



Chain Analysis GridFlex Heeten

Report 2020

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Author(s): lamerpp

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ICT Group N.V.
Weena 788
3014 DA Rotterdam
The Netherlands

info@ict.nl
+31 (0)88 908 2000

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Document history

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1. Introduction

ICT Group N.V. (“ICT”) aspires to maintain level 4 of the CO₂-Performance Ladder. This report contains the results of one of the two supply chain analysis required to comply with requirement 4.A.1.¹ and 4.B.1.² of the CO₂ Performance Ladder.

This report contains the quantitative supply chain analyses of the GridFlex Heeten project, and more specifically, the Energy Management System (EMS) ICT Group developed for this project (chapter 2). CO₂ reduction targets are formulated based on this analysis in chapter 3.

For more information about ICT and the qualitative assessment of ICT’s most material CO₂ emissions, see report ‘CO₂ Scope 3 Chain analyses ICT Group NV’. For the second supply chain analysis, see report ‘Chain analysis – Loading poles’.

1.1 Topic of this analysis: GridFlex Heeten - Energy Management System (EMS)

With this supply chain analysis, we meet the first part of the requirement as described in Handbook CO₂-Performance Ladder:

‘One supply chain analysis needs to be made for one of the two most material emissions, and one other supply chain analysis for one of the six most material emissions.’ The ranking of the most material emissions can be found in table 2 in the report ‘CO₂ Scope 3 Chain analyses ICT Group NV’.

The product/market combination (PMC) ‘Energy’ is ranked first in the materiality table. Therefore, it was decided to make a supply chain analysis of the energy product as used in the GridFlex Heeten project: Energy Management System (EMS).

GridFlex Heeten

With the GridFlex Heeten project, a local energy market is developed in which an optimal local energy system is achieved by means of pricing mechanisms, incentives and energy flexibility. Energy

¹ 4.A.1. ‘4.A.1. The organisation has a demonstrable insight into the most material emissions from scope 3, and can present at least two analyses of these scope 3 emissions of GHG-generating (chains of) activities.’ (Handbook CO₂-Performance Ladder)

² 4.B.1. ‘4.B.1. The organisation has formulated CO₂ reduction objectives for scope 3 based on the 2 analyses in 4.A.1. Or, the organisation has formulated CO₂ reduction objectives for scope 3 based on 2 material GHG-generating (chains of) activities. A related action plan has been drawn up, including the measures to be taken. Objectives are expressed in absolute values or percentages in relation to a reference year and within a fixed period of time.’ (Handbook CO₂-Performance Ladder)

cooperative 'Endona' received an exemption on the Dutch Elektriciteitswet ('electricity law') to experiment. Using this exemption, a local energy market will be realized in Heeten in which innovative pricing mechanisms will be tested with local renewable energy sources and energy storage. Consumer flexibility and demand-side management ensures the energy is consumed locally, especially using the combination of storage and photovoltaics. By innovative pricing mechanisms good behaviour is stimulated. This leads to reduced losses and delaying or even making further investments in the grid unnecessary. The achieved savings are shared in a fair way.

ICT is a partner in the project and is responsible for developing the EMS – Energy Management System, enabling the local energy market and changes in behaviour of users. This project has been completed in August 2020.

Energy Management System (EMS) for GridFlex Heeten

The EMS is a product of ICT that contributes to the development of efficient, decentralized energy networks.

The hardware of the EMS is linked to the smart meter of households that participate in GridFlex Heeten. Data is sent via the EMS to the cloud. A central computer can send signals to the EMS modules at each participating household. Users get access to an app & web portal to gain insights into their energy consumption, production and storage. Through the central computer the energy market is managed, for instance using storage capacity at households to balance the grid or enabling users to buy electricity when prices are low. See figure 1 & 2 for a visualization of the EMS system and app & web portal.

