# An Interactive GIS-Tool for Collaborative Local Renewable Energy Planning

Johannes Flacke
University of Twente,
Faculty of Geo-Information Science
and Earth Observation (ITC)
P.O Box 6, 7500 AA
Enschede, Netherlands
j.flacke@utwente.nl

Cheryl de Boer
University of Twente,
Faculty of Geo-Information Science
and Earth Observation (ITC)
P.O Box 6, 7500 AA
Enschede, Netherlands
c.deboer@utwente.nl

**Abstract**

Several cities in the Netherlands have developed ambitious local climate change mitigation plans to become carbon neutral in the future, including measures for significantly increasing the amount of locally produced renewable energy. The paper describes the GIS-based interactive tool COLLAGE that allows stakeholders to negotiate together where to locate a pre-determined demand of renewable energy within their municipality. The COLLAGE tool is implemented for stakeholder workshops of Dalfsen municipality, Netherlands. The interactive mapping sessions were perceived useful for better understanding the scope of envisioned development of renewable energies.

*Keywords*: Interactive planning tool; maptable; renewable energy; stakeholder participation

## 1 Introduction

Cities are key actors for reaching ambitious climate change mitigation goals [1]. One increasingly popular goal of many cities is achieving a net-zero greenhouse gas (GHG) emission level. This often involves incorporating renewable energy (RE) production within the municipal boundary in order to localise the costs and benefits of energy production. However, the question of where to set up what kind of renewable energies is a heavily contested debate. The development and implementation of a local renewable energy plan requires the integration of multiple stakeholders, who have different preferences and levels of willingness to accept and implement the installation of RE systems in their own backyard.

A number of tools are available that support the development and implementation of RE. The US Federal Energy Management Program (FEMP) for example offers a variety of renewable energy resource maps and screening tools, such as the FEMP Screening Map that examines the viability of three solar technologies including annualized economic calculations (http://maps.nrel.gov/femp_atlas). Roth and Gruehn [2] have used digital landscape data and web-based participatory approaches determine the most suitable locations for wind turbines. The Dutch Zonnekaart (sun-map; www.zonnekaart.nl) is a web-based mapping tool analysing the suitability of roofs for setting up solar panels in different municipalities. Nonetheless, there is no tool yet that supports municipalities in capturing stakeholder interests in renewable energy planning, e.g. by capturing preferences for location and type of RE systems.

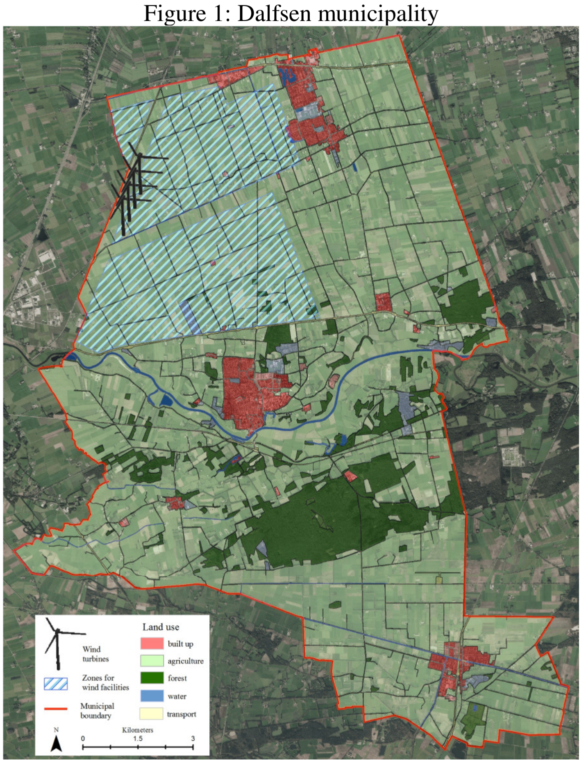
The paper describes a GIS-based interactive tool (COLLAGE – Collaborative Location and Allocation Gaming Environment) that allows stakeholders to negotiate together where to locate a pre-determined demand of RE within their municipality. COLLAGE allows the stakeholders to jointly discuss desired and undesired locations and types of RE, and to sketch and plan areas for renewable energy landscape features (RELF).

