LCA modelling of waste management systems
- Learn to use the EASETECH model

Offered by Tsinghua University (THU), Beijing Normal University (BNU), and Technical University of Denmark (DTU)

(In connection with ISIE 2019 in Beijing http://isie2019.env.tsinghua.edu.cn)

Tuesday July 2nd to Saturday July 6th 2019

Tentative Program

Introduction

Life cycle assessment (LCA) is becoming an important tool in assessing the environmental performance of solid waste management systems. The waste hierarchy has long governed waste management in major parts of the world, but the increasing complexity of waste management and the increasing demand for renewable energy has created the need for more detailed and accurate models for assessing resource conservation and environmental emissions from waste management. The EU has recommended life cycle thinking for decision support, reinforcing the importance of LCA modeling for more sustainable waste management strategies.

LCA models dedicated to waste management can be used as decision support and for technology development for a variety of issues within solid waste management. Examples are assessing alternatives in a municipal master plan for waste management, identifying key areas for improving current waste management systems, assessing new treatment technologies, setting optimum national criteria for material recycling, and quantifying effects of waste minimization.

A number of product LCA models and a few dedicated waste LCA models have been used to provide quantitative environmental assessment of many issues in waste management. The models are very different with respect to level of detail, user-friendliness, flexibility, transparency, databases provided and level of impact assessment.

This course introduces and applies the waste LCA model EASETECH developed at the Technical University of Denmark in collaboration with highly acknowledged scientists in waste management and in LCA methodology. The EASETECH model is very detailed, user-friendly, flexible, transparent, provides databases, and offers an advanced impact assessment characterization factors, normalization reference and weighting factors, and can quantify uncertainties.

Content of the course

The course provides an introduction to waste management as well as to LCA methodology. Focus is on providing the technical approach of modeling the various processes and technologies in waste management including the data structure and input to the model. Setting up scenarios (systems for comparison), acquiring data on waste processes as well as external processes (electricity, fuel combustion, etc.), performing the environmental assessment as well as the data interpretation are demonstrated several times during the course and also implemented by the participants using software installed on their own PCs.

The course additionally addresses limitations of the LCA modeling, ISO standards on LCA, sensitivity analysis and reporting.

Actual case stories are presented as part of lectures in order to provide insight into how real world problems are approached in modelling.

Details are provided below in terms of the daily program and the scheduled lectures and exercises.

Learning objectives

At the end of the course the participants should have a clear understanding of key issues in assessing resource conservation and environmental emissions from waste and resources management.

The aim is to provide to the participants necessary skills and expertise to perform an analytical environmental assessment of a waste management system. This will include an analysis of the technical system, its impact assessment and overall evaluation. The aim of this course is also to demonstrate the importance of sensitivity and uncertainty analysis and communication of results within LCA in general and specifically the framework of the EASETECH model.

The participants will become familiar with the application of the software tool EASETECH in assessing solid waste technologies and systems in a management context as well as in a research and technology development perspective.

The participants will obtain hands-on experiences in setting up new technologies and processes in the model and in assessing the results in terms of limitations, data quality, uncertainty and main outcome.

The participants will obtain access to the software free of charge for research purposes (restrictions for commercial uses apply).

At the end of the course, the participants will be made part of a DTU share group, where questions can be posted, and knowledge shared on EASETECH, and where users will have access to EASETECH updates.

Participants
The course is intended for PhD students, researchers and faculty within waste management, resource recovery and/or environmental biotechnology and a certain knowledge about waste management is expected. Participants must bring own PC. The course has a maximum of 35 participants.

Course fee
The course fee is 1500 RMB. EASETECH has no commercial ambitions or profit interests, and the course fee contributes to organization of the course, materials, lunch, coffee, refreshments, etc.

Registration
Application for the course is done by sending a motivation letter before April 1st 2019 to yanzhao@bnu.edu.cn. Participants and participants are accepted and announced by the organizers via email before May 1st 2019. Registration is confirmed by paying the course fee according to the guidance in the acceptance email.