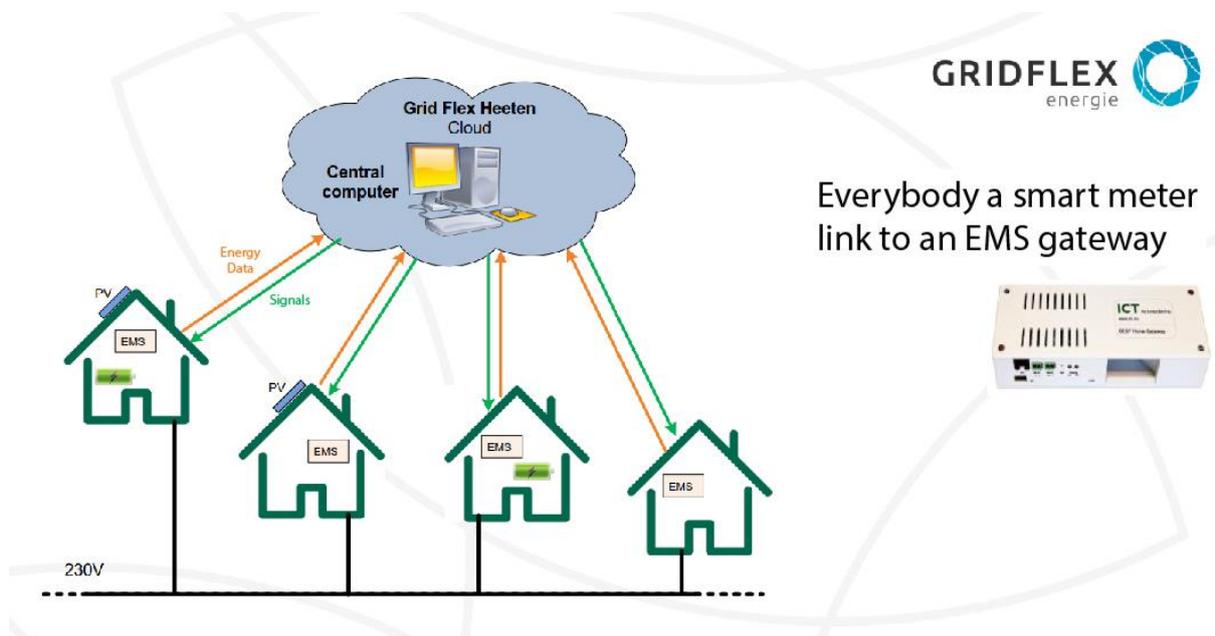


Figure 1: EMS sends energy data to the GridFlex Heeten cloud. A central computer can send signals to the EMS at every household.

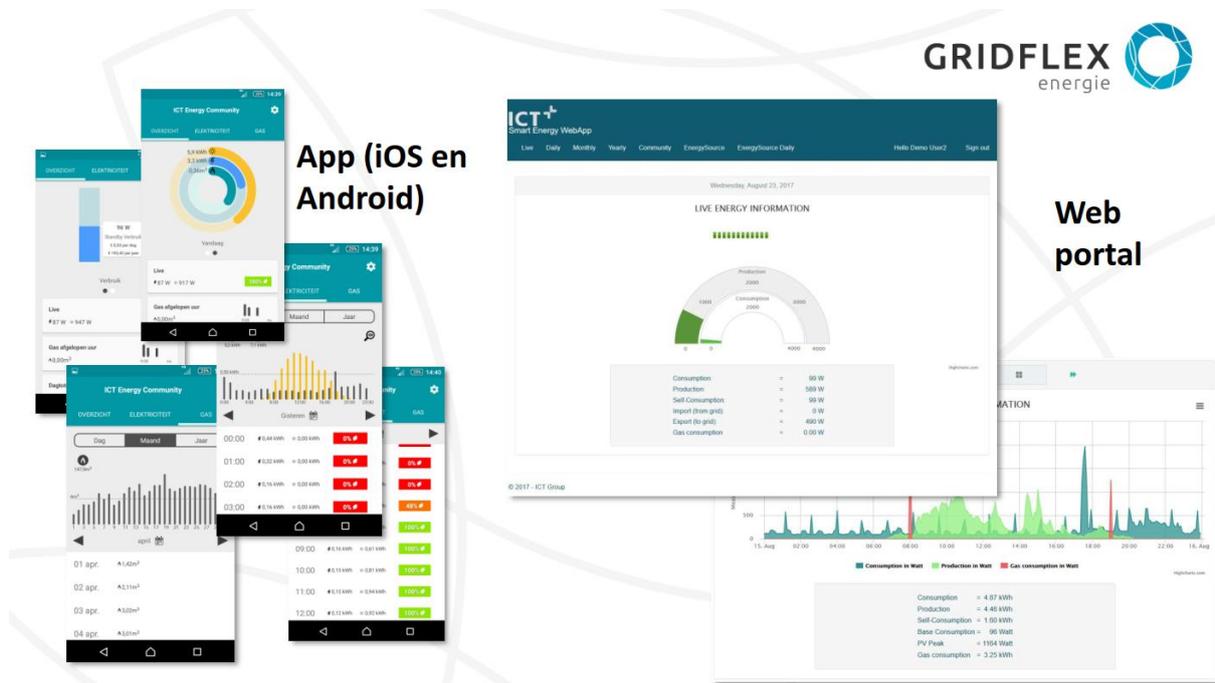


Figure 2: Visualizations of possible app & web portal interfaces.

