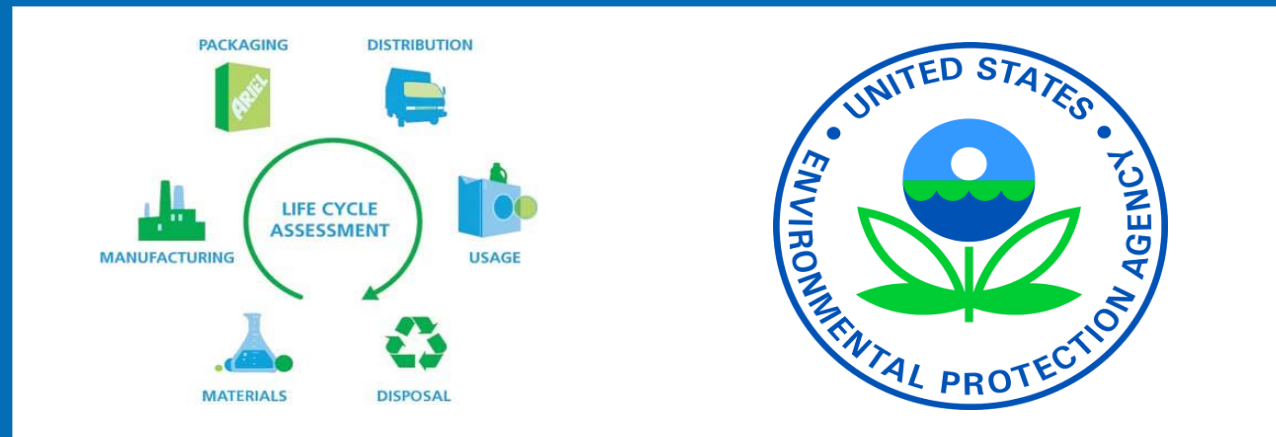


Using extended input-output modeling to take a whole-economy approach to sustainable materials management with a state



Wesley Ingwersen, David Meyer (EPA)



Disclaimer

The U.S. Environmental Protection Agency through its Office of Research and Development collaborated in the research described here. It has not been subject to Agency review and does not necessarily reflect the views of the Agency. No official endorsement should be inferred.

Sustainable Materials Management

- Keys to SMM:
 - *Using materials effectively over their life cycle*
 - *Consider all materials and wastes*
 - *Reduce all environmental impacts and avoid burden shifting*
- *The Road Ahead* (2009) established the beginnings of an analytical framework for SMM prioritization - A whole economy approach using an environmentally-extended input-output model



Input-output modeling

- Economic modeling based on input-output tables
- Detailed (~ 400 industry) Make (industry-by-commodity) and Use (commodity-by-industry) tables released every five years based on Industry Census data
- Combined with IO techniques they can be used to estimate direct and total economic requirements
- Used to model direct and indirect economic effects

A

	S1	S2	S3	S4	S5	S6	S7
S1	.01	0.8	0.1	.04	0.3	0.1	0.8
S2	0.3	0.2	0.5	.04	0.1	0.5	0.2
S3	0.5	0.1	.01	0.1	0.5	.01	0.1
S4	0.1	0.5	0.3	0.5	.01	0.3	.01
S5	0	.01	0.3	.01	0.3	0.8	0.3
S6	0.8	0.3	0.1	0.3	0.1	0.2	.04
S7	0.2	0.5	0.1	0.1	0.1	0.1	0.1

f

	H	G
S1	109	40
S2	40	30
S3	5000	988
S4	34	100
S5	0	56
S6	100	234
S7	30	670

W

	S1	S2	S3	S4	S5	S6	S7
Labor	.01	0.8	0.1	.04	0.3	0.1	0.8
Taxes	0.3	0.2	0.5	.04	0.1	0.5	0.2

$$(I - A)^{-1} * f$$

Environmentally-extended input-output modeling

- Direct environmental releases or resource use (stressors) associated with sectors can be linked to the economic input-output data, and used with indicators

C

	H2O	Cr	N2O	Land	P
Water Use	1	0	0	0	0
GHG	0	0	200	0	0
Mineral Use	0	120	0	0	0
Eutrophication	0	0	0	0	4.1

B

	S1	S2	S3	S4	S5	S6	S7
H2O	10	1	0	5	100	92	1
Cr	0.6	10	2	0.6	10	2	0.6
N2O	0.5	0.1	.01	0.1	0.5	.01	0.1
Land	0.1	2	0.6	10	2	2	0.6
Wast	0	10	2	10	1	0	5
DD	0.8	0.3	0.1	0.3	0.1	0.2	.04
P	1	2	0.6	10	2	2	0