## 2 Context of the study

This research has taken place in the Netherlands, which has been among the lowest achievers from the EU in increasing the share of renewable energy in the overall production in the country. Many contributing factors including poor and unstable policy support from the government and highly contested land use changes can be identified as having led to this poor performance [3]. Despite this, many cities in the Netherlands have developed ambitious local climate change (CC) mitigation policies to become carbon neutral by a target date in the future [1]. These policies often include plans for significantly increasing the amount of locally produced RE. One particularly successful case has been the municipality of Dalfsen where they have a plan to become carbon neutral by 2025 (Meerjarenprogramma Duurzaamheid 2014-2015, Dalfsen). Based on their plan they will need to implement 60 MW of solar and 19 MW of wind capacity to achieve their target. To date, 4 wind turbines have been installed on the north-west municipal border with a total capacity 9.9 MW (figure 1). Current plans include adding 3 more turbines each having a capacity 3 MW. In terms of solar energy a total capacity of 7 MW had been implemented by the end of 2015. The solar energy capacity has come from urban installations on top of roofs and industrial facilities. A number of projects have begun which propose to develop small scale solar farms in the rural area of Dalfsen. These developments have faced difficulties due to land use and planning regulations, as well as issues related to obtaining financial support. The land use policy in the Province of Overijssel, where Dalfsen is located, permits solar panels in the rural area only once all other options have been considered and proven unfeasible. However due to the emerging interest in developing local solar farms, attention is being given to updating the relevant policies so that RE can be promoted, while preserving important natural areas and landscapes. Developments in spatial planning, the professionalization of local renewable energy initiatives, connecting local demand and supply, reducing energy use and appropriate levels and types of subsidies are all issues influencing the pathway to a Carbon Neutral Dalfsen [4].

Since space is quite intensely used in the Netherlands, changes are susceptible to strong public debate and judicial actions when they infringe on the valuable (scarce) natural landscape. Within Dalfsen there are a number of different interest groups actively involved in processes related to the development of RE. Following interviews in 2014/15 with these different stakeholder groups, a number of different issues that are particular to Dalfsen with respect to achieving carbon neutrality were translated into spatial data and assumptions, used to support the stakeholder workshop undertaken in September 2015. This informed the choice of different options for RE that could be implemented in the COLLAGE model.

Figure 1: Dalfsen municipality




## 3 Model framework

COLLAGE is a GIS-based interactive tool that allows stakeholders to negotiate where to locate RE within their municipality. The tool is built upon three components:

1. Mapping component, that enables stakeholders to allocate RELFs within the municipal area;
2. Calculation component, calculating total land consumption, MW production, cost & benefits per RELF;
3. An output component displaying results for relevant indicators (land consumptions for RE, MW production, costs and benefits) in bar charts.

The current settings for the interactive mapping component allow allocation of different types of RELFs within a 50 x 50m grid system simply by selecting a specific type of RELF and allocating single grid cells. Each RELF is equipped with a number of variables indicating efficiency, investment costs and 10 year gross income (table 1). Wind turbines are allocated within a 400 x 400 m grid system, with 1 grid cell representing one turbine. These categories were chosen based on the local context in Dalfsen. The associated variables were calculated based on a number of assumed and averaged data. Stakeholders were advised that the values should be considered as “realistic” but not “real”.

Certain types of RELF are restricted outside of zoned areas, according to Dutch planning regulations. Urban solar RELF are only applicable in the so-called Binnengebied (inner area), i.e. the built up, urban area), while rural RELFs are only applicable in the outer, rural area (Buitengebied). The two major differences between these types of RELF are related to the amount of capacity per square meter, and the price of energy that can be assumed (Dutch law provides a substantial incentive to produce urban residential solar energy). Natural areas, e.g. forest, are completely prohibited for all types of RELF. Installation of new wind turbines is restricted to an area north-west of the urban core, which was earmarked as a potential wind energy area during a regional planning process.

The calculation component automatically calculates for each type of RELF a number of indicators, like total energy capacity produced, land area consumed, costs and benefits per RELF, etc. based on the characteristics of each type as given in table 1. For sessions with expert stakeholders these variables can also be user defined, i.e. altered during the stakeholder session. The results display section (figure 2) shows bar charts for land consumptions, MW capacity, costs and benefits. Alerts are included for the MW production chart indicating when a pre-defined goal is reached during a stakeholder session.