1.2 Approach Supply Chain Analysis

The approach as described in the SKAO manual 'Handbook CO₂-Performance Ladder', requirement 4.A.1. was followed for this supply chain analysis. Data was collected through interviews with Mark van Eesteren – Sustainability Officer ICT Group N.V., Marten van der Laan, senior business consultant smart energy at ICT Group and Victor Reijnders, PhD TU Twente. Additional sources and studies were used to substantiate the supply chain analysis, for references go to the Sources chapter.

Data

The CO₂ impact factors were selected from CO₂emissiefactoren.nl and milieudatabase.nl, in accordance with CO₂ Performance Ladder. Since we could not find all impact factors here, we also used the database Eco-costs 2017 V1.2. This database is made by TU Delft and is calculated using Simapro 8.5.0.0. using LCI database Ecoinvent 3.4.

CO₂ equivalents

Carbon Footprint is expressed in CO₂ equivalents (CO₂e) in all the databases used. This is based on the Global Warming Potential (GWP 100); the extent to which a gas contributes to the greenhouse effect in 100 years' time. For example, methane has a GWP 100 of 28 and Nitrous oxide (N₂O) a GWP 100 of 265 (IPCC Fifth Assessment Report (AR5), 2014).

Results: CO₂e and energy

The results (paragraph 2.5) are expressed both in CO₂e and in energy (kWh). GridFlex Heeten households use solar energy, which results in low CO₂e emissions in the use phase compared to using the EMS in a conventional setting in which grey electricity is used. This while energy savings are higher in the GridFlex Heeten scenario. By adding energy as a result, the extra benefit of avoiding losses of solar energy by enhancing grid stability in the GridFlex Heeten project can be shown.

2 Supply chain analysis GridFlex Heeten - Energy Management System (EMS)

As indicated in the Handbook of the CO₂ Performance Ladder, the supply chain analysis follows the structure as described in chapter 4 of “A Corporate Accounting and Reporting Standard” (WBCSD, 2004).

- Describe the value chain (section 2.1)
- Determine which scope 3 categories are relevant (section 2.2)
- Identify partners along the value chain (section 2.3.)
- Quantify scope 3 emissions (section 2.4.)

2.1 Describe the value chain

“Because the assessment of scope 3 emissions does not require a full life cycle assessment, it is important for the sake of transparency, to provide a general description of the value chain and the associated GHG sources (WBCSD, 2004)

A simplified version of the supply chain is depicted in figure 3. In every phase of the supply chain energy and materials be added, and emissions to air, soil and water are released. Transport takes place between the phases. For this analysis only CO₂e is considered as an emission, in accordance with the requirements of the CO₂ Performance Ladder.

Setting system boundaries

The system boundaries determine which processes and activities are included in the overall analysis. This to define where to stop tracking energy and material uses of processes, otherwise the analysis would be infinite and the impacts to the environment would be diluted in those of the several processes studied.

This analysis focusses on the EMS and its functioning within the GridFlex Heeten project. The following system boundaries are set:

- For this analysis the full life cycle of the EMS is considered.
- Electricity in the use phase is considered for supporting ICT, such as the cloud service by Microsoft Azure and the central computer.
- The CO₂e emissions of other technologies needed to make GridFlex Heeten function, such as batteries and servers, are outside the scope of this analysis. Batteries can be added to this calculation in a later stage of the project when batteries are selected and integrated into the GridFlex Heeten project. At this moment (May 2018) this is not the case yet.
- Development of the software is included in the scope 1 & 2 emissions of GridFlex Heeten.

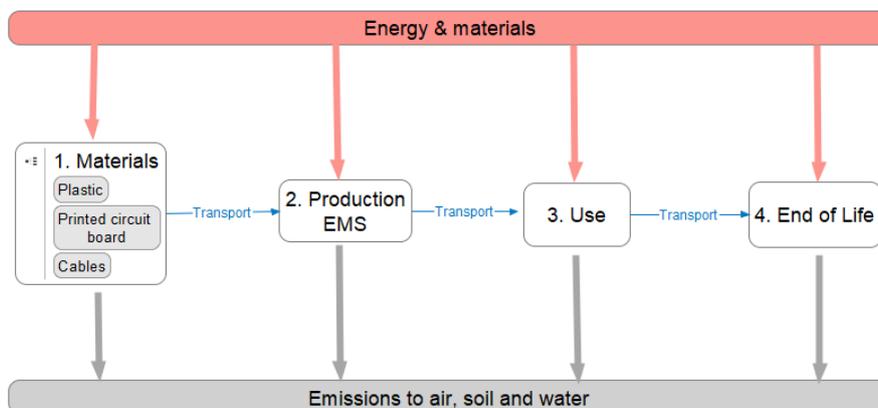


Figure 3: Simplified supply chain of the EMS

Supply chain phases

The following phases are identified:

1. Materials

The hardware of the EMS is made of an injection moulded plastic casing, a printed circuit board (PCB) and the following cables: a power cable, a connection cable to connect the EMS to the smart meter and an internet cable.

