NETL CO2 Utilization LCA Guidelines





June 26, 2019



Presentation Agenda



- Motivation for NETL Guidelines
- NETL CO2U LCA Toolkit Goals and Overview
- LCA/TEA CO2U Workshop
- LCA Methods Example Discussion





Motivation – U.S. DOE Carbon Use and Reuse Program FOA Requirements



Applications for Technologies Directed at Utilizing Carbon Dioxide from Coal Fired Power Plants (DE-FOA-0001622), states that the Principal Investigator (PI) shall provide

"...Life Cycle Analysis further demonstrating the potential of the proposed process to be a substantive CO₂ mitigation option, by verifying the lifecycle GHG reduction potential of the products(s) and technology (on a percent reduction basis) relative to current state-of-the-art pathways"



CO2U LCA Requirements in U.S. Federal Programs and Policy



- 26 USC 45Q: Credit for carbon oxide sequestration (aka, 45Q)
 - LCA (GHG analysis) required for tax credit (non-EOR utilization)
 - "(B) Measurement
 - (i) In general For purposes of determining the amount of qualified carbon oxide utilized by the taxpayer under paragraph (2)(B)(ii) or (4)(B)(ii) of subsection (a), such amount shall be equal to the metric tons of qualified carbon oxide which the taxpayer demonstrates, **based upon an analysis of lifecycle greenhouse gas emissions** and subject to such requirements as the Secretary, in consultation with the Secretary of Energy and the Administrator of the Environmental Protection Agency, determines appropriate...





- 1. Provide LCA guidance, data, and tools to U.S. DOE Carbon Use and Reuse Program project PIs to complete their project LCA and documentation requirements
- 2. Foster better decision-making for the U.S. DOE Carbon Use and Reuse Program by providing an analysis and reporting structure for the project LCAs that allows for consistency and transparency
- 3. Provide LCA guidance, data, and tools to others seeking guidance on conducting LCA in the area of CO2U
- 4. Contribute to the global discussion on CO2U LCA and LCA methods



Why the need for additional guidance beyond ISO 14040/14044?



- All of the guidance included in the NETL CO2U LCA Toolkit is ISO compliant
- Additional guidance is helpful for handling CO2U systems to
 - 1. Ensure methodological consistency in applying the ISO standards ISO standards provide a broad framework for applying LCA to a wide range of applications. This can lead to inconsistency in modeling choices and results interpretation that can confound or negate study conclusions.
 - 2. Define study goal & scope based on project Technology Readiness Level (TRL) There can be a lot of unknowns in the life cycles of emerging technologies. This guidance aims to assist principal investigators with the expectations of completing their comparative LCAs at different stages of technology development.



NETL CO2U Guidance Key Points



Comparative LCA

LCA goal is to compare the CO2U system to the long-run marginal competitor in the market (comparison system)

Multiproduct functional unit with system expansion

Improve comparability and results interpretation

Default scenarios for CO2 sources

Coal-fired power generation: flue gas, captured CO₂ greenfield and retrofit

Guidance for comparison processes and system

Data quality and representativeness: expectations based on TRL

Three modeling options

- 1. openLCA with provided data
- 2. Excel-based documentation sheet
- 3. Other commercial LCA modeling software

Interpretation requirements

Specific data/figures to provide consistency to study comparisons





GUIDANCE DOCUMENT



Analysis requirements and instructions for using the supporting data and tools

OPENLCA LCI DATABASE



openLCA database that includes NETL unit process data and an example CO2U LCA

OPENLCA CONTRIBUTION TOOL



Excel template that translates openLCA results into required charts

DOCUMENTATION SPREADSHEET



Excel file that can be used to document data when not using openLCA



LCA REPORT TEMPLATE



Word report template for summarizing data and results

OPENLCA MODEL TRAINING



Provided to PIs to aid in the modeling of their LCA in openLCA

SUBJECT MATTER EXPERT SUPPORT



Available to PIs for all phases of the LCA from conception to documentation







LCA/TEA Workshop: Overview

- Gathering of government, academia, industry, NGOs on April 10-11, 2019
- Discussion of two guidance documents UM Global CO₂ Initiative and NETL
- Exploration of metrics, best practices, validation
- Next steps for building global toolkit for measuring and reporting
- Target applications: project investment, product marketing, and policy needs

















