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Participatory life cycle sustainability analysis

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In cooperation with Chalmers University of Technology

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Preface

This report is based on three presentations from SETAC Europe 26th Annual Meeting: an oral presentation and two posters. All presentations relate to the same methodology and case study: an approach to life cycle sustainability assessment that was applied to assess a pipeline for transfer of residual heat from chemical industries in Stenungsund to the district-heating systems in Kungälv and Göteborg.

The content of this report is the short abstract of the oral presentation in English and Swedish, the extended abstract of the oral presentation, the two posters, and the slides from the oral presentation.

Short abstract

This presentation aims to contribute to the development and demonstration of an operational approach to life cycle sustainability analysis (LCSA). This approach originates from the framework developed within the EU project CALCAS. The framework is different from the life cycle sustainability assessment outlined by Klöpffer in that it not only broadens the scope of life cycle assessment (LCA) to include economic and social aspects, but also allows for deepening of the analysis. It is also different in that it does not predefine the LCSA to be the sum of LCA, life cycle costing (LCC) and social LCA. Instead, the sustainability indicators, the systems investigated and the methods used for the analysis are all decided case by case. Our LCSA approach has two distinct features: 1. the case-specific research questions are defined in a participatory procedure that involves an Open Space workshop; 2. the analyses are carried through by a network of researchers and experts. A network is necessary because the research questions are not known in advance.

We applied the approach in a sustainability assessment of a 50 km pipeline for transfer of residual heat from industries to a large district-heating system. The LCSA included 14 research questions on economic, environmental and social aspects. The results indicate that the pipeline is likely to reduce the total costs of the system, but the expected profit is rather small and uncertain, and it is difficult to find a market model that ensures everyone a share of this profit. The environmental benefits of the pipeline are highly dependent on what electricity production increases when the use of residual heat in the DH systems reduces the combined heat and power production in these systems. The pipeline is likely to have no significant impact on the employment and a somewhat negative impact on the land owners.

In conclusion, our LCSA approach proved to be operational. The Open Space format for workshops can generate a good basis for the research questions; however, care must be taken to ensure a balanced participation at the workshop, and complementary research questions might have to be added after the workshop. We found that an LCSA that is the sum of LCA, LCC and social LCA does not cover all sustainability aspects that stakeholders can consider important. We also found that the sustainability of a pipeline for residual heat is uncertain in this specific system and in the time frame investigated.

Kort sammanfattning

Denna presentation syftar till att demonstrera och bidra till utvecklingen av en fungerande metod för livscykelhållbarhetsanalys (LCSA). Metoden baseras på ett ramverk som utvecklats inom EU-projektet CALCAS. Ramverket skiljer sig från det ramverk som tidigare beskrivits av Klöpffer i det att det inte bara breddar omfattningen av livscykelanalys (LCA) till att inkludera ekonomiska och sociala aspekter, utan även gör det möjligt att fördjupa analysen. Vårt ramverk är också annorlunda i det att den inte i förväg definierar LCSA som summan av LCA, livscykelkostnadsberäkning (LCC) och social LCA. I stället bestäms hållbarhetsindikatorerna, de system som undersökts och de metoder som används för analysen från fall till fall. Vår LCSA-metod tillvägagångssätt har två viktiga särdrag: 1. fallspecifika frågeställningar definieras i en deltagandeprocess som inkluderar en så kallad Open Space-workshop; 2. analyserna genomförs av ett nätverk av forskare och experter. Ett nätverk är nödvändigt eftersom forskningsfrågorna inte är kända i förväg.

Vi tillämpade metoden i en hållbarhetsbedömning av en 50 km lång ledning för överföring av restvärme från industrin till fjärrvärmesystem. Studien kom att omfatta 14 forskningsfrågor om ekonomiska, miljömässiga och sociala aspekter. Resultaten tyder på att ledningen sannolikt bidrar till att minska de totala kostnaderna för systemet, men den förväntade vinsten är ganska liten och osäker, och det är svårt att hitta en marknadsmodell som säkerställer att alla parter får del av vinsten. De miljömässiga fördelarna med rörledningen är starkt beroende av vilken elproduktion som ökar när användningen av restvärme i fjärrvärmesystemen reducerar samproduktionen av el och värme i dessa system. Rörledningen kommer sannolikt inte att ha någon betydande inverkan på sysselsättningen men en något negativ inverkan på markägarna.

Sammanfattningsvis har vår LCSA-metod visat sig möjlig att använda praktiskt. Open Space-tekniken kan ge värdefulla bidrag till valet av forskningsfrågor. Det är dock viktigt att sträva efter en balanserad fördelning mellan deltagarna i workshopen, och resultatet från workshopen kan behöva kompletteras med ytterligare frågeställningar. Vi fann att en LCSA som är summan av LCA, LCC och social LCA inte täcker in alla hållbarhetsaspekter som intressenter kan anse vara viktiga. Vi fann också att det är osäkert om rörledningen för restvärme leder till ökad hållbarhet i det specifika system och den specifika tidsram som undersöktes.