The materials are transported from different locations to the production location.

2. Production

The EMS is produced in the Netherlands at ICT Group N.V.

The EMS is transported from ICT Group N.V. to participating households in Heeten.

3. Use

The GridFlex Heeten project is developed to save electricity & materials. But the system also uses electricity to function. This will be calculated in the Use paragraph of this supply chain analysis.

Electricity use:

- The EMS, the cloud service by Azure and the central computer use electricity.

Electricity savings:

- Behaviour change of households due to increased transparency of their electricity use.
- Balancing the net – avoiding transport & transformer losses due to local renewable electricity use & storage.

Materials savings:

- Balancing the net – avoiding investments in strengthening the net.

4. End of Life

The end of life of the EMS is estimated at 15 years. This is a standard depreciation time for simple electronics. Since it is a new product, the actual lifetime in use has not yet been determined.

2.2 Relevant scope 3 categories

Table 1 shows the relevant scope 3 categories per supply chain phase, in accordance with the GHG Protocol (2011).

Table 1: Relevant scope 3 categories

Supply chain phase	Relevant scope 3 categories
1. Materials	1. Purchased goods and services 4. Upstream transportation and distribution 5. Waste generated in operations
2. Production	1. Purchased goods and services 4. Upstream transportation and distribution 5. Waste generated in operations
3. Use	9. Downstream transportation and distribution 11. Use of sold products
4. End of Life	9. Downstream transportation and distribution 12. End-of-life treatment of sold products

2.3 Identify partners along the value chain

Table 2 lists the partners involved in the supply chain. Below this table the activities is described of the parties mentioned in 3. Use.

Table 2: Partners along the value chain

Supply chain phase	Partners
1. Materials	Suppliers of production facility
2. Production	Production facility
3. Use	Households participating in GridFlex Heeten (Buurkracht), ICT Group, Endona, Enexis, Enpuls, Twente University (see below for more information).
4. End of Life	Waste companies

- **Buurkracht**
Buurkracht is the organization of Heeten households that have joined GridFlex Heeten.
- **ICT Group N.V.**

ICT Group N.V. is responsible for the IT architecture and data retrieval with respect to GridFlex Heeten.

- **Endona**
Endona is the local energy cooperation of Heeten. Endona is the local representative for the realisation of the local energy market.
- **Enexis**
Enexis is the local energy network manager in Heeten and is therefore responsible for the stability and reliability of the local energy network used to transfer energy.
- **Enpuls**
Enpuls is an advisor on realizing local energy ambitions. In the GridFlex Heeten project Enpuls will advise the consortium.
- **Twente University**
Twente University will perform studies regarding innovative market models with flexible price mechanisms. The aim is to investigate which pricing models fit best with a local energy market.

2.4 Quantify scope 3 emissions

The analysis is elaborated in the paragraphs below.

Materials & production of the EMS (Phase 1 & 2)

Appendix A contains the calculation of the CO₂ emissions of the materials & production of the EMS. Ecoinvent database 3.4 was used to determine the emission factors. The electronics in the EMS cause 85% of the CO₂e impact.

Materials & production: 4 kg CO₂e

Use (Phase 3)

Appendix B & C contain the calculation of the CO₂e emissions of the use of the EMS. We chose two different use scenarios, because the EMS can also be applied to other households besides GridFlex Heeten. In this case a different energy mix will be applicable:

- In the scenario 'Conventional' the household uses the standard electricity mix of the Netherlands.
- In the scenario 'GridFlex Heeten' the household uses solar energy.

Electricity use:

- The EMS:
The EMS uses 1.6 Watts. This leads to an annual energy use of 14 kWh yearly and an energy use of 210.2 kWh during the EMS’s total lifetime (15 years). In table 3 the CO₂e emissions of the conventional scenario are calculated and in table 4 the emissions of the GridFlex Heeten scenario.

Table 3: The energy use and its corresponding CO₂e emissions of the EMS - conventional scenario

Scenario	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
Conventional lifetime (15 yrs)	210.2	0.649	Grey electricity	136.4

Table 4: The electricity use and its corresponding CO₂e emissions of the EMS - GridFlex Heeten scenario

Scenario	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
GridFlex Heeten lifetime (15 yrs)	210.2	0.07	Solar power including production solar panel	14.7

- Cloud service by Microsoft Azure.
GridFlex Heeten uses approximately 16 kWh a year for storing data of a single household on the Microsoft Azure server. In 2017 44% of the electricity used at Microsoft’s servers was renewable (Greenpeace USA, 2017). The other emissions are compensated by unbundled Renewable Energy Certificates and offsets.

