R-ACES
Energy Cooperation Platform

D2.2 Description and material of the impact-assessment tool available

AUTHORS: CHRISTA DE RUYTER & MAX BROUWER (S-ISPT)

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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

[2] R = Document, report
DEC = Websites, patent fillings, video, etc.
DEM = Demonstrator, pilot, prototype
OTHER = other

Document history

	Date	Author (name, organisation)	Description
V0.1	6/5/2021	Christa de Ruyter & Max Brouwer (S-ISPT)	Draft description and material of the Self-Assessment Tool available
V0.2	18/05/2021	Federica Blasi (Spinergy)	Review

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V1.0	26/05/2021	Christa de Ruyter & Max Brouwer (S-ISPT)	Description and material of the Self-Assessment Tool available

Project Summary

The R-ACES project is an initiative promoted by 7 partners from 6 European countries, with the vision to support high-potential industry parks and clusters to become fully fledged ecoregions that reduce emissions by at least 10%. R-ACES means a step-change in the contribution of European Industry to the climate targets of the EU. The industry sector after all represents 25% of all energy demand – and 50% of the total cooling and heating demand on the continent; yet only 16% comes from renewables. By focusing on collective measures and clustering, the efficiency of industry can be drastically increased.

The focus of R-ACES therefore is to turn high-potential, high-impact industrial clusters into ecoregions that achieve at least a 10% reduction in emissions. They do so by exchanging surplus energy, making extensive use of renewables, and tying everything together with smart energy management systems. An ecoregion is a geographic area where energy and information exchanges occur between various companies and actors to reduce waste and energy consumption. Ecoregion can be centred on an (eco-)industrial park or (eco-) business park, linked to its surroundings by a 4th/5th generation district heating/cooling network.

R-ACES is the capping stone, condensing the knowledge and experience gathered throughout EU and national projects into a set of three focused tools, namely a self-assessment tool, a legal decision support tool, and a smart energy management platform for clusters. The tools are embedded in support actions built around peer-to-peer learning, more formal coursework and webinars, and serious games. Together they enable a cluster to really become an eco-region and set up meaningful energy collaboration. The entire package of tools and support is aimed at the high-potential clusters identified in the European Thermal Roadmap. It will be validated in three eco-regions, actively deployed in another seven regions, and disseminated to identified ninety regions European wide. In addition, the tools and support methodology will be made available to third parties in a sustainable way after the end of this project.

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Partners

Institute for Sustainable Process Technology https://ispt.eu/

Condugo https://www.condugo.com/

Spinergy http://www.spinergy.it/

energy CLUSTER DENMARK https://www.energycluster.dk/

L≡2C LOMBARDY ENERGY CLEANTECH CLUSTER http://www.energycluster.it/en

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ESCI European Science Communication Institute https://www.esci.eu

EUROHEAT & POWER https://www.euroheat.org/

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Executive Summary

R-ACES has the ambition to equip practitioners with capacities, knowledge, and skills to make them confident and well informed about the possibilities of energy cooperation. At the same time, we want to support them with an implementation approach that fits their specific needs.

To achieve this goal, several tools are developed: a Self-Assessment Tool, a Legal Decision Support Tool, and an Energy Management Platform. In this deliverable, we describe the several steps taken to come to a Self-Assessment Tool. We also describe the first public release.

Key Words

R-ACES keywords

Industrial Symbiosis, Energy System Integration, District Heating and Cooling, Energy Cooperation, Ecoregion, Eco-Industrial Parks

Deliverable keywords

Self-Assessment Tool, Starting Energy Cooperation

Disclaimer

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1 Introduction

1.1 Objective of the work package ‘development’

In the scope of the work package ‘development’, we aim to develop three different tools (a Self-Assessment Tool, a Legal Decision Support Tool, and an Energy Management Platform) to enhance energy cooperation in industrial clusters. An important aspect of this development is meeting the needs of the target group, to ensure the tools will be used in the end. The needs are identified through interviews with energy managers from the industry, cluster/site managers and policy/governmental persons. The development of the R-ACES Tool Box follows these interviews, starting with the Self-Assessment Tool, a Legal Decision Support Tool, and an Energy Management Platform.

The Self-Assessment Tool
The Self-Assessment Tool helps ecoregions to determine the next steps they have to take in the energy cooperation process. The tool exists of a number of questions practitioners have to answer. Based on the answers, the practitioners will get a score and some practical considerations they should take into consideration.

The Legal Decision Support Tool
The legal decision support tool supports practitioners by giving the legal decision support for joint contracts. A low threshold for usage is a critical requirement. The tool is self-explanatory, application oriented, using well-defined and clear terminology. The tool should be able to deal with a high diversity of local situations.

The Energy Management Platform
The Energy Management Platform supports ecoregions to scout for and follow up on energy collaborations. To scout for opportunities, a heat map dashboard allows the ecoregion to map and overlap excess and demand, thus pinpointing the best energy exchange opportunities. To follow up on the collaboration, a custom Sankey dashboard shows the actual amount of energy exchanged in the energy cooperation.

1.2 Objective of the Self-Assessment Tool

R-ACES has the ambition to equip practitioners with capacities, knowledge, and skills to make them confident and well informed about the possibilities of energy cooperation. At the same time, we want to support them with an implementation approach that fits their specific needs. One of tools we would like to offer is a Self-Assessment Tool that helps practitioners with starting up concrete energy cooperation projects.

Of course, we are not the first ones with this ambition. To help practitioners learn about possibilities of energy savings and cooperation, two methodologies are commonly used: energy auditing and ‘self-assessment’ or ‘peer-assessment’ (see box).

Energy audits
Energy audits are a measure of the Energy efficiency directive (EED). An 'energy audit' means a systematic procedure with the purpose of obtaining adequate knowledge of the energy consumption profile of one individual company, identifying and quantifying its cost-effective energy saving opportunities, and reporting the findings. The EED

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requires Member States to ensure mandatory and regular audits for large enterprises[1]. Energy audits are not mandatory for small to medium enterprises. **Self-assessment or peer-assessment tools** 'Self-assessment' or 'peer-assessment' tools use a series of questions that help the practitioner to assess aspects of projects or organizations such as investment readiness[2], management commitment[3] or costs[4]. These aspects are proven key components of a successful energy project. In this way, the self-assessment or peer-assessment helps the practitioner to select and prioritize feasible projects.

Table 1. Box on energy audits and assessment tools

Most auditing and Self-Assessment Tools are conducted at an enterprise level and focus on energy savings within the company. In R-ACES, we want to extend the perspective to a regional level. In doing so, the focus on individual energy savings may shift towards mutual benefits such as collective energy savings, exchange of energy through industrial symbiosis or even supplying a neighboring residential area with surplus energy.

Therefore, the R-ACES Self-Assessment Tool aims to help organizations to explore their energy cooperation potentials by mapping out all aspects that have proven to be important for successful energy cooperation. In this way, R-ACES wants to help practitioners to explore energy cooperation potentials, prioritize projects and to facilitate dialogue between stakeholders in the region.

2 Development Process

To develop the Self-Assessment Tool, different steps were and will be taken: (1) gathering input for the tools through a literature review[5] and from experts in the field, (2) setting requirements, (3) developing the tool by using an agile development process, (4) publishing the first public release of the Self-Assessment Tool, (5) validation and (6) development of the definitive version. In the upcoming paragraphs, the different steps of the development process are further explained.

