

Ensuring Economically Feasible Biogas Projects by Optimisation of the Value Chain

Jensen, Ida Græsted; Juul, Nina

Publication date: 2015

Document Version Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA): Jensen, I. G. (Author), & Juul, N. (Author). (2015). Ensuring Economically Feasible Biogas Projects by Optimisation of the Value Chain. Sound/Visual production (digital)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.

- · You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



7182818284

Ensuring Economically Feasible Biogas Projects by Optimisation of the Value Chain

 $f(x+\Delta x) = \sum_{i=0}^{\infty} \frac{(\Delta x)^i}{i!} f^{(i)}(x)$

(日) (部) (王) (王)

Ida Græsted Jensen MSc & Nina Juul MSc PhD Department of Management Engineering, Systems Analysis

e-mail: idje@dtu.dk

DTU Management Engineering

Department of Management Engineering

 Introduction
 Input side model
 Preliminary results
 Concl.

 •0000
 0000000
 00000
 00

Concluding Remarks

イロト イポト イヨト イヨト 二日



The system



Input side model

Preliminary results

Concluding Remarks

DTU

Motivation for using biogas

- ► High share of wind energy ⇒ need of an alternative electricity source
- In 2020, 50% of all manure must be used for biogas production - corresponding to approximately 13 PJ



Input side model

Preliminary results

Concluding Remarks

イロト 不得 トイヨト イヨト 二日



What is biogas?

Biogas is gas based on waste or other methane sources, e.g.:

- Animal manure
- Deep litter
- Household waste
- Waste water
- Energy crops

Biogas can be produced by:

- Thermal gasification
- Anaerobic digestion

Input side model

Preliminary results

Concluding Remarks



Why biogas?

Biogas production has several advantages:

- Renewable energy storage opportunities
- Reduction on GHG emissions
- Improved fertiliser
- Redistributions of nutrients
- Reduced smell

Input side model

Preliminary results

Concluding Remarks



The plant level model

Objective:

 Optimise the production of biogas while ensuring economic feasibility for all partners



Input side model

Preliminary results

Concluding Remarks



The plant level model

Objective:

 Optimise the production of biogas while ensuring economic feasibility for all partners



Input side model

Preliminary results

Concluding Remarks



The plant level model

Objective:

 Optimise the production of biogas while ensuring economic feasibility for all partners



Input side model •0000000 Preliminary results

Concluding Remarks



Input side model

More complicated than the output side:

- Flow of different biomasses
- Both mass and energy potential must be accounted for:
 - Mass needed for capacities and fertiliser output
 - Energy potential needed for the final biogas yield changes during storage and pretreatment

Input side model

Preliminary results

Concluding Remarks



Flow model

- A 3D graph network: Dimensions are process p, time t and biomass potential e
- A variation of a minimum cost multi-commodity flow problem with node capacities

Small segment of the model - shown in 2D:



3

Input side model

Preliminary results

Concluding Remarks



Variables

- ► x_a: Flow on arc a (arc defined by: (i, p, t, e, p', t', e'))
- c_p: Capacity of process p
- $u_{o,p}$: If p is owned by owner o
- ► u^{trans}_{o,p,o',p'}: If p is owned by owner o and p' is owned by owner o'
- ► x^{trans}_{o,p,o',p'}: How much is transported from process p owned by owner o to p' owned by owner o'

Input side model

Preliminary results

Concluding Remarks



Objective and simple constraints

Objective:

m

$$\begin{aligned} \max Z &= \sum_{a \in \mathcal{A}^{plant}} (p^{gas} BMP_i e + p^{fert}) x_a \\ &- \sum_{a \in \mathcal{A}} OPEX_{p,p'} x_a - \sum_{p \in \mathcal{P}} CAPEX_p c_p \\ &- \sum_{(p,p') \in \mathcal{P}} \sum_{(o,o') \in \mathcal{O}} TRANS_{o,p,o',p'} x_{o,p,o',p'}^{trans} \end{aligned}$$

Simple(st) constraints:

- Flow: includes mass loss for each process
- Input: what biomasses are available in each time step
- Maximum biomass type: restrictions on e.g. percentage energy crop of total mix

Input side model

Preliminary results

Concluding Remarks

DTU

Capacity constraint



duction	Input side model	Preliminary results	Concluding Rema
Proces	ss time		

Introduc



Input side model

Preliminary results

Concluding Remarks



Ownership constraints

One owner per process:

$$\sum_{o \in \mathcal{O} \mid (p,o) \in \mathcal{PO}} u_{o,p} = 1 \qquad \forall p \in \mathcal{P}$$

Same owner for consecutive processes:

$$egin{aligned} & u_{o,p}+1 \geq u_{o,p'}+u_{o,p''} \ & orall o \in \mathcal{O}, \ i \in \mathcal{I}, \ (p,p',p'') \in \mathcal{P}^i \land p'$$

Input side model

Preliminary results

Concluding Remarks



Transportation constraints

If two processes are owned by different owners:

$$\begin{aligned} u_{o,p,o',p'}^{trans} + 1 &\geq u_{o,p} + u_{o',p'} \\ \forall \{ (p,p') \in \mathcal{P}^{comb}, \, (o,o') \in \mathcal{O} | (p,o), (p',o') \in \mathcal{PO} \} \end{aligned}$$

Amount transported between different owners:

$$\begin{split} x_{o,p,o',p'}^{trans} &\geq \sum_{a \in \mathcal{A}(p,p')} x_a - M\left(1 - u_{o,p,o',p'}^{trans}\right) \\ \forall \{(p,p') \in \mathcal{P}^{comb}, \, (o,o') \in \mathcal{O} | (p,o), (p',o') \in \mathcal{PO} \} \end{split}$$

14 / 21

Input side model

Preliminary results

Concluding Remarks



Results

Case considers co-digestion of sugar beet (SB) and pig slurry (PS).

- All cost functions are linear
- Data is preliminary the costs of each process is partly being determined in the BioChain project

Input side model

Preliminary results

Concluding Remarks



Fixed amount of SB



Negative net income with SB up to maximum level

DTU Management Engineering, Technical University of Denmark

Input side model

Preliminary results

Concluding Remarks



SB price decreased



 Price of SB needs to be lower to make co-digestion profitable

DTU Management Engineering, Technical University of Denmark

Input side model

Preliminary results

Concluding Remarks



SB gas yield increased



 Uncertainty on the gas yield of SB can make co-digestion profitable

DTU Management Engineering, Technical University of Denmark



DTU

Income for farmer and plant - different ownerships



the project

DTU Management Engineering, Technical University of Denmark

э.

イロト イポト イヨト イヨト

Input side model

Preliminary results

Concluding Remarks



Next step

- Data on the input side must be validated
- Constraints for feasibility of ownership included
- Detailed restrictions on the plant, e.g. seasonal variation
- Transportation more detailed included
- CAPEX and OPEX included as piece-wise linear functions

Input side model

Preliminary results

Concluding Remarks



Is it really worth the effort?

Today in Denmark:

- Existing biogas plants typically have long time contracts on price of output, i.e. the variation on prices might not be used in practice
- Existing biogas plants cannot control what the biogas is used for due to the ownership structure

Input side model

Preliminary results

Concluding Remarks

イロト 不得 トイヨト イヨト



Is it really worth the effort?

Today in Denmark:

- Existing biogas plants typically have long time contracts on price of output, i.e. the variation on prices might not be used in practice
- Existing biogas plants cannot control what the biogas is used for due to the ownership structure

This will hopefully change over the next years!

э.