“We achieved carbon neutrality in 2014 and have met our goal of averaging 1.125 power usage effectiveness (PUE) for any new datacentre—exceeding the industry average by more than 30 percent.” (Microsoft, 2018).

Electricity use Microsoft Azure: 0 kg CO₂e annually; 0 kg CO₂e over lifetime EMS. – applicable both scenarios

- The central computer:
The central computer uses electricity, we assume that the central computer will be used 0.5 day a week for a year. ICT Group N.V. has an energy mix of 60% renewable and 40% grey electricity. Most renewable energy is wind energy. See table 5 for the calculation.

Table 5: Electricity use central computer – applicable both scenarios

Energy mix	Percentage grey / renewable	Hours	Watts	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
Annual electricity use – grey	40%	26	200	1.508	0.649	Grey electricity	1.35

Annual electricity use – renewable (mainly wind)	60%	26	200	3.692	0.012	Wind energy including production wind turbine	0.04
Total annual							1.39
Total lifetime (15 yrs)							20.8

Electricity savings:

- Behaviour change of households due to increased transparency of their energy use. Multiple sources (Fischer 2008 & Darby 2006) cite energy savings potentials related to transparency in energy use. Current, the Dutch provider of energy manager Qbox, reports average savings of 10% over the lifetime of the energy manager. Savings mainly take place in the first year of using the energy manager. We assume similar energy savings related to the EMS. In table 6 the CO₂e emissions of the conventional scenario are calculated and in table 7 the emissions of the GridFlex Heeten scenario.

Table 6: Behaviour change (lifetime EMS) – Conventional scenario

Scenario	Scenario	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
Lifetime energy savings due to energy manager (15 yrs)	10% of 3000 kWh – average energy use Dutch household	300	0.649	Grey electricity	- 194.7

Table 7: Behaviour change (lifetime EMS) – GridFlex Heeten scenario

Scenario	Scenario	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
Lifetime energy savings due to energy manager (15 yrs)	10% of 3000 kWh – average energy use Dutch household	300	0.07	Solar power including production solar panel	- 21

- Balancing the net – avoiding transport & transformer losses due to local renewable electricity use & storage.

Note: This effect can only be reached in the GridFlex Heeten scenario and not in the conventional scenario.

Electricity losses can be avoided by limiting the transportation distance of electricity. Through stimulating using local renewable electricity when it is generated by means of pricing mechanisms and local battery storage, these losses are minimized.

In 2016, Enexis had a grid loss of 4.5% in its electricity grids (ACM (2017)). These grid losses are caused by technical causes (electrical resistance) and administrative causes (e.g. vacancy or fraud) (AMC, 2017). Approximately 70% of net losses are due to technical causes (3.2%) and 30% is due to administrative causes (1.3%) (Energieia (2014) & KEMA (2011))

Annual losses due to technical causes can be reduced by balancing supply and demand. This limits transportation distances and losses, due to transforming electricity from low (LS) to medium (MS), high (HS) and ultra-high (UHS) voltage. We assume, substantiated by an interview with Victor Reijnders of TU Twente, that 50% of technical energy losses can be avoided by deploying the EMS in the GridFlex Heeten project. Noting that the real savings can only be known later in the project, when the GridFlex Heeten project is fully operational and has been running for several years. See table 8 for the calculation.

Table 8: energy savings due to avoiding technical energy losses – GridFlex Heeten scenario

	Scenario	kWh	Emission factor kg CO ₂ e	Emission factor	Emission kg CO ₂ e
Year 1: Annual energy savings due to avoiding technical energy losses per household	Potential smart grid (50% reduction of energy losses being 1.6% of 3000 kWh ³)	48	0.07	Solar power including production solar panel	- 3.4
Year 2-15: Annual energy savings due to avoiding technical energy losses per household	Potential smart grid (50% reduction of energy losses being 1.6% of 2400 kWh)	38.4	0.07	Solar power including production solar panel	- 2.7

³ The scenario is made up as following. In the first year we use 3.000 kWh and in year 2-15 we use 2.400 kWh. This because we consider 10% of energy savings due to the EMS. Savings mainly take place in the first year of using the energy manager.

Lifetime energy savings due to avoiding technical energy losses per household						- 41
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- Balancing the net – avoiding investments in strengthening the net.

Note: This effect can only be reached in the GridFlex Heeten scenario and not in the conventional scenario.