2.1 Gathering input for the tools

Earlier in the R-ACES project, a literature review has been conducted to identify important drivers and barriers of energy cooperation[6]. This literature review serves as a basis for the development of the Self-Assessment Tool. Drivers and barriers were identified in relation to legal, economic, spatial, technical, and social/managerial categories. Afterwards, we asked five experts to indicate which drives and barriers were most common in their experience. The results of this process were written down in a report called "D1.2 Harmonised overview".

Some of the barriers mentioned by literature and by experts were related to the collection of heat mapping data. The collection of data is considered time and resource intensive, especially when taking a long-term development perspective on the energy system ('can

[1] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52013SC0447
[2] For example, the Self-Assessment Tool by the European Commission assesses investment readiness in the region for sustainable chemical production.
[3] For example, the Energy Management Self-Assessment Tool by Carbon Trust.
[4] For example, the Flexynets pre-design tool for low temperature DHC networks.
[5] For more information, see D1.1 and D1.2 of the R-ACES project: https://r-aces.eu/downloads/.
[6] For more information, see D1.1 and D1.2 of the R-ACES project: https://r-aces.eu/downloads/.

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the technology fit in the future energy system?'). And matching energy demand and supply is complex, as not only energy quantity but also quality (temperature, water pressure), business case and trust between stakeholders are crucial for the project development.

Input from experts in the field
The literature review formed only a part of the input for the development of the Self-Assessment Tool. To develop a tool that actually assists regional managers in setting up energy cooperation projects, it was determined that it was important to have regular contacts with various experts in the field of energy cooperation projects. In the table below, an overview is given of the experts (non R-ACES partners) whose input was used in the development of the Self-Assessment Tool. A first round of talks with these experts was conducted to determine the requirements[7]

Country	Number of experts	Experience of experts	Main input
Belgium	3	Energy broker (3x)	Communication of long- and short-term goals and having a good representation of stakeholders around the table as most important factors for success
Denmark	2	Energy experts (2x)	Stakeholder management is the most crucial factor in early stage energy cooperation projects
Italy	4	Energy managers (4x)	Kind of technical information that should be part of the tool
The Netherlands	3	Energy broker (1x), Facilitation of heat exchange (2x)	Involvement of top management is important for successful energy cooperation projects KPIs are important

The regular contacts helped us to determine focus points for the Self-Assessment Tool. In the beginning of the project, the R-ACES project aimed to develop a Self-Assessment Tool for all energy cooperation phases. The regular contact with the experts taught us that it was more interesting to have a tool that focusses on the starting phase. The take-off of energy cooperation projects is often difficult. When the take-off is organized well and a good representation of stakeholders is guaranteed, a project is more likely to end up being successful.

2.2 Setting requirements

To develop a good Self-Assessment Tool that matches the wishes and expectations of the R-ACES stakeholders, some requirements were set before starting the development of the tool[8]. A summary of the main requirements is described below:

- **The tool will be mostly used in the initial phase of an energy cooperation to verify whether there is a match for energy collaboration or not.**
- **The tool itself should not be the only thing we provide. If we are only providing a digital tool, it will rarely be used in practice to enhance energy cooperation. The tool should, therefore, be part of a package to facilitate a dialogue in an ecoregion.**
- **Four key issues that should be covered: The available energy supply (Technical), the available energy demand (Technical), the involvement of key stakeholders (Social/Managerial), and the existing infrastructure (Spatial). Especially the social/managerial element "The involvement of key stakeholders" is important.**
- **It was originally planned to include legal issues as well, but later it was decided to cover them exclusively in the legal decision support tool.**

[7] For more information, see D2.1 of the R-ACES project: https://r-aces.eu/downloads/.
[8] For more information, see D2.1 of the R-ACES project: https://r-aces.eu/downloads/.

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- **The tool should pave the path from the initial phase of the cooperation to the implementation phase.**

Target group

Initially the target group was briefly described as ‘regional managers’ or ‘practitioners’ who want to determine the next steps in energy cooperation in their ecoregion. From our contacts with various regions in Europe some ideas were collected on who those ‘practitioners’ are (see box).

Some examples of ‘practitioners’ that collect data and develop energy exchange projects

- In the Antwerp region, a so called ‘energy broker’ is tasked to identify opportunities for energy savings and energy exchange in business parks (a concept developed in the INTERREG project DOEN).
- In the industrial park Kleefsewaard in the Netherlands, a dedicated non-profit organization located in the business park pro-actively seeks to develop energy projects based on a roadmap.
- In Bergamo, an energy service company (ESCO) helps local district heating networks to find new customers.
- In Denmark, the government and municipalities develop energy plans under the Heat Supply Act. The majority of district heating systems are owned and maintained by municipalities, as is the case for example in Nyborg.

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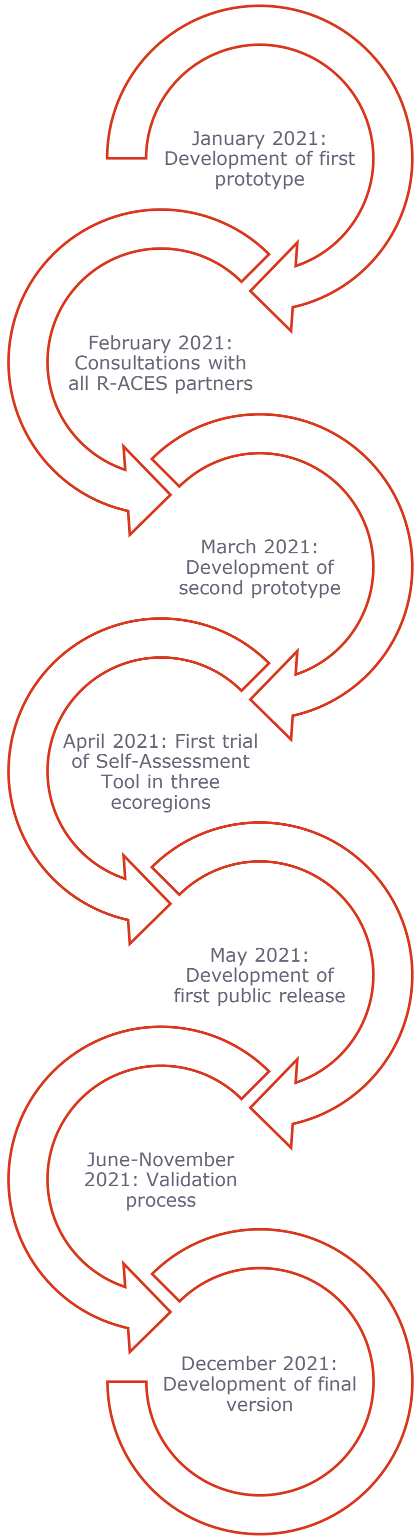
2.3 Agile development process

After the crucial input was collected, it was time to build the tool. To guarantee that the Self-Assessment Tool was in line with the requirements from the regions, a development process was designed. In figure 1, an overview is illustrated of the different steps of the development process. Below, a more detailed description is given.