- 1. General agreement on methods and approach
- 2. Graduated approach based on TRL; approaches for streamlining
- 3. Harmonization of data for life cycle inventories and scenario development
- 4. Standardization of terminology where possible
- 5. Impact assessment beyond global warming potential
- 6. Interest in guidance for policymakers, investors, etc. for reviewing LCA results



One Area of Method Development is Upstream CO₂ and Electricity Co-Product Determination



- Including upstream CO₂ in the boundary – results in an electricity co-product in the system boundary
- What should be the source of the electricity in the comparison case?
- How do we maintain functional equivalence between the cases?





One Area of Method Development is Upstream CO₂ and Electricity Co-Product Determination



- Including upstream CO₂ in the boundary – results in an electricity co-product in the system boundary
- What should be the source of the electricity in the comparison case?
- How do we maintain functional equivalence between the cases?





The Electricity in the Comparison Case Depends on How the CO_2 Is Procured for CO2U





ATIONAL

TECHNOLOGY







ATIONAL

HNOLOGY



ΔΤΙΟΝΔΙ

rather than used

What if the Source of the CO₂ is <u>Flue Gas</u>?

- Assume diversion of flue gas for alternative use does not affect the net electricity output the power plant prior to diversion of the flue gas
- Comparison case is the same power plant with the CO₂ being emitted

Upstream CO₂ in Proposed Case



Electricity Co-product in Comparison Case





What if the Source of the CO₂ is Captured CO₂ From a Retrofitted Power Plant?







What if the Source of the CO₂ is Captured CO₂ From a <u>Retrofitted</u> Power Plant?



- <u>IF</u>, retrofitting the power plant results in a decrease in the net power output, then the "Proposed CO2U Case" will require "make-up" electricity
- "Make-up" electricity shall be equal to the electricity consumption mix (marginal supplier) in the geographical area defined in the study scope



*The carbon capture plant loses some of its capacity to run the carbon capture equipment, so make-up electricity in the proposed case is required to have the same amount of electricity output.



What if the Source of the CO₂ is Captured CO₂ From a <u>Retrofitted</u> Power Plant?



- <u>IF</u>, retrofitting the power plant DOES NOT result in a change in the net power output, then assume external source of heat and power to operate the carbon capture and compression system (e.g., Petra Nova)
- IF, the auxiliary power system produces excess electricity, in turn increasing the net power output of the "Proposed CO2U Case", then additional "make-up" electricity has to be added to the "Comparison Case" to ensure system equivalence



*The carbon capture plant gains capacity by installing auxiliary power to run the carbon capture equipment, so make-up electricity in the comparison case is required to have the same amount of electricity output.



What if the Source of the CO₂ is Captured CO₂ From a New Power Plant?







What if the Source of the CO₂ is Captured CO₂ From a <u>New</u> Power Plant?



- The comparison case is determined based on the long-run marginal electricity generator(s) that would have been installed if the new power plant with carbon capture was not built
- The electricity generator(s) are determined using capacity expansion modelling for the on-line (start) year of the power plant for the stated geographical scope of the study



Electricity Co-Product in Comparison Case





What if the Source of the CO₂ is Captured CO₂ From a <u>New</u> Power Plant?



- 1. Determine year of proposed CO2U project deployment (same as power plant on-line [start] year)
- 2. Compile mix of technologies composing capacity additions for that year
- 3. Develop weighted emission factors



Figure 1. Cumulative capacity additions in the U.S. electric sector, based on the U.S. EIA's Annual Energy Outlook 2018, reference scenario. Source: EIA Annual Energy Outlook 2018, Electricity Generating Capacity



What if the Source of the CO₂ is Captured CO₂ From a <u>New</u> Power Plant?