Extended abstract

Introduction

The scope of a sustainability assessment can be overwhelming, particularly if it also has a broad systems perspective. Each of the three sustainability pillars – environment, economy and social aspects – includes a large number of potential aspects and indicators. In addition, many sustainability aspects can be difficult to quantify and/or communicate. The objective of this presentation is to contribute to the development and demonstration of an approach to life cycle sustainability analysis (LCSA) that allows for dealing with this extreme complexity.

We applied the LCSA approach in a sustainability assessment of a 50 km pipeline for transfer of residual heat from the chemical industries in Stenungsund to the district-heating (DH) systems of Kungälv and Gothenburg – all on the Swedish west coast.

The LCSA approach

Our LCSA approach originates from the framework developed within the EU project CALCAS [1]. This framework is different from the life cycle sustainability assessment outlined by Klöpffer [2] in that it not only broadens the scope of life cycle assessment (LCA) to include economic and social aspects, but also allows for deepening of the analysis. It is also different in that it does not predefine the LCSA to be the sum of LCA, life cycle costing (LCC) and social LCA. Instead, the sustainability indicators, the systems investigated and the methods used for the analysis are all decided case by case.

Our LCSA approach has two distinct features (see Figure 1). One is that the case-specific sustainability indicators are identified through a participatory approach that involves an Open Space workshop [3]. A coordinator interprets the output from the workshop and translates it into research questions. These can be presented to the participants of the workshop for feedback and possible revision.

The other key feature is that the actual analyses are carried through by a network of researchers and experts. A network is necessary because the research questions are not known in advance and because no single researcher can respond to all possible research questions. The coordinator identifies suitable experts in the research network for each of the research questions. The coordinator also produces a synthesis based on the results of all analyses.

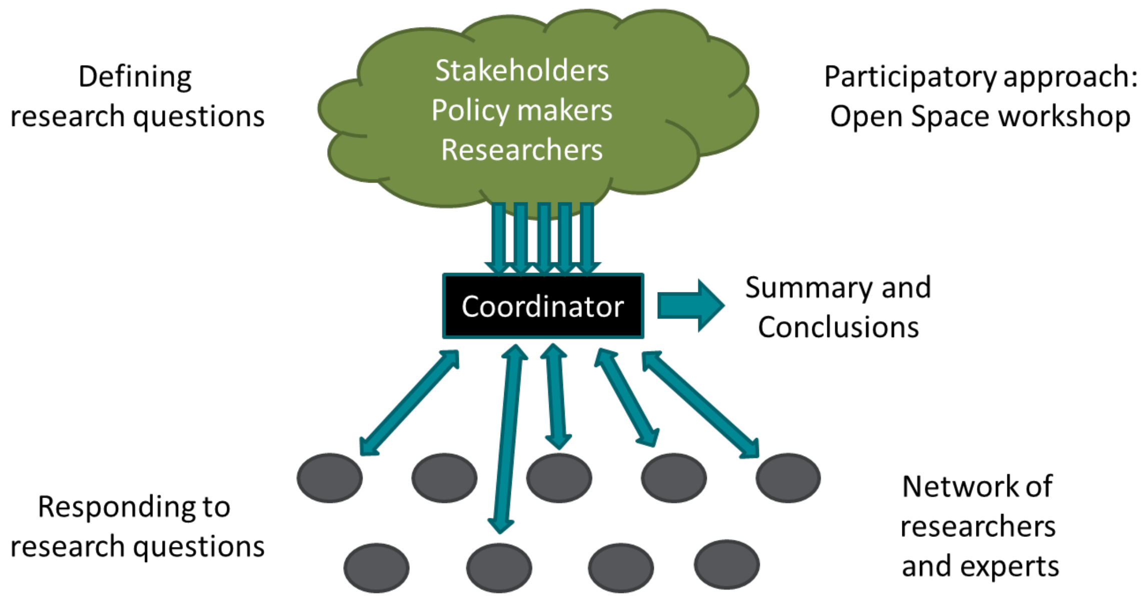

Figure 1: The conceptual framework of the LCSA approach.

Case study

Research questions

In the LCSA of a pipeline for residual heat, we organised two Open Space workshops and two internal meetings before a set of 14 research questions was completed. This set included six questions on the economic impacts, five on the environmental impacts and three on the social impacts. The Open Space workshops mainly produced questions related to economic aspects. They ranged from the profitability of the pipeline, over the possibility to ensure that all stakeholders gained from it, to business risks and opportunities, and to the impact on the district-heat users.

The environmental issues highlighted by the Open Space workshops were restricted to climate impacts, resource use and the risk of lock-in to a fossil energy system. The core research group added acidification and eutrophication at an internal meeting.

The workshops gave priority to no social aspects. Impacts on employment were added at a meeting with the directly involved stakeholders. The impact on land owners along the pipeline was added by the coordinator.

The emphasis on economic issues at the Open Space workshops was probably because many of the workshop participants represented companies involved in producing or using the residual heat.

The sustainability of the pipeline

The 14 research questions were analysed with a combination of quantitative and qualitative methods: pinch analysis, energy systems modelling, consequential LCA, qualitative enquiries, and deliberations. Four different research groups and nine stakeholders contributed to the analysis. The analysis took into account impacts until the year 2040. The results indicate that:

- The investment in the pipeline is likely to reduce the total costs of the system, but the expected profit is rather small and uncertain, and it is difficult to find a market model that ensures everyone a share of this profit.
- The environmental benefits are highly dependent on what electricity production increases when the use of residual heat in the district-heating systems reduces the combined heat and power production in these systems.
- The pipeline is likely to have no significant impact on the employment and a somewhat negative impact on the land owners.