Stage 1: Development of the first public release

In January 2021, the input gathered previously was used to develop a first prototype of the tool, which consisted of checklists on various aspects of energy cooperation (legal, economic, spatial, technical, social/managerial). Afterwards, the tool was discussed with various R-ACES partners. It was decided that the checklists were too generic to have an added value in the complex world of energy cooperation. Instead, need was identified for a more hands on tool that described the actual status in an ecoregion.

In response to the given feedback, a different approach was chosen. The Self-Assessment Tool should consist of three stages: (1) description of energy cooperation status in the ecoregion, (2) self-assessment questions to reflect on the status in the ecoregion, and (3) results of the self-assessment. The second prototype was developed in the form of an excel file. In the course of March, several experts were contacted to reflect on the tool. The development team got the following feedback:

- **The general framework of the tool was a very good way to start thinking about new energy cooperation projects.**
- **The tool is focused on the ecoregion, which is very useful. However, there should be an easy way to collect necessary data at individual companies.**
- **It would be best if the tool is a web-based tool to make it more accessible**
- **Information completeness and quality can vary depending on the project maturity. In early stages, stakeholders may not have all the necessary information or are not willing to share that information yet. Missing information is further completed when confidence in the project and trust between the stakeholders is established.**

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This feedback was taken into account in the further development process. A method was developed to easily gather data at individual companies. Moreover, the options to make a web-based tool were investigated. It was decided that it would be unfeasible to make a web-based tool for the first release of the tool. However, one of the future updates might be the translation of the excel file into a web-based environment.

Regarding the completeness of information, we decided that it was important that the Self-Assessment Tool should add value even when organizations do not have all necessary information or the highest quality of data. Especially since the tool's focus is the exploration stage where it is uncommon that stakeholders have full access to all the energy supply and demand data in the region. Users should be able to fill the Self-Assessment Tool even when not all fields can be completed. For the tool this means that it should not return errors when fields are left empty and the tool should also not discourage the user in completing the assessment when this is the case.

At the beginning of April, first trials were planned in the three ecoregions. The experiences were translated into a first public release of the Self-Assessment Tool (see chapter "First Public Release").

Stage 2: Validation process
After the release of the first public deliverable, the tool will be validated in the three initial R-ACES ecoregions: (1) Bergamo, (2) Antwerp, (3) Nyborg in the second half of 2021. A sound methodology for the validation is developed by the consortium[9]. A short summary is given below.
First some validation criteria have been defined, the most important are: (1) Ease of use by users, (2) Supportive power for managers to set up the next steps of energy cooperation, (3) Adaptable to local conditions, (4) Number of users[10]. The criteria will be validated through both an external and an internal process:

- **External process: Initial users of the tool will fill out a short evaluation after using the tool in which they can give a score (1-10) to different criteria.**
- **Internal process: The ecoregion managers and tool builders will critically look at overall process of using the tool, for example, the number of users. For some criteria, the ecoregion managers will give a score (1-10). Other criteria are formulated as checks (achieved yes/no).**

The tool should get a good score on both externally and internally validated criteria. The feedback on the criteria will be used to improve the Self-Assessment Tool. At least one update of the tool is foreseen in December 2021.

Stage 3: Development of the final version
The feedback gathered during the validation process will result in an update of the existing Self-Assessment Tool. It is foreseen that a new release of the tool will be updated on the R-ACES website in December 2021. This will, under ideal circumstances, be a final version of the tool. However, also after December 2021, we will keep validating the tool and release updates in case necessary.

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[9] For more information see D3.1 "Validation Methodology": https://r-aces.eu/downloads/

[10] The full list of criteria: (1) Ease of use by users, (2) Supportive power for managers to set up the next steps of energy cooperation, (3) Adaptable to local conditions, (4) User satisfaction, (5) Amount of human effort, (6) Provides guidance and best practices, (7) Covers themes important to start energy cooperation, (8) Time to execute, (9) Number of users, (10) Flexibility in software development and updates, (11) Ability to engage users over longer period of time, (12) Security, (13) Available also after R-ACES project ends, (14) Relationship with R-ACES KPIs, (15) Provide a checklist to explore energy needs, (16) Ensure interoperability between tools.

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3 First public release

The first public release of the R-ACES Self-Assessment Tool is built in Microsoft Excel and is available for download on the R-ACES website: https://r-aces.eu/tools/. The Self-Assessment Tool consists of three parts: a region description, a self-assessment questionnaire and a results sheet. The goal of the tool is that a user can make an inventory of data in four categories that are important when exploring opportunities for energy exchange: energy supply (heating, cooling, electricity), energy demand (heating, cooling, electricity), stakeholders and existing infrastructure. The tool is used in a very early stage of project development and assists in stakeholder analysis and matching energy demand and supply.

Three important design principles underly the Self-Assessment Tool:

1. **Easy to use**
2. **Flexible to imperfect or incomplete data**
3. **Flexible to different kind of users**

The second design principle here is important, because we learned that in the exploration stage, detailed energy data are not always available or shared. Missing information is further completed when confidence in the project and trust between the stakeholders is established. With the third principle we mean that the tool can be filled in by any stakeholder or organization in the region so that, when multiple self-assessments are combined, the self-assessment tool reflects the ecoregion as a whole. With the Self-Assessment Tool, the user learns what information is missing so that the next steps can be designed.

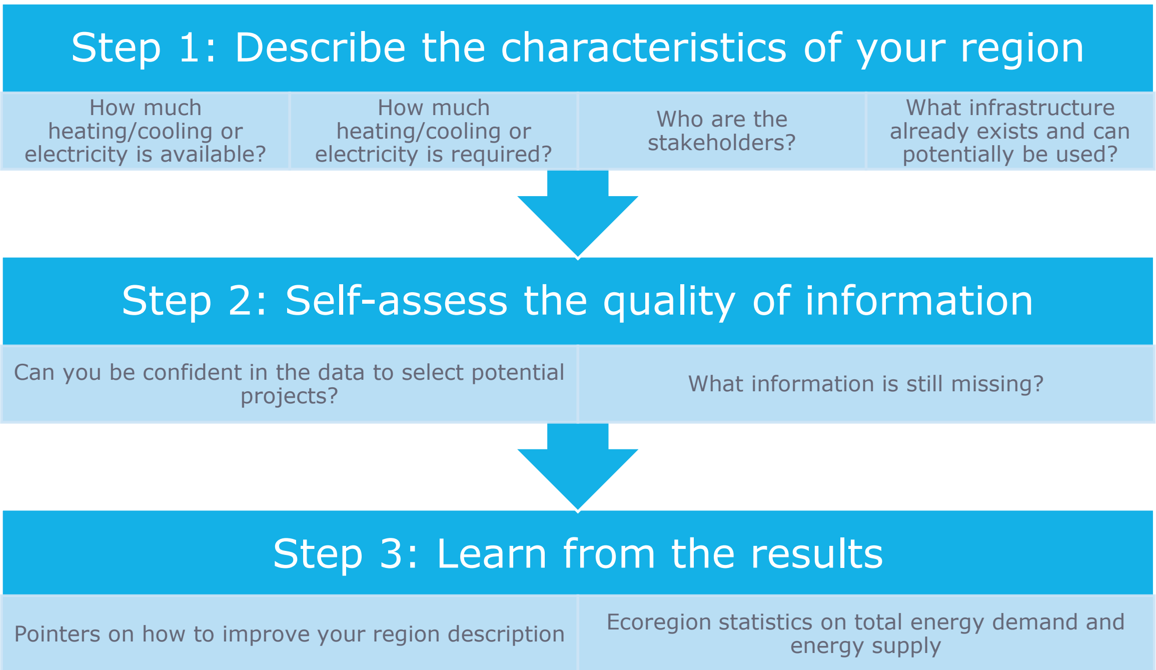

Figure 1. Overview of the R-ACES Self-Assessment tool based on the first public release.