Lecturers

Lei Shi (SHI), Professor, THU (Chair of ISIE 2019)
Anders Damgaard (ADAM), Senior Researcher, DTU (course responsible)
Wenjing Lu (LU), Associate Professor, THU
Yan Zhao (ZHAO), Associate Professor, BNU
Valentina Bisinella (VALE), Assistant Professor, DTU

Tentative Programme

DAY 1: Tuesday 2nd of July 2019

08.30 Welcome (SHI/LU): Registration and coffee/Tea.

09.00 Welcome and presentation of lecturers, assistants (ALL).

09.15 Practical arrangements (ADAM/LU): Software restrictions, signed statement, software installation, refreshments, lunch and dinners, internet access, transportation, etc.

09.30 Lecture (30 min): Why waste and LCA (ADAM/SHI): Introduction to waste and LCA, issues, system analysis.

10.00 Break

10.15 Lecture 2 (40 min): Waste generation and composition (ADAM): Waste types, unit generation rates, material fractions, substances, characterisation of waste (methods and shortcomings) + examples from EASETECH of waste material fractions, waste generation.

Examples on waste generation and composition in Chinese context (10 mins) (ZHAO).

10:45 Lecture 3 (20 min): Introduction to the EASETECH software, scenarios and documentation (ADAM): Main description, presentation of the documentation.

11.05 Exercise 1 (55 min): Waste generation.

12.00 Lunch

13.00 Lecture 4 (120 min): Introduction to LCA methodology (ADAM): Characteristics and applications of LCA, the first phases of the LCA methodology - goal and scope definition and inventory analysis (break when needed).

15.00 Break

15.15 Lecture 5 (30 min): Source segregation, waste collection and waste transport (ZHAO): Why source segregation, sorting guidelines, efficiencies, purity or contamination, relation to collection system. Collection: Types of collection, exhaust standards (refer to the evening) and transport.

Transport in Asia, Chinese emission standards and transport examples (ZHAO/LU).

16.00 Exercise 2 (60 min): Source segregation and collection.

17.00 End of Day 1

Dinner on your own.

DAY 2: Wednesday 3rd of July 2019

09.00 Lecture 6 (60 min): Material recovery facilities (MRF), transfer stations, material recycling (ADAM): Energy consumption, Output definitions, transfer coefficients, substitution ratio, and avoided virgin production.

Chinese experiences on waste transfer and recycling (ZHAO).

10.00 Break.

10.15 Exercise 3 (90 min): Source segregation, MRFs and material recycling.

12.00 Lunch.

13.00 Lecture 7 (60 min) Energy issues in LCA and EASETECH (VALE): Use of energy (resources, diesel, oil, natural gas, electricity, heat, etc). Units used? How are energy forms presented and where do I find them, what does the data cover? Production and substitution of energy (mix, marginal, cascading?). Fossil and biogenic energy forms. Electricity and heat? (Energy utilisation in terms of RDF is explained at a later stage). A presentation of the specific functionalities will be made.

14.00 Break.

14.15 Lecture 8 (60 min): Incineration (ADAM): Thermal treatment, main characteristics of incineration, modelling mass flow, emissions, energy, further routing of solid outputs.

Chinese experiences with WtE modelling (ZHAO).

15.15 Break.

15.30 Exercise 4 (75 min): Scenario with incineration.

16.45 End of Day 2

Dinner on your own.

DAY 3: Thursday 4th of July 2019

09.00 Lecture 9 (45 min) Biotechnologies (composting, anaerobic digestion) (LU): System description, background to degradation and mass transfer, transfer coefficient, rejects, energy utilisation of anaerobic digestion systems.

09.45 Break.

10.00 Lecture 10 (60 min): Use-on-land / soil manufacturing (ADAM): Description, comparison with other models, agricultural systems, emission coefficient, heavy metals emissions to soil.