The tool is implemented on a large-scale interactive maptable (figure 3) allowing optimal stakeholder interaction and collaboration. Direct interaction of the stakeholder with the tool takes place in form of placing of different types of RELFS on the landscape, and – when playing with expert stakeholders – the adjustments of efficiency and cost factors for various RELF options. Results of the model are a map of preferred locations of various types of RE. However, the mutual interaction between the stakeholders while working with the tool is considered an important contribution to the planning process as it provides insights related to barriers to implementation and new ideas for placement.

Table 1: RELFs and associated factors

| RELF | Description | Efficiency (MW/ha) | Investment (€/ha) | Gross income (€/10a) |
|---|---|---|---|---|
| Full urban solar | high percentage of people installing solar panels on their roofs | 0.15 | 300,000 | 345,000 |
| Good urban solar | medium uptake of solar panels by households | 0.10 | 200,000 | 230,000 |
| Bad urban solar | poor installation rate of solar panels for households | 0.05 | 100,000 | 115,000 |
| Intensive rural solar farm | commercial solar farm that covers 60% of the surface area | 0.5 | 500,000 | 500,000 |
| Extensive rural solar farm | commercial, locally supported project paying attention to the local landscape qualities, including multiple functions | 0.25 | 300,000 | 250,000 |
| Farm roofs | Commercial project with 100 solar panels on a farm roof, financed via households according to the residential solar policy | 0.025 | 30,000 | 55,000 |
| Wind turbine | Commercial, or local community project | 3 MW per turbine | 2,500,000 | 7,500,000 |

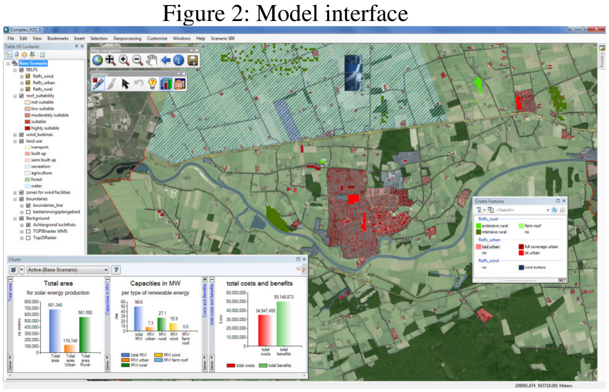
# 4 Implementation of the model framework

In September 2014 we tested the COLLAGE model during stakeholder workshops organized for the municipality of Dalfsen.

## 4.1 Hard- and Software, data

The model framework is implemented as a prototype in CommunityViz Scenario 360 planning support system (www.communityviz.com), which is an extension to ArcGIS. The extension allows interactive mapping activities and dynamic, on the fly recalculation of all indicators based on mapping inputs. The advantages of CommunityViz as a dynamic, interactive GIS tool supporting stakeholder collaboration outbalance the limitations of using ArcGIS on a touch-sensitive maptable. In future applications COLLAGE will be implemented in flexible, open source GIS environment.

Figure 2: Model interface



The following layers of secondary data are included in the tool, supporting stakeholders during the interactive mapping of RELFS (table 2).

Table 2: Data set

| data | source |
|---|---|
| Wind turbine area (designated plan area) | Dalfsen municipality |
| Existing wind turbines | Dalfsen municipality |
| Municipal boundaries | Dalfsen municipality |
| Bestemmingsplan (inner and outer plan area) | Dalfsen municipality |
| Aerial photograph(web service) | www.nationaalgeoregister.nl |
| Topographic map 1:25,000, 1:50,000(web service) | www.nationaalgeoregister.nl |
| Wind turbine area (designated plan area) | Dalfsen municipality |
| Existing wind turbines | Dalfsen municipality |

## 4.2 Stakeholder workshops

The workshop performed in Dalfsen was designed to understand the preferences and rationale of various stakeholders for certain RELFs and to capture their preferred locations and the related typical landscape characteristics. During two 45 minutes sessions, two groups of stakeholders (5 stakeholders per maptable, in total 2 maptables), that were identified during interviews beforehand (see above), were asked to discuss and negotiate where to set up different kinds of RE units, in order to reach the goal of in total 79 ha of RE. In the first round stakeholders could allocate only 5 types of RE (see table1: all urban, wind, extensive rural), which are the current possible constellations within the existing Dutch planning law. In the second round stakeholders could also allocate intensive rural solar farms and solar panels on farm roofs in the rural area (table 1) as a sort of alternative plan scenario. These two RE options were considered desirable by some stakeholders in the scoping interviews but are not strongly supported via current government policy instruments.

