coal fired CFB Boiler (S...	Demonstration	CFB Boiler			
New 135 MW Coal fired CFB Boiler (S...	Demonstration	CFB Boiler			
New 550 MW PC Boiler (Super) w/ Po...	Demonstration	PC Boiler			
New 500 MW PC Boiler (Super) w/ Ox...	Demonstration	PC Boiler			
New 329 MW PC Boiler (Super) w/ Po...	Demonstration	PC Boiler			
New 666 MW PC Boiler (UltraSuper) ...	Demonstration	PC Boiler			
New 550 MW Bituminous PC Boiler (S...	Demonstration	PC Boiler			
New 550 MW Bituminous PC Boiler (S...	Demonstration	PC Boiler			
New 98 MW CFB Boiler (Alstom) w/ c...	Demonstration	CFB Boiler			

Advance datasets filtration options

Edit or add new technology data

GMOD Interface – Outputs

- GMOD Outputs:
 - Data report
 - Analysis output

Tool for Mitigation Options

File Default Database Paint Style Tools Help

Logout Add User DLink Flows Units Materials CAUL CEPCI Controls Sectors **Filtration**

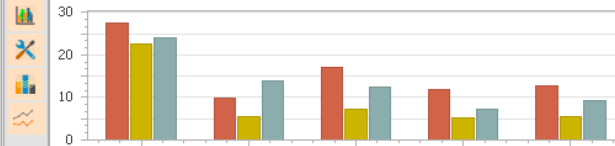
Greenhouse Gas Mitigation Options Database and Tool (GMODT)

Sectors

Mitigation Technology Description

Source Type	Status	Stage Of Development	Ref. Year	Capacity	By
Drop Column Fields Here					
Grand Total					
Description	Normalized Annual Capital ...	Normalized Annual FOC, [...]	Normalized Technology An...	Normalized Fuel Cost Befo...	Normalized Fuel ...
New 135 MW Coal fired CFB Boiler (Sub) w/ Ox...	27.61948	22.56633	24.13432	0	
New 329 MW PC Boiler (Super) w/ Post Comb-M...	9.781414	5.573162	13.82051	0	
New 379 MW PC Boiler (Super) w/ Post Comb-E...	16.98659	7.259147	12.32	0	
New 500 MW PC Boiler (Super) w/ Oxy Fire-AS...	11.93236	5.094006	7.186666	0	
New 546 MW PC Boiler (Super) w/ Post Comb-E...	12.62237	5.503875	9.24	0	
New 550 MW Bituminous PC Boiler (Sub) w/ Pos...	18.08533	14.23888	9.24	0	
New 550 MW Bituminous PC Boiler (Super) w/ P...	17.88756	14.16959	9.24	0	
New 550 MW PC Boiler (Super) w/ Post Comb-E...	12.54766	5.180899	9.24	0	
New 666 MW PC Boiler (UltraSuper) w/ Post Co...	8.567638	2.210836	12.13964	0	

Chart



Normalize comparative data

Chart-Title

X-Title

Y-Title

Legend

Show Labels

Primary Axis

Secondary Axis

Preview

File View Background

100%

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
Research Triangle Park, North Carolina 27711
Date: 1/29/2015

Technology: New 379 MW PC Boiler (Super) w/ Post Comb-Econ FG Plus, 90% CO2 Removal

Owner: EPA **Date:** 7/1/2011

Modified By: Admin **Modification Date:** 10/20/2014

Technology Status: New

Technology Type: Type 1

Stage of Development: Demonstration

Availability Year: 2015

Net Output [MW]: 379

Gross Output, [MW]: 467.29942

Aux. Power Required [kWh/MW]: 232.98

Net Annual Generation, [MWhnet/yr]: 2656032

Gross Annual Generation, [MWh-Gross/yr]: 3274834.33536

Description: Retrofitted with Econamine Flue Gas (FG) Plus Carbon Capture and Storage (CCS) at 90% CO2 Removal - low output.