A

	S1	S2	S3	S4	S5	S6	S7
S1	.01	0.8	0.1	.04	0.3	0.1	0.8
S2	0.3	0.2	0.5	.04	0.1	0.5	0.2
S3	0.5	0.1	.01	0.1	0.5	.01	0.1
S4	0.1	0.5	0.3	0.5	.01	0.3	.01
S5	0	.01	0.3	.01	0.3	0.8	0.3
S6	0.8	0.3	0.1	0.3	0.1	0.2	.04
S7	0.2	0.5	0.1	0.1	0.1	0.1	0.1

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$$C * B * (I - A)^{-1} * f$$

USEEIO: A new and transparent United States environmentally-extended input-output model

Yi Yang ^{a,*,1}, Wesley W. Ingwersen ^{b,*,1}, Troy R. Hawkins ^c, Michael Srocka ^d,
David E. Meyer ^b

- An environmentally-extended input-output model of the US
- Level of resolution: 385 goods and services
- 1875 unique releases or resource types
- 20 environmental, resource and socio-economic impact indicators
- Pulls in TRI, NEI, GHGI, DMR, RCRAINFO + USGS/USDA/EIA data, other public sources
 - > 9 million data points processed
- Formal data quality characterization
- Looking to combine efforts with **DIO**, another US model
- Open source data and modeling framework

Use of EEIO Models

- Modeling national consumption- or production-related life cycle impacts or footprints
- Can be used for single product supply chain hotspot analysis
- Prioritization of good and services
- In SMM context, goods and services that are “carriers” of materials

Benefits and Limitations of EEIO Models

- Comprehensive (full economy) and data-rich
- Can be built with public data
- Consistent with economic forecasting and good/service classification
- Level of resolution limited to national average for a good or service within an aggregated category
- Units of analysis is in \$ of goods/services

EEIO Models and SMM

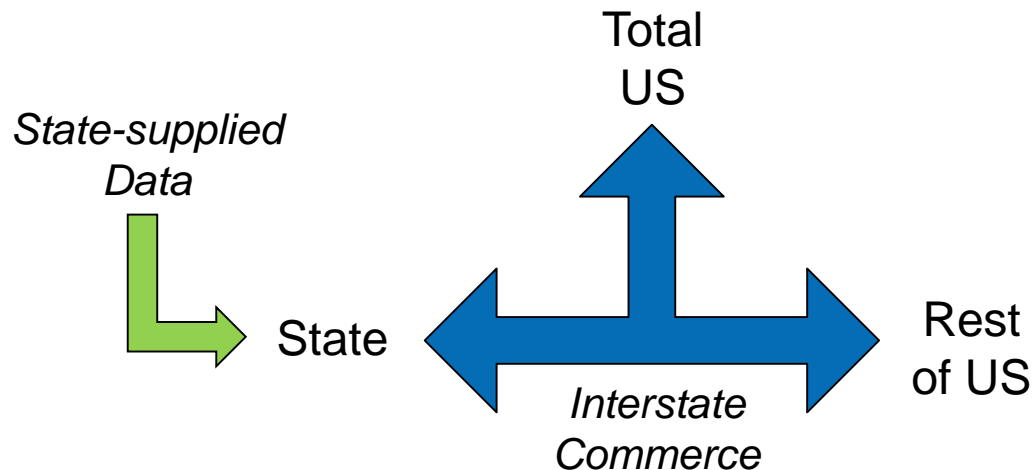
- A proprietary EEIO model was used for ‘The Road Ahead’
- Need more current, transparent, fully replicable model
- Need non-expert applications for using the model
- Needs to be customizable for smaller regions, like States

USEEIO Indicators

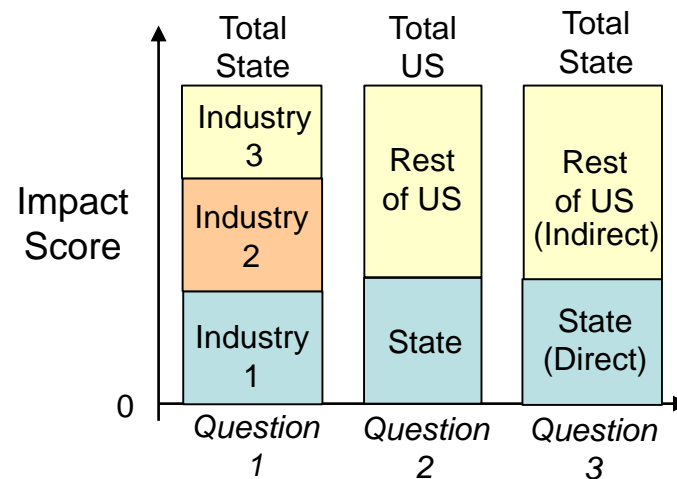
- **Potential Environmental Impacts** – acidification, respiratory effects of criteria pollutants, carcinogenic and non-carcinogenic toxicity effects, climate change, eutrophication, freshwater ecotox, smog formation, ozone depletion
- **Resource Use** – water, land, minerals
- **Environmental Releases** - HAPs, metals, pesticides
- **Economic & Social indicators** – value added, jobs
- **Waste Generated** – Hazardous waste, MSW, C&D

Customization: State-based Models

- A goal of the SMM IO Tool is to promote and support deployment of SMM at the state level
 - State-specific questions within the larger US system
- Create a state model within USEEIO
 - Reproducible and customizable



1. *Where are our hotspots?*
2. *How do we compare with other states?*
3. *Where are our impacts?*



Customization: Waste Generation and Treatment

- Detailed waste information can help start the SMM conversation.