Trends in the current energy transition in the Netherlands will require a large amount of low voltage electricity networks to be reinforced in the coming years. At the GridFlex Heeten project, alternatives to reinforcing the net are assessed by experimenting with energy storage and balancing demand & supply. It is expected that this will avoid cable reinforcements and replacing transformers (Groen, 2018). The embedded CO₂e emissions of these products will be avoided. But, because the project just started and its results regarding avoiding strengthening the net are unknown at this moment, this benefit is not considered at this moment for this supply chain analysis. Noting that it is something to consider when monitoring CO₂e emissions of the project in the future.

Embedded CO₂e due to material savings: Unknown at this moment.

End of Life (Phase 4)

Appendix B contains the calculation of the CO₂e emissions of the End of Life of the EMS. Ecoinvent database 3.4 was used to determine the emission factors.

End of Life: 0.18 kg CO₂e

Transport

Appendix C contains the calculation of the CO₂e emissions of the transport of the EMS. CO₂emissiefactoren.nl was used to determine the emission factors.

End of Life: 0.035 kg CO₂e

2.5 Results

The impact of the EMS system was analyzed using the principles and assumptions described above. Results on CO₂e and energy are listed below.

CO₂e

Table 9 provides a summary of the results for both scenarios. Figure 4 shows that the reduction of CO₂e in the use | energy savings phase is greater than the CO₂e emitted during Materials & Production, Use | EMS, End of Life and Transport for both scenarios.

Table 9: CO₂e savings per EMS conventional scenario

Scenario	Conventional	GridFlex Heeten
	Lifetime EMS (15 years)	Lifetime EMS (15 years)
Indicator	kg CO ₂ e	kg CO ₂ e
Materials & Production	4	4
Use EMS & central computer	157	36
Use Energy savings	-194.7	-62
End of life	0.18	0.18
Transport	0.035	0.035
Total	-33.2	-22.3

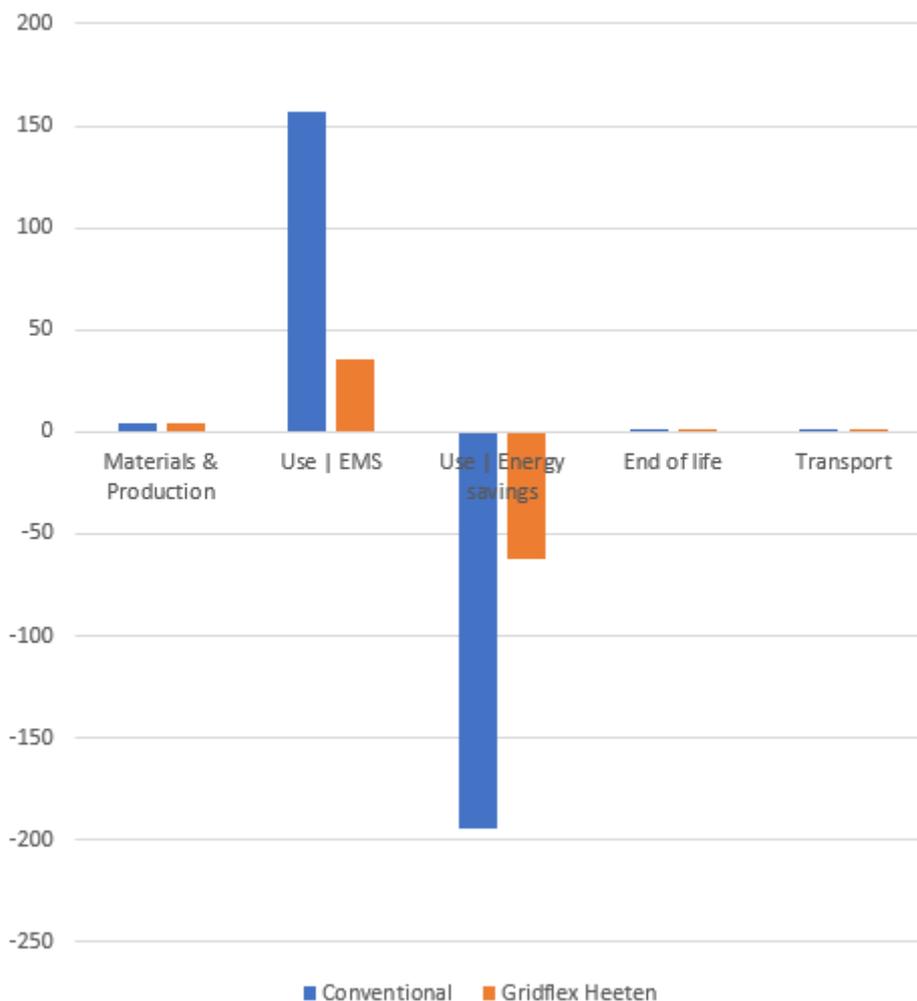


Figure 4: CO₂e EMS

Energy

If we look at energy, the GridFlex Heeten scenario saves more energy than the conventional scenario (table 10). The EMS enables balancing the net when the inflow of solar energy is high, with the benefit of avoiding net losses. The reason that the GridFlex Heeten scenario results in lower CO₂e emissions is because in the GridFlex Heeten scenario, solar energy is the source of electricity for households, resulting in lower CO₂e emissions compared to grey electricity of the conventional scenario. This gives a somewhat distorted image, which is the reason why we also report the energy use of both scenarios’.