11.00 Exercise 5 (75 min) Biotech + use-on-land.

12.15 Lunch.

13.15 Lecture 11 (120 min – 15 min break half way): Impact assessment (ADAM): Background and boundary conditions of the assessment of environmental impacts, classification, characterisation and normalisation, life cycle impact assessment and interpretation, weighting of environmental impacts, assessment of resource use and interpretation.

15.30 Break.

15.45 Lecture 12 (60 min) Data Quality (ADAM): Why is it important, how to obtain data with good quality, how can you assess it, how can it be used in the interpretation**.**

Assignment explanation (ADAM/ZHAO): Answering questions about group assignment and presentation.

16.45 End of Day 3

Dinner on your own.

DAY 4: Friday 5th of July 2019

09.00 Lecture 13 (60 min): Landfill Technologies (ADAM): Presentation of the landfill module in EASETECH. Open dump landfill, conventional landfilling technology, bioreactor and flushing bioreactor technologies, semi-aerobic technology.

Landfilling from a Asian perspective (wet and high moisture) (ZHAO).

10.00 Break.

10.15 Exercise 6 (90 min) Scenario with landfill.

11.45 Lunch.

12.45 Lecture 14 (45 min): Capital goods in waste management (ADAM): Economic issues of waste, capital investment of waste facilities, treatment costs of different technologies, introduction to cost modelling.

13.30 Break.

13.45 Lecture 15 (30 mins): A case study for China (ZHAO/LU): Integrated waste management system dominated by landfill, emission characteristics of Chinese landfills, and Chinese landfill optimization from an LCA perspective.

14.15 Exercise 7 (120 min – 15 min break half way): Scenario comparison, interpretation and presentation of results: Assignment presentation in group, interpreting the results on modelling waste system, 10 min for each group in 3 participants.

16.30 End of day 4

Dinner on your own.

DAY 5: Saturday 6th of July 2019

09.00 Lecture 16 (60 min): Uncertainty analysis (VALE): Key parameters, conventions, why uncertainty analysis is important, system boundaries, sensitivity and uncertainty, how to quantify it, how to do in EASETECH.

10.00 Break.

10.15 Exercise 8 (105 min): Sensitivity and uncertainty modelling in EASETECH.

12.00 Lunch.

13.00 Lecture 17 (60 min): H**ow quantification of sustainability helps in developing green technologies (ZHAO):** A case on quantifying global warming potential from alternative technologies for bioethanol production, aiming to how a quantitative sustainability approach changes our technological innovation.

14.00 Break.

14.15 Wrap-up, Students' discussion (75 min) (SHI/LU/ADAM/ZHAO/VALE): Wrap-up of the course, taking home messages, answers to problems.

15.30 End of Day 5

Course literature / material:

The following covers reading material for the course. Text under additional reading is not required but will be mentioned during the lectures and can be read if interested in deeper knowledge.

Required reading for the course (19 articles):

Andreasi Bassi, S., Christensen, T.H., Damgaard, A., 2017. Environmental performance of household waste management in Europe - An example of 7 countries. Waste Manag. 69, 545–557.

Bisinella, V., Conradsen, K., Christensen, T.H., Astrup, T.F., 2016. A global approach for sparse representation of uncertainty in Life Cycle Assessments of waste management systems. Int. J. Life Cycle Assess. 21, 378–394.

Boldrin, A., Neidel, T. L., Damgaard, A., Bhander, G. S., Møller, J., Christensen, T. H. (2011): Modelling of environmental impacts from biological treatment of organic municipal waste in EASEWASTE, Waste Management, 31, 619–630.

Brogaard, L.K., Damgaard, A., Jensen, M.B., Barlaz, M., Christensen, T.H., 2014. Evaluation of life cycle inventory data for recycling systems. Resour. Conserv. Recycl. 87, 30–45.

Clavreul, J., Baumeister, H., Christensen, T.H., Damgaard, A., 2014. An environmental assessment system for environmental technologies. Environ. Model. Softw. 60, 18–30.