For a full presentation of the results, we refer to the case-study report [4].

Conclusions

Our LCSA approach proved to be operational. The Open Space format for workshops can generate a good basis for the research questions; however, care must be taken to ensure a balanced participation at the workshop, and complementary research questions might have to be added after the workshop.

An LCSA that is the sum of LCA, LCC and social LCA does not cover all sustainability aspects that stakeholders can consider important. For example, it would not include an analysis of business risks and opportunities, nor the risk of lock-in effects.

Our case study indicates that the sustainability of a pipeline for residual heat is uncertain in this specific system and in the time frame investigated.

References

[1] CALCAS. 2009. Calcas – Co-ordination Action for innovation in Life-Cycle Analysis for Sustainability. http://fr1.estis.net/sites/calcas/default.asp. Accessed 24 November 2015.
[2] Klöpffer W. 2008. Life Cycle Sustainability Assessment of Products. Int J LCA 13:89-94.
[3] Owen H. 1993. OPEN SPACE TECHNOLOGY – A User's Guide. http://elementaleducation.com/wp-content/uploads/temp/OpenSpaceTechnology--UsersGuide.pdf. Accessed 24 November 2015.
[4] Ekvall T, Ljungkvist H. 2014. Sustainability assessment of residual heat transfer from Stenungsund to Gothenburg. Report C79. Stockholm, Sweden: IVL Environmental Research Institute. 39 p.

Acknowledgement - The authors thank all participants in the research project "Cooperation in West Sweden for Industrial Excess Heat" and in the Open Space workshops. The participating companies, the Swedish Energy Agency, and the Swedish Research Council Formas funded the research. Funding for preparing this presentation was provided by Formas and the Swedish Environmental Protection Agency through the Foundation for IVL Swedish Environmental Research Institute (SIVL).

Poster 1

Identifying sustainability indicators through Open Space

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BACKGROUND

What indicators are essential varies between different sustainability assessments. A case-specific approach that involves stakeholders in the selection of indicators can increase:

- the perceived relevance of the results
- the chances that the results of the assessment are accounted for in the decision process

CASE STUDY

A sustainability assessment of a pipeline for residual heat:

- from Industries in Stenungsund
- to district heating system in Gothenburg
- ~ 50 km
- ~ 1 billion SEK

OPEN SPACE

Workshop format for deciding how to organise an activity. Aiming to:

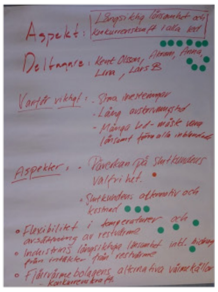
- create meetings and discussions, which each participant freely joins and leaves.
- generate energy through a dynamic mix of
  - individual deliberations
  - small-group discussions
  - reporting and discussions in plenum

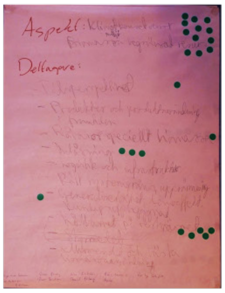
WORKSHOP AGENDA

1. Introduction
2. Generating ideas for indicators
3. Scheduling discussions
4. Group discussions in two or three consecutive sessions
5. Reporting of group discussions
6. Voting
7. Final discussion

Source: Johanne Lortie, ITC-ILO

Flipcharts from workshop (sample)





WORKSHOP OUTPUT

- Mainly economic aspects
- Sometimes vague
- Sometimes too broad

AFTER-TREATMENT

- Interpretation of output
- Additions from research group
- Feedback from stakeholders

REVISED OUTPUT

14 research questions:

- Six on economy
- Five on environment
- Three on social aspects

CONCLUSIONS

- Open-Space workshops help identifying relevant sustainability indicators
- A key challenge is to get a sufficiently large and balanced group of participants
- Interpretation of the workshop output is necessary
- Adding further indicators can be necessary
- Economic indicators are much more than life cycle cost

FURTHER READING

- Ekvall T, Ljungkvist H, Sandvall AF, Ahlgren EO. 2016. A case-dependent participatory approach to life cycle sustainability assessment. Submitted to *J. Ind. Ecol.*
- Ekvall T, Ljungkvist H. 2014. *Sustainability assessment of residual heat transfer from Stenungsund to Gothenburg*. Report C79. Stockholm, Sweden: IVL Swedish Environmental Research Institute.
- Owen H. 1993. OPEN SPACE TECHNOLOGY – A User's Guide. http://elementaleducation.com/wp-content/uploads/temp/OpenSpaceTechnology--UsersGuide.pdf.