Table 10: Energy use conventional vs GridFlex Heeten

Scenario	Conventional	GridFlex Heeten
	Lifetime EMS (15 years)	

		Lifetime EMS (15 years)
Indicator	kWh	kWh
Use EMS & central computer	231	231
Use Energy savings	-300	- 341
Total	-531	-572

Lessons learned

After closure of the GridFlex project an evaluation has been done by webinar and also the findings have been published in a white paper.

See: <https://gridflex.nl/lessons-learned-webinar-over-gridflex/>

3 Reduction targets (4.B.1)

The following reduction targets have been set for requirement 4.B.1⁴.

3.1 Goals & action plan

We are convinced that the EMS reduces CO₂ in the supply chain. ICT only indirectly influences this CO₂ reduction, since the effects take place among households and supply chain partners. By devising innovative solutions, we can make a greater contribution to a CO₂ reduction. The target of ICT Group N.V. is thereby formulated as a ‘inspanningsverplichting’ (effort commitment). ICT Group N.V. sets the following goals that are challenging and are endorsed by management.

Goals

- In 2020 deploy at least 140 EMS’s in the GridFlex Heeten project.
- Monitoring of EMS to test saving scenarios.
- Further development of the EMS.
- Further collaboration in smart grid projects.

Action plan

Our action plan for 2018 was to deploy more projects with EMS’s in future to scale up the EMS product, which is a part of the EnergyNXT platform. As the development of energy projects in which the EMS’s will be used is the investigation phase, we expect on a yearly basis to double the number of EMS’s installed. This is a careful estimation. This resulted in the following action plan:

Table 10: Action plan EMS

When	How many	What
2018	1 project	70 EMS’s deployed at GridFlex Heeten
2019	2 projects	140 EMS’s – future projects
2020	4 projects	280 EMS’s – future projects

This action plan of 2018 was conducted successfully in 2019 and 2020, as the project was further developed as EnergyNXT platform, which is an Internet of Things platform. The development of the

⁴ 4.B.1: 4.B.1. The organisation has formulated CO₂ reduction objectives for scope 3 based on the 2 analyses in 4.A.1. Or, the organisation has formulated CO₂ reduction objectives for scope 3 based on 2 material GHG-generating (chains of) activities. A related action plan has been drawn up, including the measures to be taken. Objectives are expressed in absolute values or percentages in relation to a reference year and within a fixed period of time.. (Handbook CO₂-Performance Ladder)

EnergyNXT platform is part of the internal innovation program of ICT in which ICT invests 1,5% of the adding value on a yearly basis. For more formation about the EnergyNXT platform, see <https://ict.eu/solutions/energynxt/#cases>.

Expanding the chain analysis

In this chain analysis we did not include the potential CO₂ reduction with respect to prevention of grid reinforcements as locally produced electricity is consumed. As explained in paragraph 2.4.2, there is no availability of sufficient data with respect to CO₂ reductions if future grid reinforcements will be prevented by using batteries as storage for electricity. For example, we need data about the number of kilometre cables and transformer cabinets which are not needed. Grid reinforcements are expected following due to the energy transition from which it expected that gas will be replaced by electricity and following from the increase in the use of electric vehicles.

The plan was to further investigate if in 2018/2019 we would be able to expand the GridFlex Heeten chain analysis in which the potential CO₂ reductions of using the local stored electricity instead of the electricity from the Dutch grid and preventing grid reinforcements will be calculated. This couldn't be investigated in 2019, as the team responsible for this was busy solving the issues related to battery supplies mentioned in chapter 4.

3.2 Reduction

We deployed at least 70 EMS's for GridFlex Heeten in 2018 and expected to double this amount yearly (table 10). It was unknown if the future projects would be projects like GridFlex Heeten of conventional (households using solar energy vs household using grey energy). Therefore, calculations were made for both scenarios. CO₂e savings are expected to be:

When	How many	Annual CO2 reduction (kg CO ₂ e)	
		GridFlex Heeten scenario	Conventional scenario
2018	70 EMS's	104	Not applicable ⁵
2019	140 EMS's	208	259
2020	280 EMS's	415	569

When	How many	Annual CO2 reduction (kg CO ₂ e)	
		GridFlex Heeten scenario	Conventional scenario
2018	70 EMS's	104	Not applicable ⁵

⁵ Not applicable because it is already known that the 70 EMS's will be used in the GridFlex Heeten Project. That's why the CO₂e savings of 70 times the annual savings in the GridFlex Heeten project is used for the first year for both scenarios.