Clavreul, J., Guyonnet, D. & Christensen, T.H., 2012. Quantifying uncertainty in LCA-modelling of waste management systems. Waste management, 32(12), pp.2482–2495.

Damgaard, A. et al., 2010. Life-cycle-assessment of the historical development of air pollution control and energy recovery in waste incineration. Waste management, 30(7), pp.1244–1250.

Edjabou, M.E., Jensen, M.B., Götze, R., Pivnenko, K., Petersen, C., Scheutz, C., Astrup, T.F., 2015. Municipal solid waste composition: Sampling methodology, statistical analyses, and case study evaluation. Waste Manag. 36, 12–23.

Finnveden, G., Hauschild, M.Z., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., Koehler, A., Pennington, D., Suh, S., 2009. Recent developments in Life Cycle Assessment. J. Environ. Manage. 91, 1–21.

Fruergaard, T., Astrup, T., Ekvall, T., 2009. Energy use and recovery in waste management and implications for accounting of greenhouse gases and global warming contributions. Waste Manag. Res. 27, 724–737.

Götze, R., Pivnenko, K., Boldrin, A., Scheutz, C., Astrup, T.F., 2016. Physico-chemical characterisation of material fractions in residual and source-segregated household waste in Denmark. Waste Manag. 54, 13–26.

Hauschild, M.Z. and Huijbregts, M.(Ed.) Life Cycle Impact Assessment. Chapter 1. Springer verlag.

Hauschild, M.Z., Goedkoop, M., Guinée, J., Heijungs, R., Huijbregts, M., Jolliet, O., Margni, M., Schryver, A., Humbert, S., Laurent, A., Sala, S., Pant, R., 2012. Identifying best existing practice for characterization modeling in life cycle impact assessment. Int. J. Life Cycle Assess. 18, 683–697.

Henriksen, T., Astrup, T.F., Damgaard, A., 2017. Linking data choices and context specificity in life cycle assessment of waste treatment technologies: a landfill case study. J. Ind. Ecol. 22(5), 1039-1049.

Larsen, A.W. et al., 2009. Diesel consumption in waste collection and transport and its environmental significance. Waste Manag. Res. 27(7), 652–659.

Laurent, A., Bakas, I., Clavreul, J., Bernstad, A., Niero, M., Gentil, E., Hauschild, M.Z., Christensen, T.H., 2014. Review of LCA studies of solid waste management systems--part I: lessons learned and perspectives. Waste Manag. 34, 573–588.

Laurent, A., Clavreul, J., Bernstad, A., Bakas, I., Niero, M., Gentil, E., Christensen, T.H., Hauschild, M.Z., 2014. Review of LCA studies of solid waste management systems--part II: methodological guidance for a better practice. Waste Manag. 34, 589–606.

Manfredi, S. & Christensen, T. H. (2009). Environmental assessment of solid waste landfilling technologies by means of LCA-modeling (EASEWASTE). Waste Management 29, 32-43

Yoshida, H., Nielsen, M.P., Scheutz, C., Jensen, L.S., Bruun, S., Christensen, T.H., 2016. Long-Term Emission Factors for Land Application of Treated Organic Municipal Waste. Environ. Model. Assess. 21, 111–124.

Additional reading

LCA:

Christensen, T.H., Gentil, E., Boldrin, A., Larsen, A.W., Weidema, B.P., Hauschild, M.Z., 2009. C balance, carbon dioxide emissions and global warming potentials in LCA-modelling of waste management systems. Waste Manag. Res. 27, 707–715.

European Commission (EC) – Joint Research Centre – Institute for Environment and Sustainability, 2010a. International Reference Life Cycle Data System (ILCD) Handbook – General guide for Life Cycle Assessment – Detailed guidance. First edition March 2010. EUR 24708 EN. Publications Office of the European Union, Luxembourg, LU.

Hauschild, M.Z., Olsen, S.I., Hansen, E., Schmidt, A., 2008. Gone…but not away—addressing the problem of long-term impacts from landfills in LCA. Int. J. Life Cycle Assess. 13, 547–554.