Generation Information:

Technology Location: Greenfield, Midwestern US (Generic site)

Technology Vender: Fluor

Boilers Information:

Generate Data Report

Page 1 of 2



- GMOD Introduction



- GMOD Framework
(Database & Tool)



- GMOD Usability, and
Credibility
- Future Work

Brief Example: Existing Power Unit

- A private industry would like to **upgrade an existing** power production unit under the following criteria:
 - Reduce emissions from 315 MW **PC Boiler** to meet emission reduction standards,
 - A capital expenditure budget - **\$600,000** or,
 - a normalized budget of **\$1,905/MW**,
 - Control must be commercially available, economic life - **30yrs**, utilization rate of **75%**,
- Energy-efficiency control options
 - excess oxygen control in boiler, decreased boiler air heater leakage, new turbine seals, boiler feed pump overhaul, install intelligent soot blowers, boiler condenser cleaning ductwork upgrade, modify electrostatic precipitator (ESP), and modify selective catalytic reduction (SCR)
- **Question:** What does GMOD suggest for the best control option to meet emission reduction standards?

Brief Example: Existing Power Unit (conti...)

GMOD

Recommendations

- Installing intelligent **soot blowers** for CO₂ reduction
- **Boiler condenser cleaning** that provides emission reductions with no capital expenditure

Type of Control	Change in Emissions (lbs./MWh)	Normalized Cost (\$/MW)	Source Size Range (MW)
Excess oxygen control in boiler	-5.25 to -13.6	556 to 1,000	500 to 900
Decreased boiler air heater leakage	-0.834 to -5.25	529 to 1,300	250 to 900
New turbine seals	-3.13	1500	250
Boiler feed pump overhaul	-7.87	833 to 1,500	200 to 900
Install intelligent soot blowers	-12.6 to -18.9	556 to 1,500	200 to 900
Boiler condenser cleaning	-10.5	0	200 to 900
Ductwork upgrade	-0.315	556	450
Modify ESP	-0.525	444 to 500	200 to 900
Modify SCR	-1.05	1,000 to 1,250	200 to 900

Example B: A New Power Unit Construction

- A technology developer would like to construct a new power production unit:
- Technology/geographical constraints
 - due to geographical limitations, the wind turbine, geothermal, and solar options are not viable,
 - and does not wish to build a nuclear plant in light of site selection difficulties.
- Technology choice (Available in GMOD)
 - Coal-fired supercritical pulverized coal (PC) boiler, Unit net capacity of at least 550 MW, utilization rate of 80% and economic life - 40 years
- Control options choice (Available in GMOD):
 - Demonstration level only.
- **Question:** How GMOD can help the technology developer to select most mitigative and compatible options to control emissions from PC-boiler to meet emission reduction standard?