Poster 2

Communicating results in a life cycle sustainability analysis

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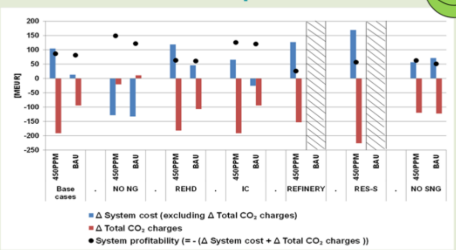
BACKGROUND

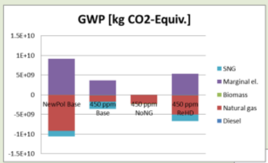
LCSA results are likely to be a mix of quantitative modelling output and qualitative discussions on widely divergent topics. Communicating such complex results is a challenge.

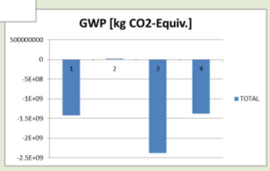
1. Is the investment profitable?



Source: Sandvall et al. 2016

8. Climate impact (electricity from natural gas)





Source:
Ekvall & Ljungkvist 2014

14. Impact on land-owners

- Weak bargaining position
- Alleviate through coordination with freshwater pipeline?

CASE STUDY

A sustainability assessment of a 50 km pipeline for residual heat from Industries in Stenungsund to district heating system in Gothenburg. Smileys were used to present the results.

Economic impact: small gain likely

1.	Profitable investment?		Refineries in Gothenburg?
2.	Can all share the profit?		Unclear
3.	Impact on vulnerability?		More options for all
4.	Demand during summer?		Refineries in Gothenburg?
5.	New heat applications?		
6.	Impact on final customer?		Potentially small gain

Environmental impact: uncertain

7.	Primary energy		Uncertain systems impacts
8.	Climate		Uncertain systems impacts
9.	Acidification		Uncertain systems impacts
10.	Eutrophication		Uncertain systems impacts
11.	Transition to renewable energy		Potential driver and barrier

Social impact: slightly negative

12.	Employment, total		Pipeline or CHP plant
13.	Employment outside urban area		Pipeline or CHP plant
14.	Impact on land owners		Coordination