- 1. Determine year of proposed CO2U project deployment (same as power plant on-line [start] year)
- 2. Compile mix of technologies composing capacity additions for that year
- 3. Develop weighted emission factors



Electricity Co-Product in Comparison Case





Conclusions



- CO2U systems are unique in that they combine two sectors (electricity and CO2U product)
- Consistent LCA approaches are necessary to ensure comparability and fairness
- The goal of the NETL CO2U Guidance is to determine the environmental preferability of utilizing captured carbon to produce products – this necessitates a consequential LCA approach





Contact Information

Timothy J. Skone, P.E. Senior Environmental Engineer • U.S. DOE, NETL (412) 386-4495 • timothy.skone@netl.doe.gov

Greg Cooney Principal Engineer • KeyLogic gregory.cooney@netl.doe.gov

Michele Mutchek Senior Engineer • KeyLogic michele.mutchek@netl.doe.gov















Backup Slides





26

HNOLOGY

Guidance Document Development Timeline

• 2017

- August First exploratory draft of the guidance document is completed
- October A workshop was held in D.C. with subject matter experts and CO2U project principal investigators

• 2018

 Second draft of guidance document is finalized based on stakeholder feedback

• 2019

- March Soft release of guidance document
- April Final release incorporating feedback from Global CO₂ Initiative TEA/LCA Workshop





Workshop on LCA/TEA for CO₂-based products Agenda



- Overview of LCA/TEA resources
- Stakeholder interests
- LCA/TEA breakouts to define needs/outcomes
- Examples of firms at various stages of development in the CO2U space
- CO2U-related policy (45Q, LCFS)
- Policy implications for TEA and LCA guidance





Workshop on LCA/TEA for CO₂-based products

Report Objectives and Schedule

- Discuss the uniformities and differences between the various LCA TEA approaches, and
- Recommend what is needed to harmonize the approaches - or why there are differences.
- Propose next steps in guideline development to promote CCU













GUIDANCE DOCUMENT



Analysis requirements and instructions for using the supporting data and tools CARBON DIOXIDE UTILIZATION LIFE CYCLE ANALYSIS GUIDANCE FOR THE U.S. DOE CARBON USE AND REUSE PROGRAM

March 22, 2019





TIMOTHY J. SKONE, P.E.; MICHELE MUTCHEK; MICHELLE KRYNOCK; GREGORY COONEY; AMBICA PEGALLAPAT; SRILANA RA; JOSEPH CHOU; DERRICK CARLSON; MATTHEW JAMIESON; ARANYA VENKATESH; JAMES LITTLEFIELD; GEORGE G. ZAIMES; SELINA ROMAN-WHITE; AND EVELYN DALE

DOE/NETL-2019/2069



OPENLCA LCI DATABASE



openLCA database that includes NETL unit process data and an example CO2U LCA

PROCESS CATEGORY	PROECSS NAME
Fuel Production and Combustion	Diesel, Gasoline, Natural Gas
Materials	Ammonia, Ethanol, Hydrogen, Concrete, Steel
Transportation	Train, Ocean, Pipeline
Grid Electricity	Coal, Natural Gas, Fuel Oil, Nuclear, Geothermal, Wind, Solar
CO ₂ Sources	NGCC, SCPC, SubPC – with and without carbon capture