SMM

Life Cycle Thinking

Multiple Impacts

Necessity and Efficiency

How to bridge the gap?



Solid Waste Management

End-of-Life

Reduce Landfilling

Increase recycling

- MSW Waste tracking for USEEIO is built on public data
 - State MSW Annual Reports (Generation and Diversion)*
 - Waste characterization studies
 - EPA Facts and Figures

* Not all states provide such data publicly



Stakeholder Engagement - Georgia

- Working with GA since 2014 to build state model, explore its uses
- Evaluated and discussed GA model through webinars and two moderated in-person workshops in Atl (2016 and 2018)
- Strong interest from GA EPD, GA Recycling Coalition, and GA Economic Development Dept. to apply GA model

Ongoing modeling challenges

- Complex scenario analysis
- More explicit material and waste tracking
- Accurately modeling environmental burdens associated with imports
- Automating updates and creation of state-based models

USEPA / USEEIO

Unwatch 6 Unstar 1 Fork 0

Code Issues 0 Pull requests 0 Projects 0 Wiki Insights

US Environmentally-Extended Input-Output Modeling Framework

2 commits 1 branch 0 releases 2 contributors

Branch: master New pull request Create new file Upload files Find file Clone or download

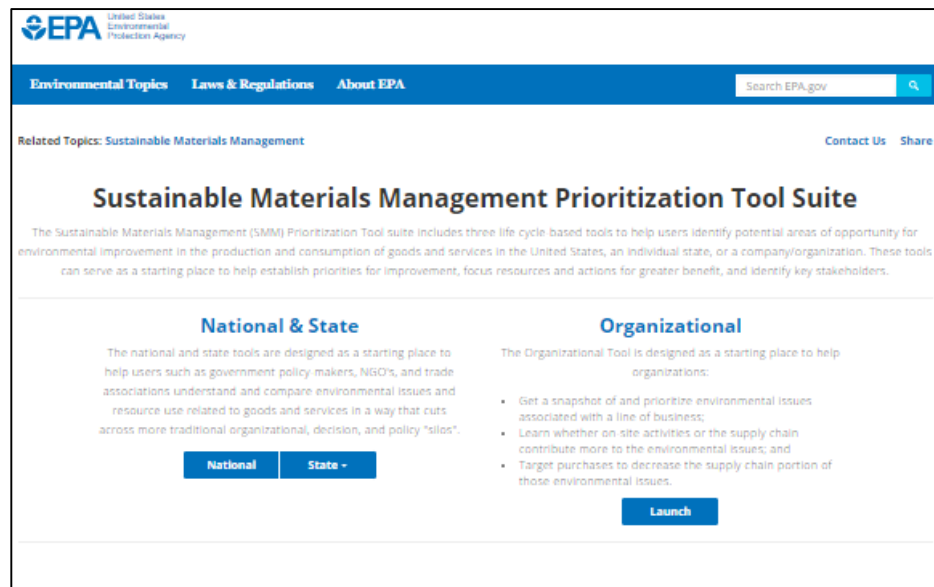
File	Version	Latest commit
Weslingwersen	Version 0.1 beta	14 days ago
R	Version 0.1 beta	14 days ago
SI	Version 0.1 beta	14 days ago
example	Version 0.1 beta	14 days ago
useeio.py	Version 0.1 beta	14 days ago
.gitignore	Version 0.1 beta	14 days ago
LICENSE.md	Version 0.1 beta	14 days ago
README.md	Version 0.1 beta	14 days ago
setup.py	Version 0.1 beta	14 days ago

README.md

United States Environmentally-Extended Input-Output (USEEIO) Modeling Framework

A modeling framework for creating versions of the USEEIO model for estimating potential impacts of goods and services in the US economy in approximately 400 categories. This framework supports the Sustainable Materials Management program at US EPA (www.epa.gov/smm), but may also be useful for other purposes. It is built using a technique from life cycle assessment (LCA) that combines industry economic data with data on environmental releases and resources used. A background and description of USEEIO can be found in the following publication:

- Open source framework (R and Python)
- Supports model transparency, and model variations developed and maintained by others



USEEIO
Modeling
Framework

USEEIO
API

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- Michael Srocka (GreenDelta)