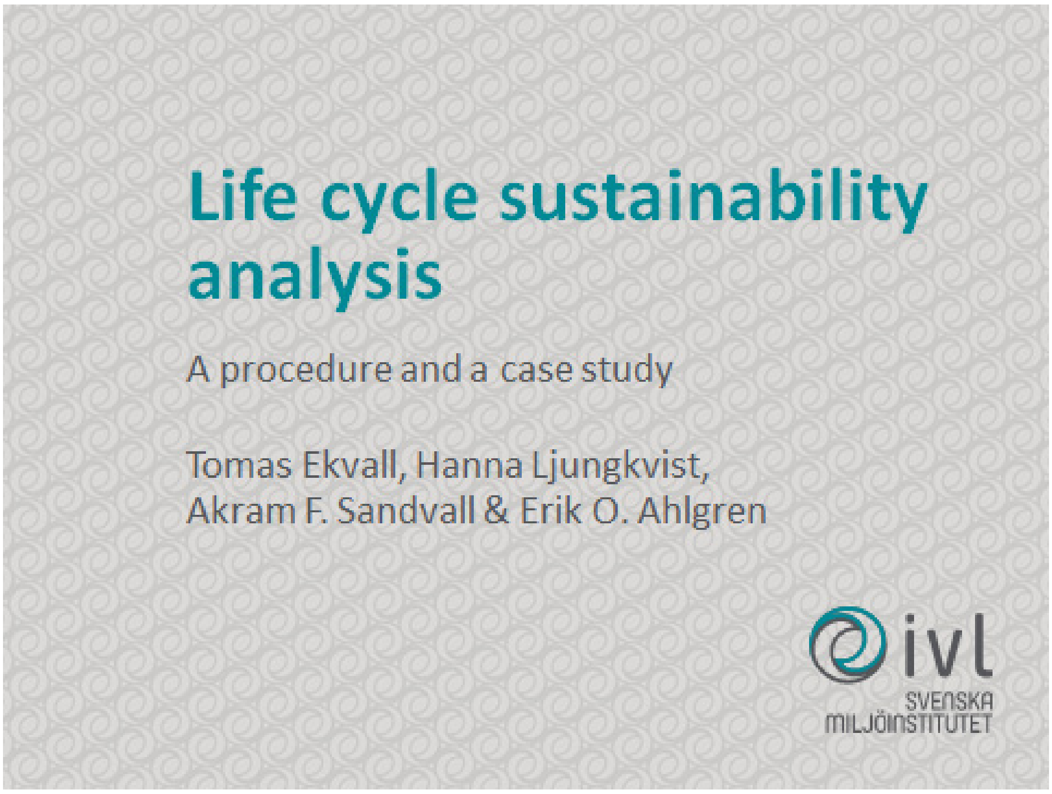
OBSERVATIONS

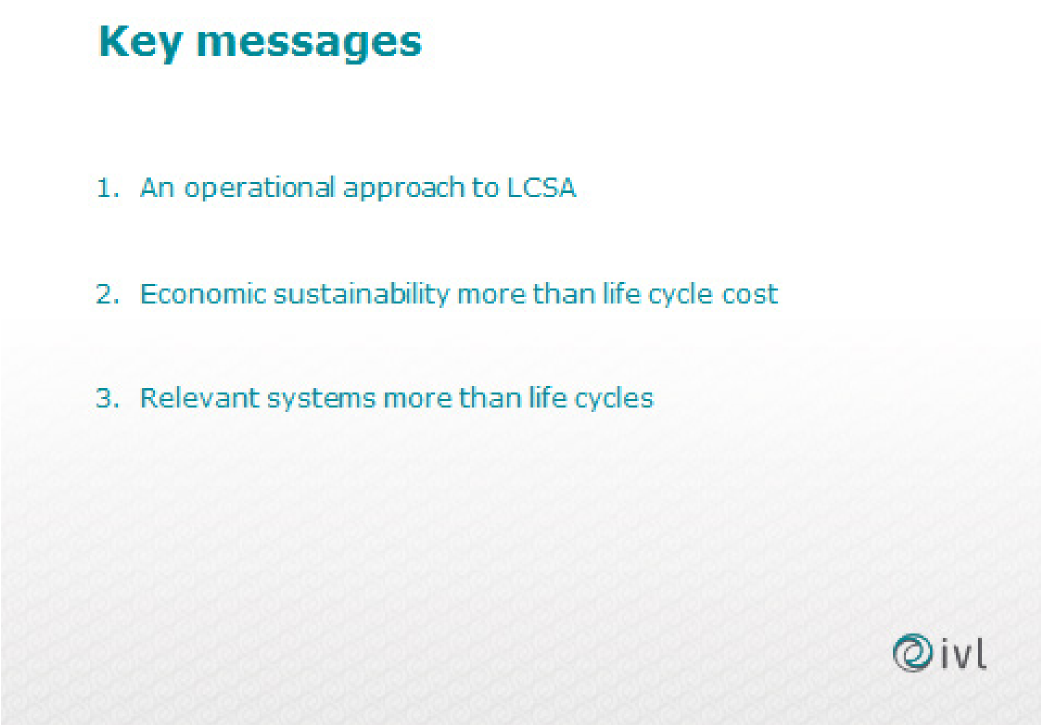
- Smileys are efficient for communication of LCSA results.
- They risk closing the door for reflection and debate.

FURTHER READING

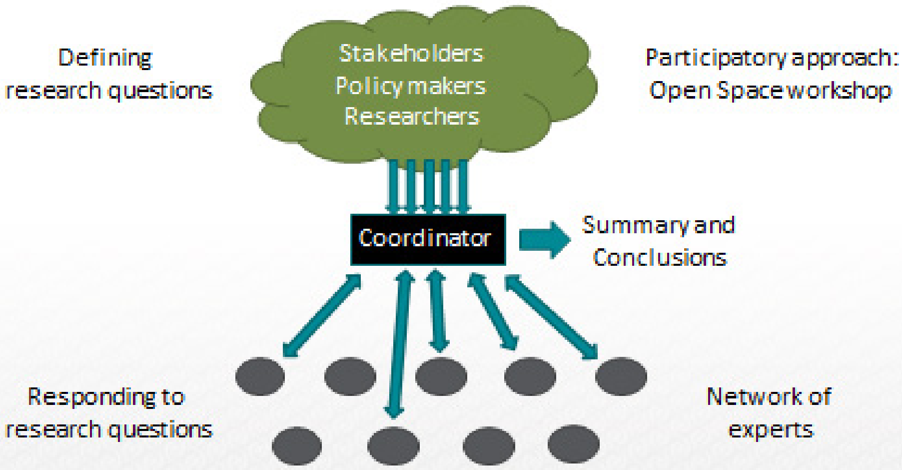
- Ekvall T, Ljungkvist H. 2014. Sustainability assessment of residual heat transfer from Stenungsund to Gothenburg. Report C79. Stockholm, Sweden: IVL Swedish Environmental Research Institute.
- Ekvall T, Ljungkvist H, Sandvall AF, Ahlgren EO. 2016. A case-dependent participatory approach to life cycle sustainability assessment. Submitted to *J. Ind. Ecol.*
- Sandvall AF, Ahlgren EO, Ekvall T. 2016. System profitability of excess heat utilisation – A case-based modelling analysis. *Energy* 97: 424-434.

Slides from oral presentation





Conceptual framework



Open Space

Source: Wikipedia

Open Space

- Coffee-break conversations
- Plenum/groups/individual
- Notice boards

Source: Johanne Lortie, ITC-ILO

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Case study

Pipeline for excess heat from Stenungsund to Göteborg

~ 50 km
~ 100 MEUR

6

Sustainability aspects identified

Open-space workshops

Economic aspects	Environmental aspects	Social aspects
1, Profitable investment?	7. Primary energy demand	
2. Can all share the profit?	8. Climate	
3. Impact on vulnerability?		
4. Demand during summer?		
5. New heat applications?		
6. Impact on final customer?		

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Sustainability aspects identified

Open-space workshops + research group

Economic aspects	Environmental aspects	Social aspects
1, Profitable investment?	7. Primary energy demand	
2. Can all share the profit?	8. Climate	
3. Impact on vulnerability?	9. Acidification	
4. Demand during summer?	10. Eutrophication	
5. New heat applications?	11. Fossil-fuel lock-in	
6. Impact on final customer?		