Step 1 – Describe the characteristics of your ecoregion

In the first step of the Self-Assessment Tool, the energy supply, energy demand, stakeholders and existing infrastructure of the ecoregion are characterized. As an individual organization it is usually not possible to fill in data for other organizations in the region. The idea is that each organization can fill in their own data as complete as possible in the self-assessment tool so that when multiple inventories combined will yield the picture of the ecoregion.

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Since information is collected at the level of an ecoregion, the first column has the user naming the different companies/ organizations that make up the inventory. The inventory includes excess heating and cooling sources and available electricity sources. These make up the potential energy supply for the ecoregion.

The available electricity sources

Company*	Electricity source*	Yearly production (kWh)*	Operating hours (h)	Power (kW)	Yearly production in excess (KWh)*	Day pattern*	Week pattern*	Seasonality effect*	Please describe notifiable major interruptions planned*	Voltage (V)	Can information be shared?*	How long will the source continue to exist?*	Notes*
Company 1													
...													
...													
...													
...													
...													
...													
...													
Total		0	0	0									

Figure 2. Excerpt of the region description in the first release of the R-ACES Self-Assessment Tool. It depicts the template for the inventory of available electricity sources.

With respect to the availability of the data, we already learned a lot from our experts in the field. Companies are likely to share yearly energy production or power of an energy source. However, hourly data throughout the year is information that is less likely to be available at the start of a negotiation or project since the information is often market driven. In the SAT, information that is more likely to be available at the start of a negotiation is indicated with a deep red color and information that is harder to obtain is indicated with a light red color. The self-assessment can be completed by filling in the dark red columns, but it contains richer information when the light red columns are also completed.

Step 2 – Self-assess the quality of information

At the end of step 1, an inventory for the ecoregion as a whole is obtained with available energy supply, demand, existing infrastructure, and a stakeholder analysis. The second step of the Self-Assessment Tool helps the ecoregion to 'self-assess' (see box) the quality of information that was collected in step 1 in all four areas. This part of the tool can also be filled in by an individual organization and combined for multiple organizations, for example by averaging the scores. Or alternatively, a coordinator of the region fills it in for the region.

What is self-assessment?

Self-assessment is a technique that is commonly used in education to promote learning and achievement. It is a process in which students collect information about their own performance or progress, compare it to explicitly stated criteria, goals or standards and revise accordingly. It involves students in thinking about the quality of their own work, rather than relying on their teachers as the sole source of evaluative judgements (Andrade & Valtcheva, 2009)[11].

R-ACES believes that this technique can be effective for practitioners in the exploration stage of energy cooperation, when data on energy supply, demand, infrastructure and stakeholders is collected and evaluated and projects are defined.

Several questions are asked related to information quality focusing on completeness and relevance of the data. The user selects a score between 1 (does not apply) and 5 (fully applies) on whether the statements apply to their situation. In addition to a score, the user can also fill in notes to explain the reasoning of their own scoring. The scores total up to a maximum score which is used in the results sheet.

[11] https://doi.org/10.1080/00405840802577544

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Energy supply			
Characteristic	Score		Notes
	Actual	Max	
Level of insight in and knowledge of the currently used heat, cooling & electricity sources in the region		5	
Level of insight in and knowledge of potential (unused) heating/cooling & electricity sources in the region		5	
Extent of overcapacity (i.e. sources that can produce more heating/ cooling/ energy than they currently deliver)		5	
There is insight in the operating hours of the potential heating, cooling & electricity sources		5	
There is insight in the temperature of all heating & cooling sources		5	
The day pattern and week pattern of the different heat & energy sources is known		5	
There is insight in the continuity of the heating, cooling & energy supply sources. (Will there be major interruptions?)		5	
The data on quantity and quality of potential heating/ cooling & energy sources was verified by the owners / engineers		5	
The data on quantity and quality of potential heating, cooling & energy sources was recently updated		5	
Total Score	0	of 45 maximum	

Figure 3. Excerpt of the self-assessment questionnaire in the first release of the R-ACES Self-Assessment Tool. It depicts the questions and statements asked about energy supply.

Important in this part is that there is no 'right' or 'wrong'. A low score may suggest a lower information quality, but this is not necessarily problematic for a specific step in the project. In early stages of a project, it is normal to not know the answer to all the questions. The goal here is that the user is taught to think critically about data and learns on what areas he or she can improve on.

Step 3 – Learn from the results

In step 3, results from the inventory in step 1 and the self-assessment in step 2 are reported in one sheet. A spider-web diagram displays the total score of energy supply, energy demand, existing infrastructure and stakeholders.

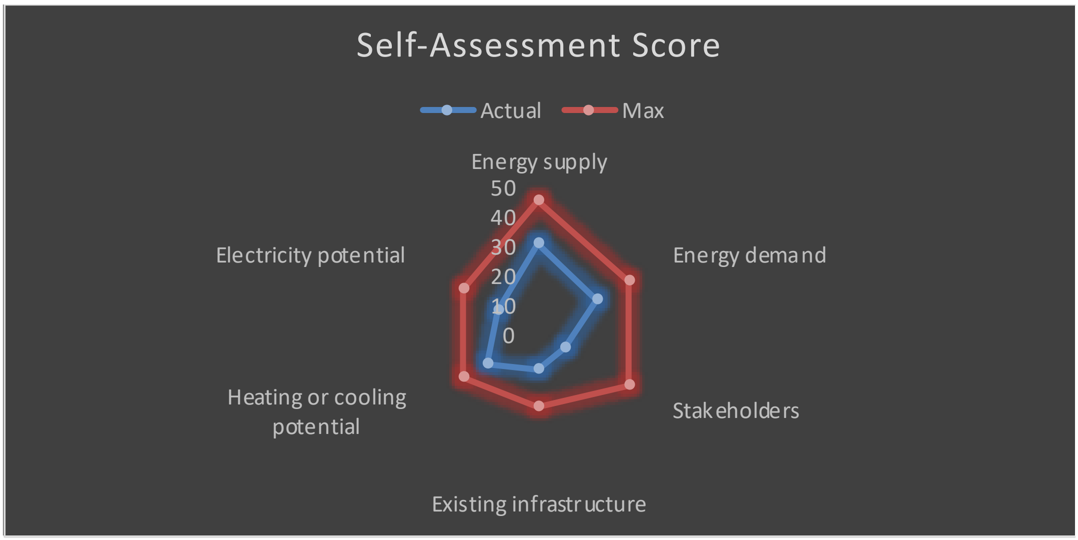

Figure 4. Excerpt of the spider web diagram in the first release of the R-ACES Self-Assessment Tool. The red color indicates the maximum score possible in the four fields: energy supply, energy demand, stakeholders and existing infrastructure. The blue color is the actual score filled in by the user in the self-assessment.