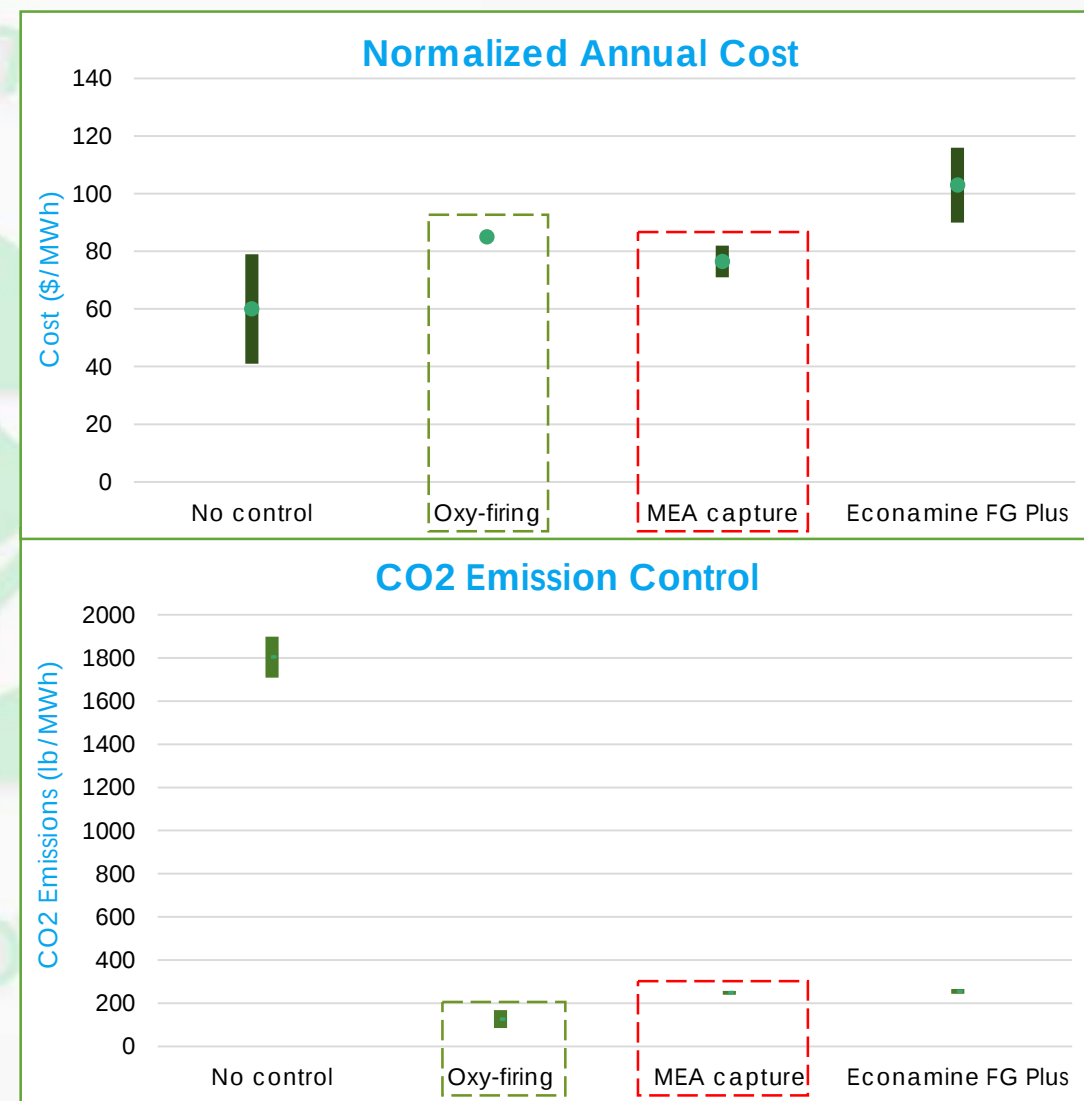
Example B: A New Power Unit Construction

- Selected demonstration level mitigation options for the technology of interest:
 - No GHG Control
 - Oxy-firing and an air separation unit plus carbon capture and storage (cryogenic distillation for 95% oxygen purity; energy requirements supplied by the PC boiler and subtracted from the gross output)
 - Post-combustion using MEA2 carbon capture and storage
 - Post-combustion with Econamine FG Plus carbon capture and storage
 - **Post-combustion chilled NH3 carbon capture and storage**
 - **Post-combustion dry carbonate carbon capture and storage**

} Eliminate –
Pilot Scale

Example B: A New Power Unit Construction

- GMOD emissions reduction and cost recommendations:
 - Oxy-firing has the lowest CO₂ emission rate (approx. 170 lbs./MWh)
 - Post-combustion MEA is the most cost-effective (total generation costs approx. \$77/MWh).
 - CO₂ emission rates for post-combustion MEA and post-combustion Econamine FG Plus are closer but total generation cost of the Econamine FG Plus is higher.



GMOD Status

- Current version of database contains approximately 400 datasets for power, refinery, cement, pulp and paper, and landfill sectors
- User friendly interface allows users to:
 - Project best mitigation technologies
 - Compare similar technologies
 - Generate and compare various technologies scenarios
- Database Sector Status:
 - Power, Cement and Pulp and Paper will be publically available by end of FY2016
 - Refinery sector will be publically available by end of FY2016, Iron & steel sectors expected by end of FY2018.
 - Collecting Iron & Steel Sector data and updating Cement and Pulp & Paper sectors.

GMOD Development will:

- Identify mitigation concepts for GHG emissions which are of high interest to researchers and policy makers (“GHG tailoring Rule”)
- Fill information gaps in existing greenhouse mitigation databases
- Provide the user with information on real-life examples from the literature and control options for various sectors.
- Help the user determine the most attractive options from performance and cost perspectives
- Provide a comprehensive and reliable source to view, compare and evaluate various mitigation options data

Thank You!

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