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Sustainability aspects identified

Open-space workshops + research group + stakeholder feedback

Economic aspects	Environmental aspects	Social aspects
1, Profitable investment?	7. Primary energy demand	12. Employment, total
2. Can all share the profit?	8. Climate	13. Employment, rural
3. Impact on vulnerability?	9. Acidification	
4. Demand during summer?	10. Eutrophication	
5. New heat applications?	11. Fossil-fuel lock-in	
6. Impact on final customer?		

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Sustainability aspects identified

Open-space workshops + research group + stakeholder feedback + own addition

Economic aspects	Environmental aspects	Social aspects
1, Profitable investment?	7. Primary energy demand	12. Employment, total
2. Can all share the profit?	8. Climate	13. Employment, rural
3. Impact on vulnerability?	9. Acidification	14. Impact on land-owners
4. Demand during summer?	10. Eutrophication	
5. New heat applications?	11. Fossil-fuel lock-in	
6. Impact on final customer?		

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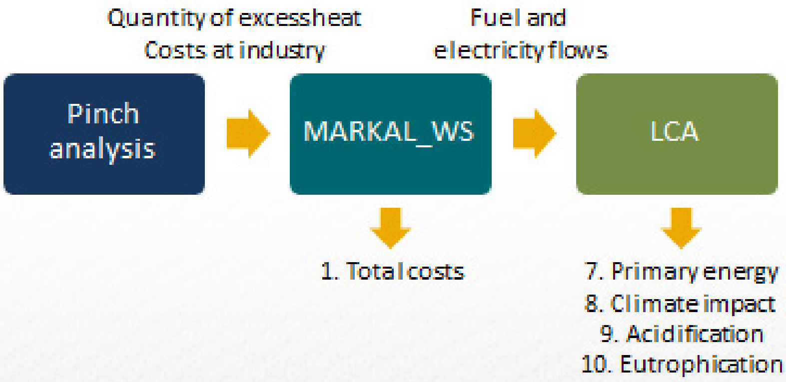
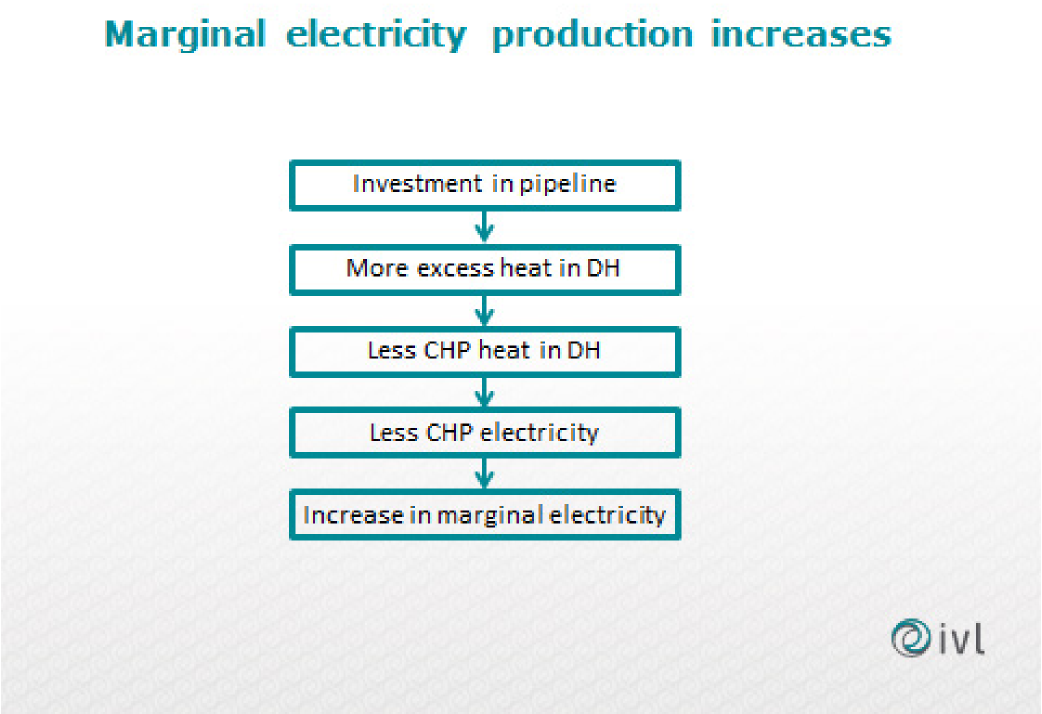
Conclusions on indicators

1. Open Space gives valuable input
2. Economic sustainability more than life cycle cost
3. Results from Open Space needs interpretation and additions

Modelling (simplified)