In addition, for each field, a result rationale is automatically generated that describes the meaning of a low score (< 33% of total score) or a high score (> 33% of total score).

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Energy supply	
Low score	You scored low (<33%) in this category. This indicates that detailed information about energy supply is missing in your inventory. This information is necessary for matching the energy supply with energy demand. However, incomplete information may still be useful for identifying potential energy sources in the region. You can revise your scores in tab 2 of the Self-Assessment tool.
High score	You scored high (>33%) in this category. An inventory of all available heating, cooling and electricity sources is essential in planning energy infrastructure. A complete inventory has precise information about the power – the amount of energy transferred or converted per unit time – over the year. It also includes information about the energy quality, such as supply temperature for heat or voltage for electricity. You can revise your scores in tab 2 of the Self-Assessment tool.
Energy demand	
Low score	You scored low (<33%) in this category. This indicates that that detailed information about energy demand is missing in your inventory. This information is necessary for matching the energy supply with energy demand. However, incomplete information may still be useful for identifying the energy needs as well as the required energy carriers. You can revise your scores in tab 2 of the Self-Assessment tool.
High score	You scored high (>33%) in this category. An inventory of all available heating, cooling and electricity demand is essential in planning energy infrastructure. A complete inventory has precise information about the power – the amount of energy transferred and used per unit time – over the year. It distinguishes peak demand from base demand. It also includes information about the desired energy quality, such as the temperature for heat.
Stakeholders	
Low score	You scored low (<33%) in this category. This indicates that detailed information about stakeholders is missing in your stakeholder analysis. You can use tab 2 to identify what information is missing.
High score	You scored high (>33%) in this category. Even though a project idea may be technically and economically sound, it can only succeed when key stakeholders are interested and capable to realize the idea. Projects therefore always include stakeholder management.
Infrastructure	
Low score	You scored low (<33%) in this category. This indicates that information about existing infrastructure in the region is incomplete. You may want to consider exploring the use of existing infrastructure first before designing new infrastructure. You can revise your scores in tab 2 of the Self-Assessment tool.
High score	You scored high (>33%) in this category. Developing new infrastructure can take a decade from start to finish. Therefore, most energy systems are designed to last a multiple of decades and with room to grow. For example, through access of new energy suppliers or by expanding to new customers with energy demand.

Figure 5. Excerpt of the result rationales in the first release of the Self-Assessment Tool. Depending on the score (<33% or >33% of the total possible score) respectively the low score text or the high score text is shown to the user.

The total energy supply and demand from the first step of the tool is summarized here under 'Ecoregion statistics'. The gap between demand and supply is calculated where a value greater or smaller than zero indicates a mismatch between supply and demand. This is a simple approach for energy matching, a more extensive analysis would take into account the full demand and supply profiles in relation to time, e.g. hourly pattern and in relation to quality, e.g. required temperature for heating and cooling in relation to outside temperature. A score between 0 and 30 is calculated based on the match between supply and demand. A maximum score is when supply and demand are equal. When supply > demand, the score is calculated by dividing demand by supply and multiplying the result with the maximum score. E.g. in the example figure, for heat this is (200/300)*30 = 20.

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When demand > supply, an additional penalty factor is included in the equation; supply is divided by demand and then multiplied with the maximum score and with a penalty factor of 0.75. This was done so that the score reflects the idea that it is more difficult to set up energy cooperation in the case of a shortage of supply rather than a shortage of demand. E.g. in the example figure, for electricity this is (500/700)*30*0.75 = 16. The scores awarded here are included in the spider web diagram.

Ecoregion:
Date completed:
By:

Ecoregion statistics

	Total demand [kWh]	Total supply [kWh]	Gap/ Potential*	Score*	Max
Heating or cooling potential	200	300	100	20	30
Electricity potential	700	500	-200	16	30

Figure 6. Excerpt from the Ecoregion statistics generated from the ecoregion inventory in the first release of the R-ACES Self-Assessment Tool. Gap / Potential calculates the sum between supply and demand. A negative value indicates an excess in supply and a positive value indicates an excess in demand.

4 Concluding remarks

The R-ACES consortium is very happy to present the first version of the Self-Assessment Tool to you. We hope that the explanation of the development process and the First Public Release were clear. We will continue to update the tool and to develop new materials in order to facilitate you with realizing real energy cooperation projects.

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5 Annexes

Annex 01 Project Glossary

Definition of Key Concepts in the R-ACES project

Business park: An area of land in which many office buildings are grouped together with a common infrastructure (Wikipedia). Business parks, like industrial sites, often have similarities in heating and cooling demand. Certain businesses may even have residual energy streams, for example data centers. As such, business parks may also organize as an ecosystem or eco business park (EBP) and become an important stakeholder within an ecoregion.

Eco Business Park: *"An eco-industrial park is a community of businesses located on a common property in which businesses seek to achieve enhanced environmental, economic and social performance through collaboration in managing environmental and resource issues. This is known as industrial symbiosis, which is a means by which companies can gain a competitive advantage through the physical exchange of materials, energy, water and by-products, thereby fostering inclusive and sustainable development."* (United Nations Industrial Development Organization)

Communicate: professional and public coverage of the project results and achievements, benefits and potential deployment. This will be realised via the adoption of a large variety of distribution channels, including already existing platforms focusing on energy cooperation in industrial sites and business parks and energy exchange/cooperation at large.

Disseminate: exploitation of the project results to relevant stakeholders in the regions. It intends to ensure a low threshold in accessibility, usage of R-ACES tools and methods. This includes access to the tools, to the use case libraries and to the training and capacity building material and related self-explanatory instruction manuals.

DHC: Abbreviation of District Heating and Cooling. A system for distributing heating/cooling generated in a centralized location through a system of insulated pipes for residential and commercial heating requirements such as space heating/cooling and water heating/cooling.

> 4th generation DHCs: *"4GDH systems provide the heat supply of low-energy buildings with low grid losses in a way in which the use of low-temperature heat sources is integrated with the operation of smart thermal grids. Smart thermal grids consist of a network of pipes connecting the buildings in a neighbourhood, town centre or whole city, so that they can be served from centralised plants as well as from a number of distributed heating and cooling producing units (or decentralised units) including individual contributions from the connected buildings. The concept of smart thermal grids can be regarded as being parallel to smart electricity grids. Both concepts focus on the integration and efficient use of potential future renewable energy sources as well as the operation of a grid structure allowing for distributed generation which may involve interaction with consumers."* (adapted from Lund et al, Energy 68; 2014, p1-11).
>
> 5th generation DHCs: *"5GDHC is a highly optimized, demand-driven, self-regulating, energy management system for urban areas. Its key features are: 1) ultra-low temperature grid with decentralized energy plants; 2) closed thermal energy loops*