Waste Technologies, Composition and Energy

Fruergaard, T., Hyks, J., Astrup, T., 2010. Life-cycle assessment of selected management options for air pollution control residues from waste incineration. Sci. Total Environ. 408, 4672–4680.

Fruergaard, T. & Astrup, T., 2011. Optimal utilization of waste-to-energy in an LCA perspective. Waste management, 31(3), pp.572–582.

Hansen, T.L., Bruun, S., Bhander, G.S., Stoumann-Jensen,L. & Christensen,T.H. (2006): Life cycle modelling of environmental impacts from application of processed organic municipal solid waste on agricultural land (EASEWASTE). Waste Management and Research, 24, 153-166.

Larsen, A.W., Fuglsang, K., Pedersen, N.H., Fellner, J., Rechberger, H., Astrup, T., 2013. Biogenic carbon in combustible waste: waste composition, variability and measurement uncertainty. Waste Manag. Res. 31, 56–66.

Merrild, H., Larsen, A.W. & Christensen, T.H., 2012. Assessing recycling versus incineration of key materials in municipal waste: The importance of efficient energy recovery and transport distances. Waste management, 32(5), pp.1009–1018.

NordTest Methode for waste sampling, 1995

Pressley, P.N., Levis, J.W., Damgaard, A., Barlaz, M. a, Decarolis, J.F., 2016. Analysis of material recovery facilities for use in life-cycle assessment. Waste Manag. 35, 307–317.

Riber, C., Bhander, G., & Christensen, T. H. (2008): Environmental assessment of waste incineration in a life-cycle-perspective (EASEWASTE). Waste Management & Research. 26: 96–103.

Riber, C., Petersen, C. & Christensen, T.H., 2009. Chemical composition of material fractions in Danish household waste. Waste management, 29(4), pp.1251–1257.

Turconi, R., Butera, S., Boldrin, A., Grosso, M., Rigamonti, L., Astrup, T., 2011. Life cycle assessment of waste incineration in Denmark and Italy using two LCA models. Waste Manag. Res. 29, 78–90.

Turconi, R., Boldrin, A., Astrup, T., 2013. Life cycle assessment (LCA) of electricity generation technologies: Overview, comparability and limitations. Renew. Sustain. Energy Rev. 28, 555–565.

Capital Goods

Brogaard, L.K., Christensen, T.H., 2012. Quantifying capital goods for collection and transport of waste. Waste Manag. Res. 30, 1243–1250.

Brogaard, L.K., Riber, C., Christensen, T.H., 2013. Quantifying capital goods for waste incineration. Waste Manag. 33, 1390–1396.

Brogaard, L.K., Stentsøe, S., Willumsen, H.C., Christensen, T.H., 2013. Quantifying capital goods for waste landfilling. Waste Manag. Res. 31, 585–598.

Brogaard, L.K., Petersen, P.H., Nielsen, P.D., Christensen, T.H., 2015. Quantifying capital goods for biological treatment of organic waste. Waste Manag. Res. 33, 96–106.

Models and Uncertainty

Clavreul, J., Baumeister, H. Christensen, T.H., Damgaard, A., 2014. EASETECH – an Environmental Assessment System for Environmental TECHnologies, Supporting Information.

Gentil, E.C. et al., 2010. Models for waste life cycle assessment: review of technical assumptions. Waste management, 30(12), pp.2636–2648.

Weidema, B.P. & Wesnaes, M.S., 1996. Data quality management for life cycle inventories - an example of using data quality indicators. Journal of Cleaner Production, 4(3-4), pp.167–174.

It is expected that the students READ THE REQUIRED LITERATURE. No copy of the papers will be provided during the course.

All copies can be downloaded from
https://www.dropbox.com/s/gcw9umoq89fz4zg/12902_Literature.zip?dl=0

A copy of the manuals and documentation on EASETECH will be distributed to each delegate. Further articles where EASEWASTE and EASETECH have been used will be made available on request.