At the end of the stakeholder session a feedback discussion was conducted to capture immediate reactions and experiences of the stakeholders regarding the usability of the tool and what they could take away from the process. For further analysis of the stakeholder sessions the interactions of stakeholders on the maptable (screen capture) as well as their discussions were recorded. Finally the maps of allocated RELFS on both maptables were captured to be used for further analysis.

Figure 3: stakeholder workshop

Source: Photo taken by Melanie Gils, Dalfsen municipality

## 5 Results and conclusions

Both stakeholder groups, each group working on one maptable, had discussions regarding preferred types of RELF where some opposing perceptions were voiced. While some stakeholders argued that wind turbines were preferable because of their limited environmental impacts in terms of land consumption compared to solar farms, others preferred solar farms due to the long distance visual impacts of wind turbines. Stakeholders refraining from urban solar installations argued that the traditional thatched roofs in the urban areas of Dalfsen should not be impacted by solar panels. Arguments against large scale rural solar farms brought the high environmental quality and recreational relevance of the rural area forward. A first lesson learned by all stakeholders after playing the game was that in order to achieve an ambitious goal of 79 MW, an integrative strategy that combined various types of RE could lead to success.

The strictly spatial approach of using interactive mapping sessions on maptables was perceived as very useful, because it aided in providing a much clearer picture about the spatial scope of the envisioned development of RE. While some stakeholders realized that it takes less space than expected to produce a certain amount of RE, others learned that certain types of installation are not very space efficient. Another interesting finding was that such a spatialization of RE systems initiated for some participants a stronger willingness to strengthen efforts to reduce energy consumption, such as insulation of houses, as an alternative GHG reduction strategy.

The prototype of the tool as applied in the workshop turned out be conceptually suitable, however the functionality could be substantially improved. Though the stakeholders managed to perform their tasks on the maptable properly after a short introduction and a little bit of training, it became obvious that the usability of the ArcGIS interface on a large scale maptable is very limited, as it allows no gestures. In the near future the COLLAGE model will be implemented in an open source GIS environment particularly suited for use on a maptable and by a group of actors. A further development will be a synchronous 3D visualization of the landscape on a second screen allowing for better spatial orientation and a more realistic understanding of the visual impacts of wind and solar energy by participants.

To summarize, the tool captures the preferences of local stakeholders for types of RELFs as well as spatial priorities of where to locate them within the municipal boundaries. As such it helps to raise awareness and understanding of RE issues among stakeholders, and it provides relevant inputs to local RE planning processes. Preferences of various stakeholders will further be used as an input to a RELF land use model [5] that simulates future land use configurations under different renewable energy policy scenarios.

**Acknowledgements**

The research presented in this article was carried out under the remit of the EU 7th Framework Programme project "COMPLEX", reference 308601. The authors are extremely grateful for the helpful collaboration of all the stakeholders contacted in Dalfsen as part of this research. We would also like to thank Map Gear Geo Apps and Services for contributing data related to solar potential of roof tops in Dalfsen.

## References

[3] Reckien, D.; Flacke, J. et al. Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries. *Climatic change* 122: 331–340, 2014

[2] Roth, M.; Gruehn, D. Digital Participatory Landscape Planning for Renewable Energy - Interactive Visual Landscape Assessment as Basis for the Geodesign of Wind Parks in Germany. In U. Fricker P. et al. (Eds.): Peer Reviewed Proceedings of Digital Landscape Architecture 2014 at ETH Zurich. Zuerich, 2014.

[3] De Boer, C.; Bressers, H. Climate Related Energy Developments in the Netherlands. EU FP7 Project Reference Number: 308601, 2013.

[4] De Boer, C. Duurzaam Dalfsen. Report COMPLEX Project. EU FP7 Project Reference Number: 308601, 2015

[5] De Boer, C.; Hewitt,R.; Bressers, H.; Martinez Alonso, P.; Hernández Jiménez, V.; Díaz Pacheco, J.; Román Bermejo, L. Local power and land use: spatial implications for local energy development. *Energy Sustainability and Society*, 5 (31): 1-8, 2015.