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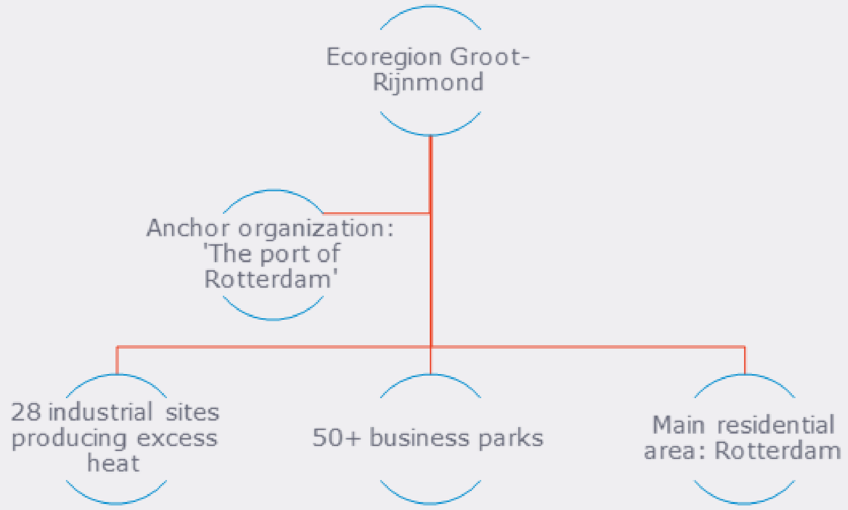
ensuring hot and cold exchange within and among buildings; 3) integration of thermal and electricity grids." (D2grids, Interreg NWE)

Ecoregion: An ecoregion within the R-ACES project is a geographic area where energy and information exchanges occur between stakeholders of various types to reduce energy consumption. Geographical size does not matter (the size of an ecoregion can be as small as a business park or as large as a city). Important is that an ecoregion relies on an anchor organization responsible for managing the area (for example park management). Another aspect is the proximity of stakeholders to ensure interconnected energy flows (continuity of supply, quality of supply, quantity). Within an ecoregion, a wide range of assets could be involved: office parks, data centers, multimodal centers, technological centers, agro-centers, science parks, brain parks, lighthouse parks, chemical parks, eco-industrial parks, and cluster/business parks. For the demand of heat, also residential areas could be taken into account. As such, the term ecoregion functions as an 'umbrella term'.

Example of a high priority/ high impact ecoregion

An example of a high priority/ high impact ecoregion is the Groot-Rijnmond region in the Netherlands. According to the Heat RoadMap the region belongs to priority group 1. The conventional excess heat is 179.65 PJ and the total heat demand is 35.53. Demand and supply are located close to each other. This means that the region has a high potential impact on primary energy savings (KPI 1). A main anchor organization of the region is 'The port of Rotterdam'. Within the region, there are 28 industrial sites that produce excess heat. There is also a large number of business parks (50+). Considering the large number of industrial sites and business parks present, the region also has a high potential impact on KPI 3.



High priority region: A high priority region is an Ecoregion, as defined above, that has balanced potential match of heating/cooling supply and heating/cooling demand in both quantitative (amount of heating/cooling) and qualitative (temperature, form of heat) terms. The region should be identified by heat roadmap studies (for example, the Heat RoadMap Europe or Stratego) or other research activities. In addition, the regions should have networking possibilities. The regions can include industrial sites, business parks and residential areas.

The table below gives an indication of the priorities. R-ACES will focus on priority group 1 +2.

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Table 2.19. Excess heat ($E_{heat,o}$) and heat demand (Q_{tot}) characteristics for the definition of priority groups to identify heat synergy regions

	Characteristics			
Priority group	**Excess heat[a] [PJ/a]**	**Heat demand[b] [PJ/a]**	**Priority status**	**Comment**
1	$\sum E_{heat,o} > 10$	$Q_{tot} > 10$	Very high	High levels of both $E_{heat,o}$ and Q_{tot}
2	$1 < \sum E_{heat,o} < 10$	$Q_{tot} > 10$	High	Moderate levels of $E_{heat,o}$ and high Q_{tot}
3	$\sum E_{heat,o} > 10$	$1 < Q_{tot} < 10$	Moderate	High $E_{heat,o}$ and moderate levels of Q_{tot}
4	$1 < \sum E_{heat,o} < 10$	$1 < Q_{tot} < 10$	Low	Both $E_{heat,o}$ and Q_{tot} at moderate levels
0	$\sum E_{heat,o,max} < 2.5$	$Q_{tot,max} < 25$	No priority	Both $E_{heat,o}$ and Q_{tot} at low levels

[a] Maximal theoretical levels of annually available excess heat.
[b] Space heating and domestic hot water preparation in residential and service sectors.

High potential region: Within the project proposal, sometimes the term high potential ecoregion is mentioned. From now on, this term will not be used within the scope of the R-ACES project.

High impact (in R-ACES terms): Regions that have a high potential impact on the R-ACES KPIs. More specifically, regions are meant that have a high potential impact on KPI 1: Primary energy savings, and KPI 3: Number of plant sites and number of industrial parks where businesses commit to energy cooperation.

Energy cooperation: Energy cooperation activities between industries, which include physical clustering (e.g., of buildings and processes, energy exchange, collective production) and/ or service clustering (e.g., joint contracting). Both can deliver a more stable cumulative demand, economy of scale for larger installations with higher efficiencies and smaller spatial footprint and an optimized demand response. Within R-ACES, the focus is mainly on energy cooperation through the exchange of heating and cooling.

Energy Management Platform: is an ICT-tool that makes energy flows transparent; allows energy consumption and production to be allocated to specific installations, stakeholders and nodes; and identifies anomalies and opportunities. A key feature is that it is very easy to use for a wide range of stakeholders. In this way, it is possible to deploy it in a cluster and give access to the different company and cluster managers – each at their level of detail and with the information they should have access to. On the ecoregion level, there will be a dashboard that shows different energy flows.

ESCO: Abbreviation for Energy Service Company. An ESCO is a business that provides a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management.

Facilitator: someone who helps to bring about an outcome (such as learning, productivity, or communication) by providing indirect or unobtrusive assistance, guidance, or supervision. This task does not include technical expert know-how, instead facilitators are trained to facilitate interaction between multiple actors.

Industrial cluster: Within the project proposal, sometimes the term Industrial cluster is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial park: Within the project proposal, sometimes the term Industrial park is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial region: Within the project proposal, sometimes the term Industrial region is used. From now on, this term will not be used within the scope of the R-ACES project.

Industrial site: An area zoned and planned for the purpose of industrial development. An industrial site can be thought of as a more "heavyweight" version of a business park or

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office park, which has offices and light industry, rather than heavy industry. They may contain oil refineries, ports, warehouses, distribution centres, factories, and companies that provide manufacturing, transportation, and storage facilities, such as chemical plants, airports, and beverage manufacturers (Wikipedia).

(R-ACES) Learning community: Local group of stakeholders that are (a) directly involved with the energy collaboration on a site; and (b) engaging in both organised and informal exchange of knowledge and best practices over the course of the project period. These groups are the first beneficiaries of instruments like serious gaming. Learning communities from different sites in this project will eventually be brought into contact with each other to further stimulate the exchange of best practices.

Learning network: *"Allow for enduring relationships built on trust to develop among companies within an industrial site. In turn these relationships encourage information sharing, creative solutions, long term planning and governance among stakeholders. Social aspects increase interactions among stakeholders and strengthen collaborations and partnerships including industrial ones"* (Scaler, 2018). To establish such learning networks, the R-ACES project will use learning communities.