OPENLCA CONTRIBUTION TOOL



Excel template that translates openLCA results into required charts



Proposed Product System Comparison Product System



DOCUMENTATION SPREADSHEET



Excel file that can be used to document data when not using openLCA

Item Inset Date Page Layout Formulas Data Review View Halp International formation Final Actional formati			ା ଜିଲୋକ ବାଦ୍ୟ 🕯	-	NETL CO2U LO	CA Doc Spre	adsheet.xls	x - Last Saved	3/29/2019 10:4	4 AM 👻	Cooney, Gregory A	. (CONTR) 🖻	- 0	
Image: Section 10 Im	File	Home	Insert Draw	Page Layout	Formulas	Data	Review	View Help	🖓 Tell n	ne what you v	vant to do		🖻 Shar	e Y
Image: Solution of the solution	a 🕹	Cen	tury Gothic - 10 -	=	= _ % .	ab	General	•			👔 🔛 Insert 🔹	Σ-Α	0	
Fort Fort Fort Fort Fort Fort Fort Fort Fort Fort Alignment Fort Alignment Fort Alignment Fort Alignment Fort Styles Ell Fort	aste .	* B	7 11 - 1 - 2			= = .	\$ - %	• • 0.0	Conditional	Format as (Cell 🔛	Sort & Fir	nd &	
bailed in it is in the rest is a Algoment is Number is Styles cells Editing	- V	5				= == .	φ 70	- 00 → .0	Formatting *	Table - St	/les - 📰 Format -	< 🎽 Filter - Sel	ect -	
Image: Second	lipboard	G I	Font	T ₂₁	Alignment	Gil	Nun	nber G	-	styles	Cells	Editing		
A B C D E F G H I J K Note About This File Count This File Structure When openLCA Buildance Document. Please see the NETL CO2U LCA Guidance Document for instruction This RETL CO2U ICA CA Coundance Document and the NETL CO2U ICA Guidance Document. Please see the NETL CO2U ICA Guidance Document for instruction Key File is primarily for documenting unit processes and modeling structure when openLCA is not used. See the NETL CO2U ICA Guidance Document for instruction Key FileIds marked in orange are areas for data entry FileIds marked in blue are automatically populated and should not be adjusted Unit Process diagram number: (PROP-A)1. Image: Count of the NETL Co2U ICA Suidance Document for instruction of the NETL Co2U ICA Guidance Document for instruction Unit process name: Image: Count of the NETL Co2U ICA Guidance Document for instruction of the NETL Co2U ICA Guidance for transportation UPs): Reported Data Soundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Soundary Amount per Reported Data Soundary Amount per Reported Data Soundary Amount per Gactor Amount per Reference Filew: Reference Flow: Low Expected High Units Low Expected High Count oper Societ Amount per Societ Amount per Societ Amount per Societ </td <td>1</td> <td>-</td> <td>$:$ \times \checkmark f_x</td> <td>Note Abo</td> <td>out This File</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	1	-	$:$ \times \checkmark f_x	Note Abo	out This File									
Note About This File			А	В	с	D	E	F	G	н	1	J	к	
This NETL CO2U LCA LCA Documentation Spreadsheet is a companion to the NETL CO2U LCA Guidance Document. Please see the NETL CO2U LCA Guidance Document. This life is primarily for documenting unit processes and modeling structure when openLCA is not used. See the NETL CO2U LCA Guidance Document for instruction Key Fields marked in orange are areas for data entry Fields marked in blue are automatically populated and should not be adjusted Unit process diagram number: (PROP-A). Unit process diagram number: (PROP-A). Unit process type (Operational, Construction, or Transportation): Operational Unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount per Reported Data Boundary	Note	About Th	nis File											
This file is primarily for documenting unit processes and modeling structure when openLCA is not used. See the NETL CO2U LCA Guidance Document for instruction Key Fields marked in orange are areas for data entry Fields marked in blue are automatically populated and should not be adjusted Unit process diagram number: (PCP-A)1. Unit process name: UP Name Unit process type (Operational. Construction. or Transportation): Operational Unit process type (Operational. Construction. or Transportation): Operational Unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Amount per Reported Data Bou	This N	ETL CO2	U LCA LCA Docume	entation Spre	adsheet is a	companio	on to the	NETL CO2U L	CA Guidan		ent. Please see the	NETL CO2U LCA	A Guidance Dr	ocum
Key Fields marked in orange are areas for data entry Fields marked in blue are automatically populated and should not be adjusted Image: Comparison of the comparison of	This file	e is prim	arily for documenti	na unit proc	esses and mo	delina stri	ucture w	hen openi CA	is not used	. See the N	ETL CO2U I CA Gui	dance Docume	ent for instructi	ions o
Key Fields marked in orange are areas for data entry Fields marked in blue are automatically populated and should not be adjusted Image: Comparison of the comparison of		o io prim	any for decomon	ng onn proc	cisci ana mo	acing and		non openico/						0113 0
Key Fields marked in orange are areas for data entry Fields marked in blue are outomatically populated and should not be adjusted Image: Comparison of the analysis of the adjusted unit process diagram number: Image: Comparison of the adjusted Image: Comparison of the adjusted unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process name: Image: Comparison of the adjusted Image: Comparison of the adjusted Unit process description: Image: Comparison of the adjusted Image: Comparison of the adjusted Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Image: Comparison of the adjusted Reported Data Boundary Amount per Reported Data Boundary Amount per Reference f Madi no-product	-													