Marginal electricity production increases
Investment in pipeline
More excess heat in DH
Less CHP heat in DH
Less CHP electricity
Increase in marginal electricity
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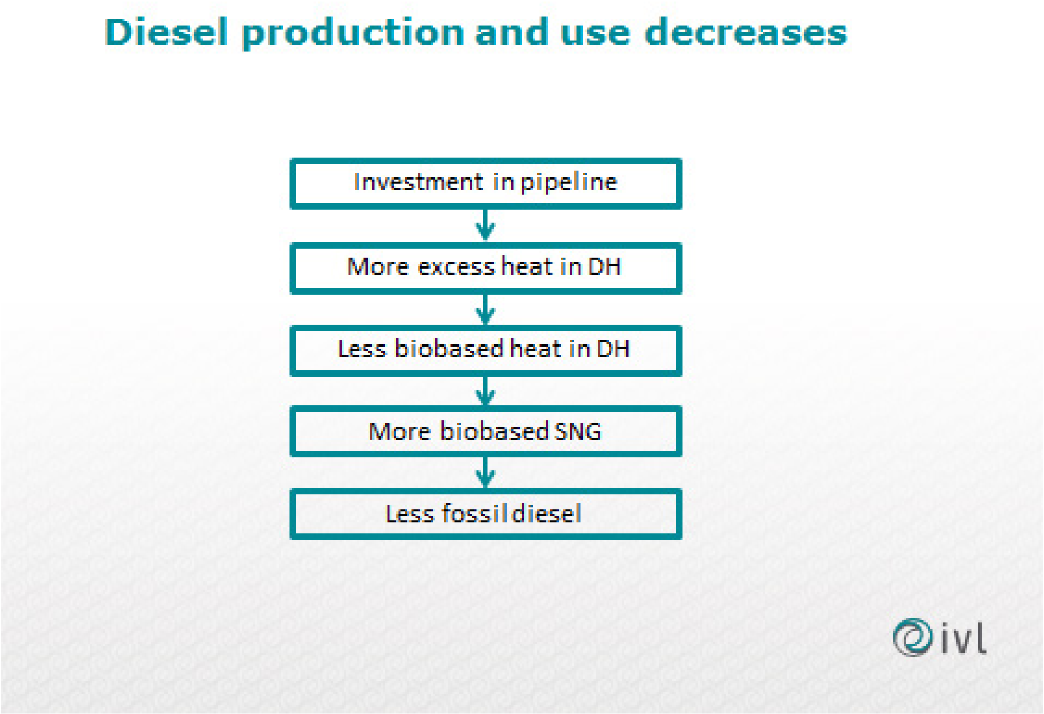
Diesel production and use decreases
Investment in pipeline
More excess heat in DH
Less biobased heat in DH
More biobased SNG
Less fossil diesel
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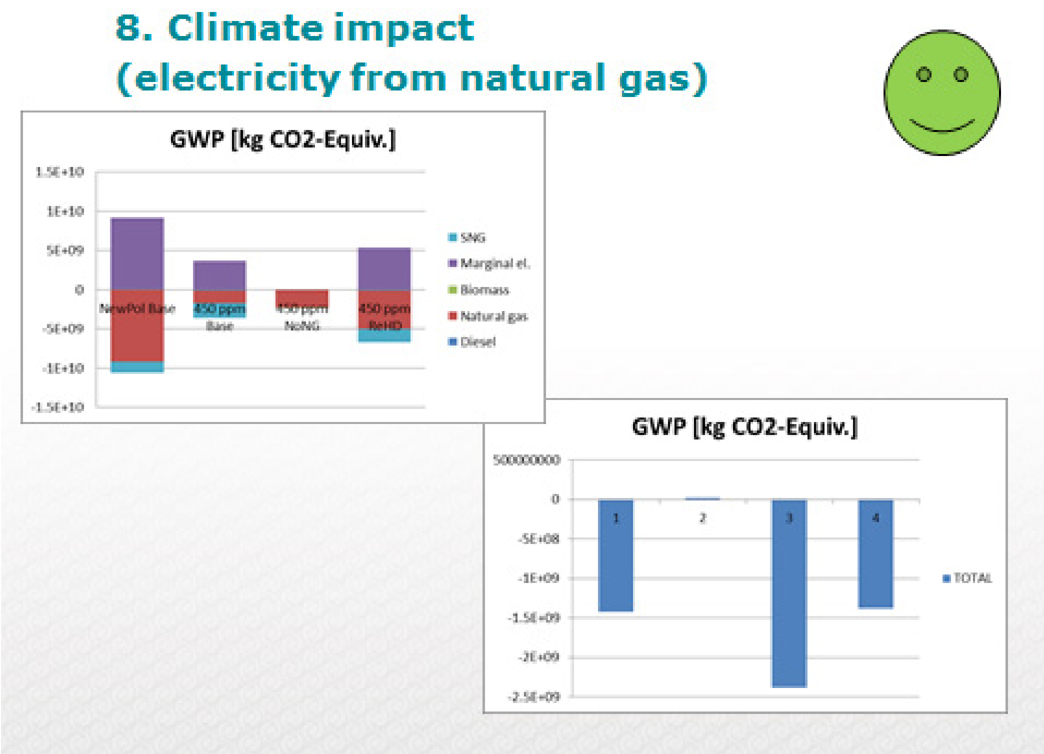
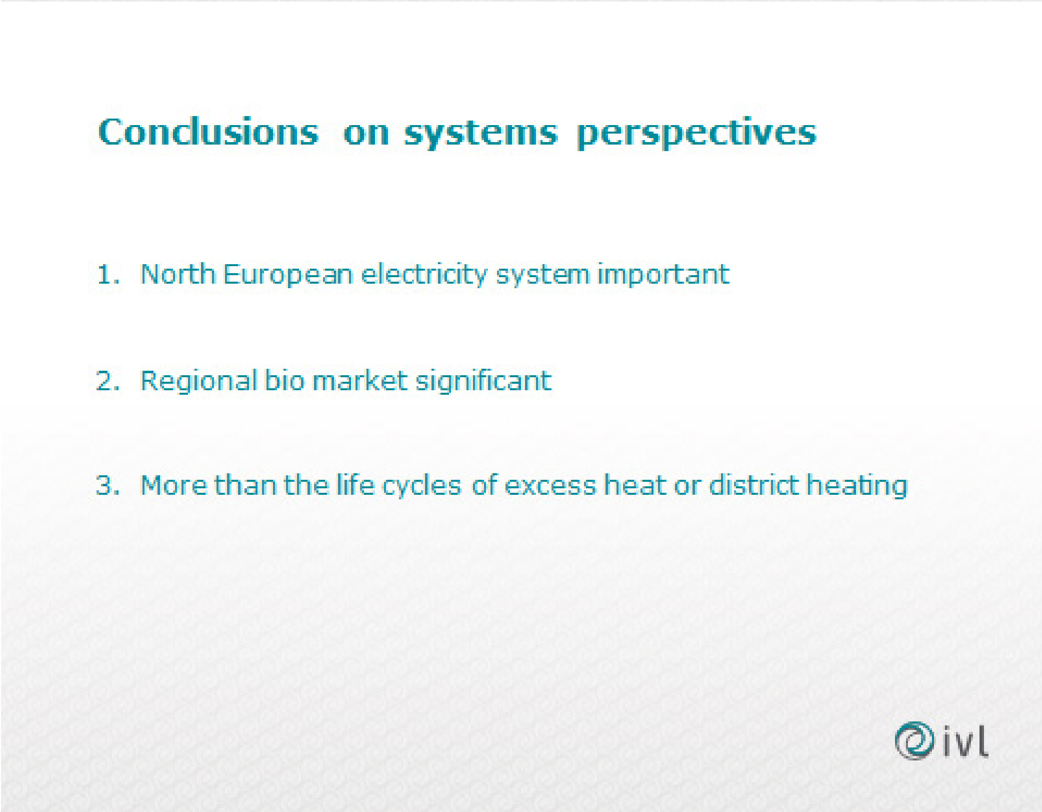