(R-ACES) Legal decision support tool: A tool that supports practitioners by giving the legal decision support for joint contracts. A low threshold for usage is a critical requirement. The tool is self-explanatory, application oriented, using well-defined and clear terminology. The tool should be able to deal with a high diversity of local situations. For practical reasons, the name of the legal tool might change during the R-ACES process. In this case, the consortium will be informed.

LESTS framework: Abbreviation for Legal, Economic, Spatial, Technical and Social/Managerial. LESTS is a framework that is used in the project to categorize barriers and drivers in ecoregions. The different categories include: Legal, e.g. liabilities, regulatory requirements, third party contracts, service agreements, rules; Economic, e.g. cost savings, waste/ resource recovery value, funding mechanism, taxes & environmental considerations; Spatial, including geographical proximity, planning rules and environmental considerations; Technical, e.g. sharing and cascading resources, system stability, facilities; Social/Managerial, e.g. with regard to workers, consumers, local communities employment, community engagement, and capacity building.

Lock-in: Exchange of by-products will lead to long term reliance on an outside company, which will restrict flexibility of the involved companies and possibility for innovation, or possibility to relocate the site.

Longlist (for example longlist of regions): Exists of lists of items (rows), for example regions, that have been selected on the basis of loose selection criteria (columns). The long list is a first step in creating a short list. The long list should cover all potential subjects that might be of interest to the short list. Example:

Region	Region	Country	Source	# DHCS	# Industrial sites	# Business parks	Contact person	Contact details
1	Maasvlakt	Nederland	...					
2	Chemelot	Nederland	...					
3	Terneuzen	Nederland	...					

Long-term: Long-term impact of R-ACES is gained after the end of the R-ACES project (in KPI terms).

Peer2peer: A network of peers (R-ACES stakeholders) that perceive each other as equal. The peers interact with each other in order to learn from each other. The peer2peer learning context is a formal or informal setting, in small groups or online. Pear learning manifests aspects of self-organization. By this is meant, that there is no hierarchical structure within a peer2peer network (Wikipedia).

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(R-ACES) Self-assessment tool: A tool that helps ecoregions to determine the next steps they have to take in the energy cooperation process. The tool exists of a number of questions practitioners have to answer. Based on the answers, the practitioners will get a score and some practical considerations they should take into consideration.

Serious gaming: A method for learning-through-experience that presents participants with a case study in which they have to play pre-assigned roles to each reach a pre-defined objective as quickly as possible. The interactive & competitive gaming element increases the attractiveness and the learning outcome of the case study. Serious gaming addresses cooperation elements among a large variety of practitioners and focus at creating acceptance and awareness, where the learning communities focus at sharing experiences between peers.

Shortlist (for example shortlist of regions): List of items, for example regions, that have been selected from a long list on the basis of (strict) selection criteria. Hereby, the advantages and disadvantages of each item are considered (OpenLearn). The shortlist contains items that have a high potential and likelihood to contribute to the R-ACES goal.

Short-term: Short-term impact of R-ACES is gained during the R-ACES project.

Use case: A written description of the sequence of steps performed by an ecoregion to come to fruitful energy cooperation.

Use case library: A library that contains multiple use cases.

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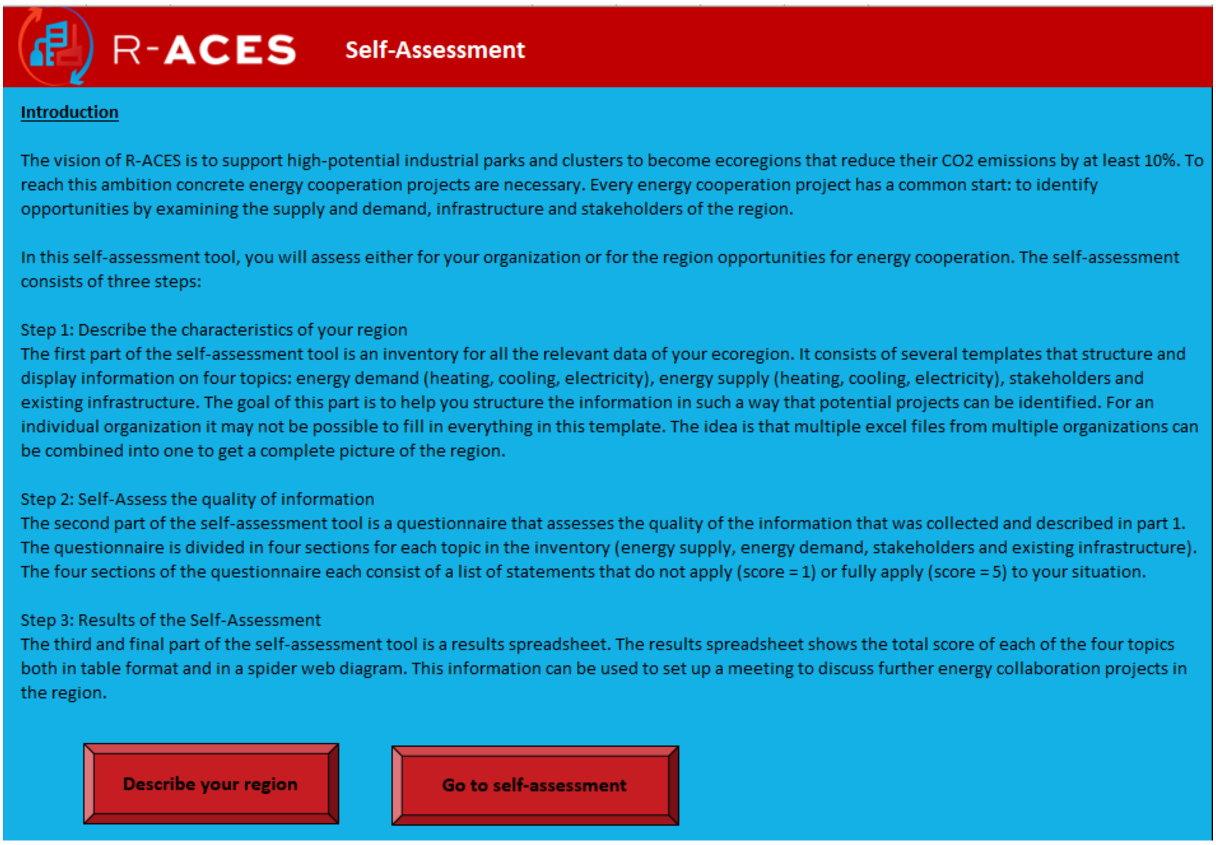
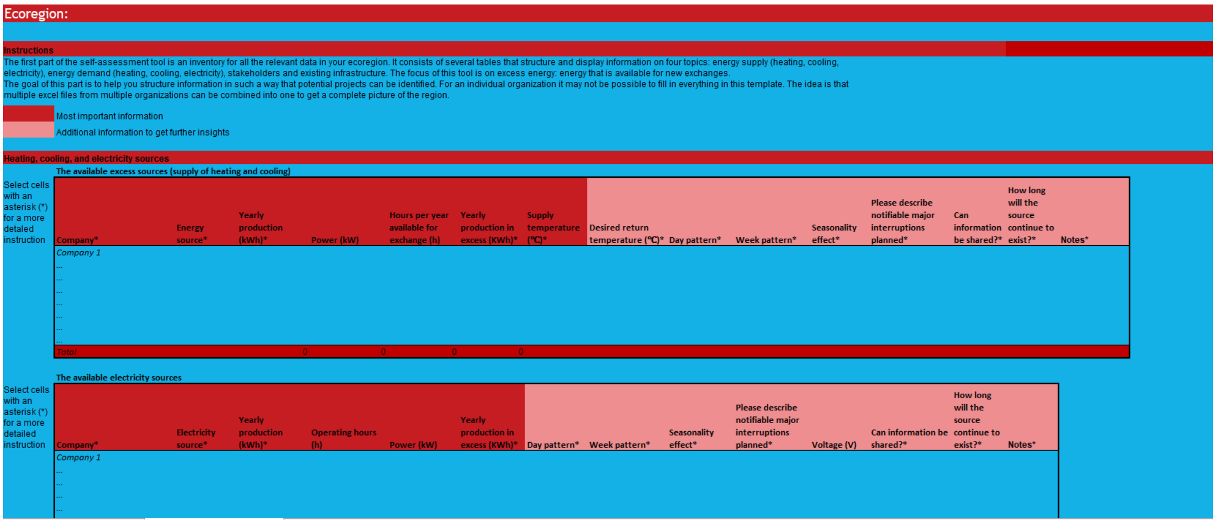
Annex 02 Screen shots Self-Assessment Tool