Reported Data Boundary Amount per Reported Data Boundary Amount per Reference Flow: Reported Data Boundary Amount per Reported Data Boundary Amount per Reference Flow: Reference Flow: Amount per Reference Flow Amount per Reference Flow Reference Flow: Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow: Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow: Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow: Low Expected High Units Y Product System Overview UP Reported Data Boundary Amount per Reference Flow Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Low Expected High Units Amount per Reference Flow Amount ner Berneted Data Boundary Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Amount ner Berneted Data Boundary Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow	Ver													
Pields marked in blue are automatically populated and should not be adjusted Image: Comparison of the comparis	Tielde	na ark a d	in orange are area	n for data a	ata.									
In blue are automatically populated and should not be adjusted Unit Processes (UPs) Unit process diagram number: (PROP-A)1. Unit process name: UP Name Unit process type (Operational, Construction, or Transportation): Operational Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference Flow: Amount per Reported Data Boundary Amount per	Fields	marked	in orange are area	as for data er	dete el ere el ele	a dal a a l	a a sellined	a at						
Unit Processes (UP2) Unit Process diagram number: Image: Comparison of the second	Fields	markea	i in blue are autom	atically popu	Jiatea ana sh	ould not i	be adjust	ea						
Unit Processes (UPs)														
Unit process diagram number:)													
Unit process diagram number: (PROP-A)1. Unit process name: UP Name Unit process type (Operational, Construction, or Transportation): Operational Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per	Unit Pr	ocesses	: <u>(UPs)</u>											
(PROP-A)1. Unit process name: Unit process name: Unit process name: UP Name Unit process type (Operational, Construction, or Transportation): Unit process type (Operational, Construction, or Transportation): Unit process type (Operational, Construction, or Transportation): Unit process description: Unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Unit process that produces the main product and construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Image: Construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Reference Flow: Image: Construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reference FI Amount per Reported Data Boundary Amount per Factor Amount per Reference FI Image: Construction UP Pactor Amount per Reference FI Imputs and Outputs: Image: Construction Data B	2 Unit p	rocess c	liagram number:											
Unit process name: UP Name Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount Por Patron Amount per Patron Amount per Reference Flow Reference Flow: Amount per Reported Data Boundary Amount Por Patron Amount Por Patron Amount per Patron	(PROP	-A)1.												
Unit process name: UP Name Unit process type (Operational, Construction, or Transportation): Operational Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Bou	1													
UP Name Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Reference Flow Implies and Outputs: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reference Flow Implies and Outputs: Amount per Reported Data Boundary	i Unit p	rocess n	ame:											
Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Factor Reference Flow Low Expected High Units Low Expected Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+03 0.00E+00 kg/yr 0.00E+00 1.00E+00 1.	UP Na	me												
Unit process type (Operational, Construction, or Transportation): Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference Flow: Amount per Reported Data Boundary Amount per	1													
Operational Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Reference Flow: Imputs and Outputs: 0.00 1000.0 Amount per Reported Data Boundary Amount per Eactor Amount per Reported Data Boundary Amount per Reported Data Boundary Imputs and Outputs: Normalization: Amount per Reported Data Boundary Amount per Eactor Amount per Reported Data Boundary Amount per Reported Data Boundary Imputs and Outputs: Normalization: Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP Imputs and Control Report	Unit p	rocess t	vpe (Operational, C	Construction,	or Transporte	ation):								
Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Expected High Units Low Expected Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+00 kg/yr 0.00E+00 1.00E+00	Operc	ational												
Unit process description: This is the main unit process that produces the main product and other co-products in the Proposed Product System (PROP-A). Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Reference Flow Low Expected High Units Low Expected High Units Low Expected Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+00 0.00E+00 kg/yr 0.00E+00 1.00E+00 1.0)													