2019	140 EMS's	208	259
2020	280 EMS's	415	569

This leads to the following reductions during the lifetime of the EMS's (15 years):

- Total reduction over lifetime EMS – GridFlex Heeten scenario: 6.230 kg CO₂e
- Total reduction over lifetime EMS – Conventional scenario: 8.536 kg CO₂e

And the following energy savings (kWh) during the lifetime of the EMS's (15 years):

- Energy savings over lifetime EMS – GridFlex Heeten scenario: 160 MWh
- Energy savings over lifetime EMS – Conventional scenario: 152 MWh

4 Project lessons learned

The project was evaluated on September 18th, 2020. See: <https://gridflex.nl/lessons-learned-webinar-over-gridflex/>

The findings were also published in a white paper: [GridFlex Heeten: Naar 'Nul op de wijktransformator'](#)

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GridFlex Publications

GridFlex: energie blijft in eigen wijk – [PDF](#)

Inspiratieboek Maatschappelijk Verantwoord Innoveren (TKI, november 2018), zie pag. 10/11.

Energie+ (maart 2018) – [PDF](#)

Whitepaper: [GridFlex Heeten: Naar `Nul op de wijktransformator`](#)

Scientific publications

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Calculation CO2e materials & production EMS

Database: Ecoinvent 3.4

Phase 1: Materials					Phase 2: Production		
Part	Material	Weight (kg)	Emission factor kg CO ₂ e	emission kg CO ₂ e	Production method	Emission factor kg CO ₂ e	emission kg CO ₂ e
Casing	ABS	0.00085	3.96	0.003	Injection molding	0.5	0.0004
Printed circuit board		0.01	339.7	3.4	Included in emission factor material		
Power cable		0.1	5	0.5	Included in emission factor material		
Connection cable		0.01	5	0.05	Included in emission factor material		
Internet cable		0.01	5	0.05	Included in emission factor material		
				4			0.0004

Table 11: CO₂e materials & production EMS

Calculation CO₂e End of Life

Database: Ecoinvent 3.4

Unfortunately, recycling electronics, for instance at Umicore in Belgium, is not included in Ecoinvent.

Material	Weight kilograms	End of life scenario	Emission factor kg CO ₂ e	CO ₂ e emission kg CO ₂ e
ABS	0.13085	Recycling (50%)	1.14	0.07
		Incineration (50%)	1.54	0.10
Printed circuit board	0.01	Recycling	-	Unknown
Power cable	0.1	Recycling	-	Unknown
Connection cable	0.01	Recycling	-	Unknown
Internet cable	0.01	Recycling	-	Unknown
Total				0.18

Table 12: Calculation CO₂e End of Life

Calculation CO₂e transport EMS

Database: CO₂emissiefactoren.nl.

Truck > 20 tonnes: 0.110 kg CO₂ / tkm

Delivery van > 2 ton: 1.153 kg CO₂ / tkm

Boat big (10-20 dwkt): 0.015 kg CO₂ / tkm

Truck waste processor average (10-20 ton): 0.259 kg CO₂ / tkm

Transport via company delivery van is not included, since this is included in scope 1 (shaded grey in table).

Phase	Weight Ton	Route	Distance km	Emission factor tkm / kg CO ₂ e	CO ₂ e emission kg CO ₂
1 → 2 Materials to production	0.0001	Truck Foshan – Guangzhou*	50	0.11	0.001
		Boat Guangzhou – Rotterdam*	18207	0.015	0.027
		Truck Rotterdam – Eindhoven*	120	0.11	0.001
2 → 3 Production to user	0.0001	Delivery van Eindhoven – Heeten	140	1.153	
3 → 4 User to waste processing	0.0001	Heeten – Olen, Belgium (Umicore, WEEE recycling)	210	0.259	0.005
Total					0.035

Table 13: Calculation CO₂e transport EMS

*Production materials EMS in Foshan, China. Transport to harbour in Guangzhou. Transport per boat to Rotterdam. By truck to Eindhoven (production at ICT Group N.V.).

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ICT Group N.V.
Weena 788
3014 DA Rotterdam
The Netherlands

P +31 (0)88 908 2000
F +31 (0)88 908 2500
E info@ict.nl
W www.ictgroup.eu