Instructions Self-Assessment Tool



Ecoregion description in Self-Assessment Tool



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Heating, cooling & electricity demand

The available heating & cooling demand

Select cells with an asterisk (*) for a more detailed instruction

Company*	Process*	Current supply source/ energy carrier*	Yearly demand (kWh)*	Power (kW)*	Temperature (°C)	Day pattern*	Week pattern*	Seasonality effect*	Please describe notifiable major interruptions planned*	Can information be shared?*	How long will the demand continue to exist?*	Notes*
Company 1												
...												
...												
...												
...												
...												
...												
Residential area - 1												
Total			0	0								

The available electricity demand

Select cells with an asterisk (*) for a more detailed instruction

Company*	Process*	Operating hours	Yearly demand (kWh)*	Power (kW)*	Day pattern*	Week pattern*	Seasonality effect*	Please describe notifiable major interruptions planned*	Can information be shared?*	How long will the demand continue to exist?*	Notes*
Company 1											
...											
...											
...											
...											
...											
...											
Residential area - 1											
Total			0	0							

Stakeholders

Select cells with an asterisk (*) for a more detailed instruction

Name of actor*	Type of stakeholder*	Role in project	Motivation to participate	Resources that actor controls*	Awareness*	Top management is involved	Knowledge & experience*	Key actor?*	Formal and informal influence*	Notes*
Actor 1..										
...										
...										
...										
...										
...										
...										
...										
...										
...										

Existing infrastructure in the region

Select cells with an asterisk (*) for a more detailed instruction

Type of infrastructure*	Location*	Description*	Owner of the infrastructure	Total capacity of the infrastructure*	Available capacity*	For DHC*: Pressure?	For DHC*: Temperature range	Is infrastructure extendable?	Stakeholders involved	Notes*

Self-Assessment Questions

R-ACES **2. Self-assessment of your region**

Instructions

This section asks a couple of general questions aimed to assess the 'quality' of the input information in part 1 "Region description" of the self-assessment tool. Note that there is no right or wrong: the goal is to help you identify whether your knowledge of energy supply & demand and stakeholders is complete. The questionnaire is divided in four sections for each topic in the inventory (energy supply, energy demand, stakeholders and existing infrastructure).

Scoring

The four sections of the questionnaire each consist of a list of statements that do not apply (score = 1) or fully apply (score = 5) to your situation.

Energy supply

Characteristic	Score		Notes
	Actual	Max	
Level of insight in and knowledge of the currently used heat, cooling & electricity sources in the region		5	
Level of insight in and knowledge of potential (unused) heating/cooling & electricity sources in the region		5	
Extent of overcapacity (i.e. sources that can produce more heating/ cooling/ energy than they currently deliver)		5	
There is insight in the operating hours of the potential heating, cooling & electricity sources		5	
There is insight in the temperature of all heating & cooling sources		5	
The day pattern and week pattern of the different heat & energy sources is known		5	
There is insight in the continuity of the heating, cooling & energy supply sources. (Will there be major interruptions?)		5	
The data on quantity and quality of potential heating/ cooling & energy sources was verified by the owners / engineers		5	
The data on quantity and quality of potential heating, cooling & energy sources was recently updated		5	
Total Score	0	of 45 maximum	

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Energy demand

Characteristic	Score Actual	Score Max	Notes
Level of insight in and knowledge on the current heating, cooling & electricity demand of companies and residential areas in the region		5	
Level of insight in and knowledge of the future heat & energy demand of companies and residential areas in the region towards 2050		5	
The current and future energy demand is known in units of kWh/MWh		5	
For heating and cooling demand, the required temperature for the application is known		5	
The day pattern and week pattern of the heat & energy demand is known		5	
There is insight in the continuity of the demand (Will there be major interruptions?)		5	
There is insight in the influence of seasonality factors on the demand		5	
Total Score	0	of 35 maximum	

Stakeholders

Characteristic	Score Actual	Score Max	Notes
There is an overview of all relevant stakeholders for the energy cooperation project		5	
There is an overview of the potential role of all stakeholders in the project		5	
There is an understanding of the motivations to participate of all actors		5	
There is insight in the resources that the respective actors control		5	
There is insight in the knowledge and experience of the different stakeholders		5	
The top management of the involved actors is involved in the energy cooperation project		5	
Non-replaceable stakeholders have a strong motivation to work on the project		5	
Total Score	0	of 35 maximum	

Existing infrastructure

Characteristic	Score Actual	Score Max	Notes
There is infrastructure (production or storage capacity, transport of energy) that enables energy collaboration.		5	
The required infrastructure is already available		5	
The required infrastructure is well-maintained		5	
The location of the infrastructure is on a reasonable location for potential energy cooperation projects		5	
There is space to build new infrastructure if needed		5	
Total Score	0	of 25 maximum	

Results Self-Assessment Tool

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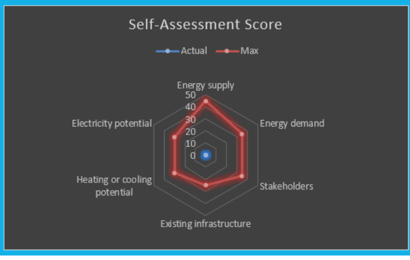
R-ACES **Energy Management Self-Assessment Summary**

Characteristic	Score Actual	Score Max	% score
Energy supply	*0*	*45*	*0%*
Energy demand	*0*	*35*	*0%*
Stakeholders	*0*	*35*	*0%*
Existing infrastructure	*0*	*25*	*0%*
TOTAL	0	140	0%

Ecoregion:	
Date completed:	
By:	

Ecoregion statistics

	Total demand [kWh]	Total supply [kWh]	Gap/ Potential*	Score*	Max
Heating or cooling potential	0	0	0	##############	30
Electricity potential	0	0	0	##############	30



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