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Factor Reference Flow: Comparison of the transport of transport of the transport of the transport of transpor	Unit n	TOCOSE O	lescription:											
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs):	This is	the mai	n unit process that	produces the	a main produ	at and at	hor on p	roducts in the	Bronord	Braduat Su	tom (BBOB A)			
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: 0.0 1000.0 0.0 kg 0.00E+00 2.00E+00 kg/yr 0.00E+00 1.00E+00 Inputs and Outputs: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Amount per Reference Flow Amount per Reference Flow 0.00E+00 1.00E+00		ine mai	n onn process mar	produces me	e main produ		nei co-pi		erroposedi	riodoci sys	aem (nor-A).			
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reference for transportation UPs): Reference Flow: 0.5 yr Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Reference Flow: Low Expected High Units Low Expected High	2													
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Reported Data Boundary Amount Units Time 0.5 yr Image: Strange Stran														
Reported Data Boundary (e.g., time for operational and construction UPs or distance for transportation UPs): Image: Construction UPs or distance for transportation UPs): Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Reported Data Boundary Inputs and Outputs: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Factor <) 													
Reported Data Boundary Amount Units Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow: Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+00 0.00E+00 1.00E+00 Inputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Normalization: Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data Boundary Amount per Factor Amount per Reference Flow Imputs and Outputs: Imputs per Reported Data	Repor	ted Dat	а воundary (e.g., fi	ime for oper	ational and c	onstructio	on UPs or	aistance for	transportat	ion UPs):				
Time 0.5 yr Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Reference Flow Low Expected High Units Low Expected Normalization: Amount per Reported Data Boundary Amou		Reporte	ed Data Boundary	Amour	nt Units									
Reference Flow: Amount per Reported Data Boundary Amount per Factor Amount per Reference Flow Reference Flow Low Expected High Units Low Expected Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+03 0.00E+00 kg/yr 0.00E+00 Inputs and Outputs: Amount per Reported Data Boundary Amount per Eactor Amount per Reference Flow Imputs and Outputs: Imputs and Outputs: Imputs and Outputs: Normalization: Imputs and Outputs: UP Template NETL Unit Process Data GWP Imputs GWP	3 Time			(0.5 yr									
Reference Flow: Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reference f Reference Flow Low Expected High Units Low Expected Moin co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+03 0.00E+00 kg/yr 0.00E+00 1.00E+00 Inputs and Outputs: Mormalization: Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP (*) * (*) *	9													
Amount per Reported Data Boundary Amount per Reported Data Boundary Amount per Factor Amount per Reference F Reference Flow Low Expected High Units Low Expected High Units Low Expected Moint co-product 0.0 1.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 1.00E+00	Refere	ence Flo	w:											
Reference Flow Low Expected High Units Low Expected High Units Low Expected Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+03 0.00E+00 kg/yr 0.00E+00 1.00E+00 Inputs and Outputs: Amount per Reported Data Roundary Amount per Factor Amount per Reference F Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP (+ : (= + 1) (= + 1)				Amount pe	er Reported D	ata Boun	darv	An	nount per Fo	actor		Amoun	t per Referenc	e Flo
Main co-product 0.0 1000.0 0.0 kg 0.00E+00 2.00E+03 0.00E+00 1.00E+00 Inputs and Outputs: Inputs and Outputs: Normalization: Normalization: Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP (+ : - Amount per Foctor Amount per Per - + 1	,	Re	ference Flow	Low	Expected	High	Unite	s Low	Expected	High	Units	Low	Expected	
Inputs and Outputs: Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP ① : 《 ① · · · · · · · · · · · · · · · · ·	Main	no prod	uct	2011	1000.0	- ngn	0 kg	0.005+0	2 005+03	0.005+00	kaha	0.005+00	1.005+00	
Inputs and Outputs: Normalization: Amount per Penorted Data Boundary Amount per Eactor Amount per Peterence 5 Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP (+ : + 1 at the temperature of temperatur	Main	-0-pi0d	001		1000.0	0.	vivg	0.002+0	2.002+03	0.002400	Ng/ fr	0.002+00	1.002+00	
inputs and Outputs: Inputs and Outputs: Normalization: Amount per Reported Data Roundary Amount per Factor Amount per Reference Factor Product System Overview (PROP-A)1. UP Name UP Template NETL Unit Process Data GWP (+ : • • • • • • • • • • • • • • • • • •														
Amount per Penoted Data Poundary Amount per Foctor L Amount per Foctor L Amount per Foctor L Amount per Penoted Data Penoted Determine	inputs	and O	utputs:									Normalization:		-1
dy			Due due Custom C	Amount ne	Pr Reported D	ata Boun	dan/	An	nount ner Fr			Amoun	t ner Referenc	e Flor
dy 🔠 🗉 💾 =+ 1	- •		Product System Over	(PRC	UP-A)1. UP Na	Ime UP	remplate	NETL UP	iit Process Da	ata GWI	🕂 🕴 🖣			
	ady										Ħ	▣ ─ -	+	100