8. Climate impact
(electricity from natural gas)
GWP [kg CO2-Equiv.]
1.5E+10
1E+10
5E+09
0
-5E+09
-1E+10
-1.5E+10
NewPol Base
450 ppm Base
450 ppm NoNG
450 ppm ReHD
SNG
Marginal el.
Biomass
Natural gas
Diesel
GWP [kg CO2-Equiv.]
500000000
0
-5E+08
-1E+09
-1.5E+09
-2E+09
-2.5E+09
1
2
3
4
TOTAL


Conclusions on systems perspectives
1. North European electricity system important
2. Regional bio market significant
3. More than the life cycles of excess heat or district heating
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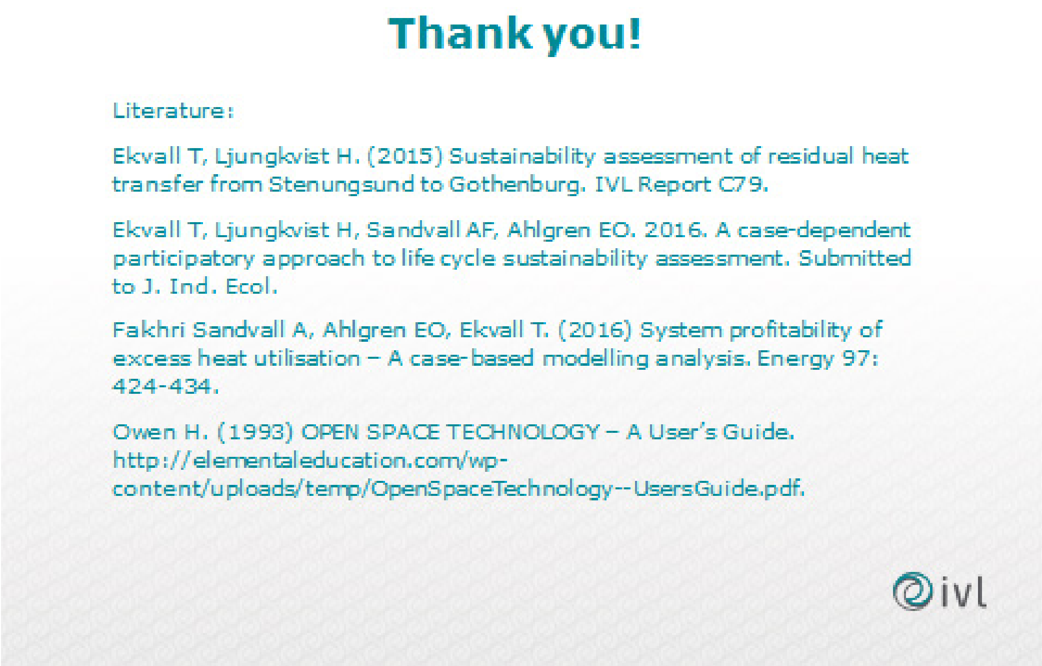
Thank you!
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