REPORT TITLE

TABLE OF CONTENTS

Appendix A: Supporting Information.

List of E	xhibits	
List of E	quations	
Acrony	rms and Abbreviations	
Execut	ive Summary	
1 Go	al and Scope	
1.1	Study Goal	
1.2	Study Scope	
1.2	2.1 Functional unit of the study	
1.2	2.2 System boundary	
1.2	2.3 Carbon dioxide source	1 Go
1.2	2.4 Technology representativeness	
1.2	2.5 Geographical representativeness	
1.2	2.6 Temporal representativeness	1.1 ST
1.2	2.7 Life cycle impact assessment methods for result	The pure
1.2	2.8 Completeness requirements	informati
1.2	2.9 Sensitivity and uncertainty analysis	These go
1.2	2.10 Reporting units and method of comparison	variation
2 Life	e Cycle Inventory Analysis	report. F
2.1	Modeling platform	demonst
2.2	Unit process descriptions	and exter
2.3	Data sources and quality assessment	consideri
2.4	Results of inventory completeness check	market p
2.5	Results of life cycle inventory model sensitivity check	describer
2.6	Allocation procedures (optional)	The spec
3 Life	e Cycle Impact Assessment	1. <u>In</u>
3.1	Life cycle impact assessment methods	G P
3.2	Data quality assessment	2 8
3.3	Life cycle impact assessment results	2. <u>N</u> (r
4 Life	e Cycle Interpretation	5
5 Cri	itical Review	3. <u>In</u>
6 Re	ferences	-

REPORT TITLE

1 GOAL AND SCOPE

1.1 STUDY GOAL

The purpose of this section is to describe <u>why</u> the study was conducted, <u>how</u> the information/results will be used, by <u>whom</u>, and if the study is <u>intended to be made public</u>. These goals are generally the same for all U.S. DOE Carbon Use and Reuse projects. Slight variations based on the TRL of the project exist and shall be clarified in this section of the report. For example, a TRL 1-4 projects primary purpose is technology improvement with DOE (the project funder) as the primary audience. Projects with a TRL of 5 or higher are focused on demonstrating the commercial viability and environmental acceptance of the project with DOE and external stakeholders (i.e., investors) as the key audience. Additional product systems considering broader national and/or international market effects based on varying levels of market penetration shall be included for projects with a TRL of 5 or higher. This shall be described in the goal of the study.

The specific goals of this LCA are described below:

- Intended application The intended application of this LCA is to compare the life cycle GHG impact of the proposed project - ADD DESCRIPTION, as modeled of a Proposed Product System, to a Comparison Product System.
- <u>Reasons for carrying out the study</u> To understand how the environmental impact (measured as life cycle GHG impact) of the PROJECT NAME life cycle compares to the life cycle of a system that produces the same products.
- Intended audience The intended audience for LCA described herein is the U.S. DOE Carbon Use and Reuse Program.
- Public disclosure The LCAs conducted as part of the U.S. DOE Funding Opportunity Announcement requirement will become part of the public record for the award within the final scientific/technical report.

1.2 STUDY SCOPE

The purpose of this section of the report is to define what was modeled, what the data quality/representative goals are, what the basis of comparison is in terms of the functional unit (inclusive of all coproducts), and how the results are to be compared. This section also defines the level of completeness required not make a comparison between the proposed and Comparison Product Systems. Expectations for sensitivity and uncertainty analysis shall also be described in this section. Variability between U.S. DDE CO; Use and Reuse projects is expected based on TRL status, project complexity, and expected market effects.

LCA REPORT TEMPLATE

*** * * 1 | |**

Word report template for summarizing data and results



OPENLCA MODEL TRAINING



Provided to PIs to aid in the modeling of their LCA in openLCA



SUBJECT MATTER EXPERT SUPPORT



Available to PIs for all phases of the LCA from conception to documentation







