

iGUESS – An integrated Geospatial Urban Decision Support System for Smart City Energy Planning

Ulrich Leopold

Resource Centre for Environmental Technologies,
Public Research Centre Henri Tudor,
Esch-sur-Alzette, Luxembourg

Solar Energy in the Urban Context: Planning, Design +
Implementation, Toronto – September 29, 2014

Let's start with the MUSIC Project

MUSIC

Mitigation of CO₂ Emissions in Urban Areas:
Solutions for Innovative Cities

**A partnership of European cities and research
institutes that takes the lead in innovative
CO₂ reduction!**

Mitigation of CO₂ Emissions in Urban Areas: Solutions for Innovative Cities

The MUSIC Project

- ▶ **is** an INTERREG IVB NWE project of 5 European cities (Rotterdam, Ghent, Aberdeen, Montreuil, Ludwigsburg) supported by 2 research institutes (DRIFT & Tudor);
- ▶ **aims** at reducing CO₂ emissions in urban areas by 2030 and beyond;
- ▶ **involves** urban stakeholders starting with frontrunners;
- ▶ **adds** energy as a geospatial layer to urban planning;
- ▶ **develops** innovative strategies for sustainable planning.

MUSIC is about creating opportunities

- ▶ Prepare for energy transition;
- ▶ Look for business opportunities;
- ▶ Reduce socio-economic and health impacts, e.g. energy poverty; urban heat island effects.
- ▶ Create a sustainable city with high quality of life;
- ▶ Explore and develop the city together.

MUSIC explores questions

- ▶ How to create a common understanding of problems and potentials for change?
- ▶ How to mobilise different types of actors and renewable energy potentials to work towards a sustainable future?
- ▶ How to get support within your organisation for an innovative approach to reduce CO₂ emissions?
- ▶ How to use decision support tools for a participatory planning process?
- ▶ How to estimate and localise renewable energy potentials to develop adequate policies and business opportunities?

What are the objectives of MUSIC?

1. **Institutional innovations:** carbon reductive /energy governance with **stakeholder based vision** via transition management.
2. **Technical innovations:** Geospatial Urban Energy **information and decision Support** System (iGUESS) for scenario analysis and decision support across different scales.
3. **Learning from pilot projects** by using implementation and assessment using transition management and iGUESS.

Let's look into iGUESS

iGUESS

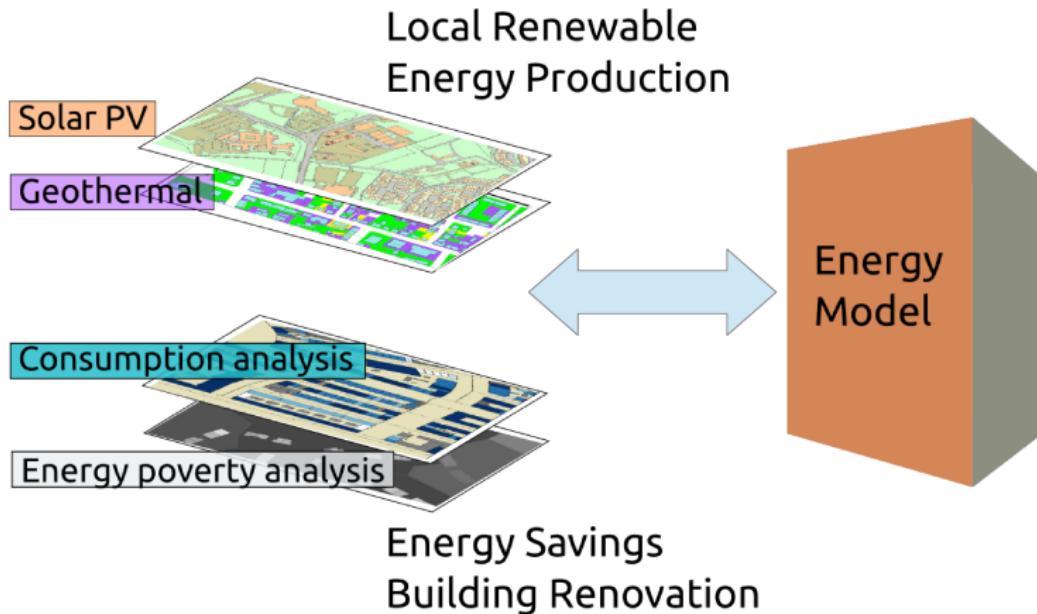
An **i**ntegrated **G**eospatial **U**rban **E**nergy
information and decision **S**upport **S**ystem

iGUESS Objectives

iGUESS – a decision support system which provides:

- ▶ **smart tools** to explore opportunities across different scales;
- ▶ a **simple interface** to complex, distributed information for sustainable urban development;
- ▶ an **open source platform** assuring interoperability and improved interaction with stakeholders.

iGUESS – An integrated web based modular framework



The iGUESS Start Page

tudor

iGUESS
Integrated Geospatial Urban Energy information and Support System

[New User | Login]

understand your options...
plan your future.

View Some Data

iGUESS can show you any registered dataset on an interactive map of your city.

Run Calculation Module

Check Running Module

View your data or register new datasets

Explore maps of my city

See my datasets

Register new data

The iGUESS Data manager

tudor
PUBLIC RESEARCH CENTRE TUDOR

iGUESS
Integrated Geospatial Urban Energy Information and Support System

Signed in as Ulrich (Luxembourg) [Account | Logout] Rotterdam

Registered Datasets

Filter: [solar] [Register New Datasets](#)

Name	Tags	Registered	Published?	Status	Server
00_solar_irradiation_UL_1	Mapping	2014-09-19	<input type="checkbox"/> Publish	Available	A mapping service generated with the iGUESS WPS Client.
01_lijn_solarirra	Mapping, solar_irradiation	2014-09-19	<input type="checkbox"/> Publish	Available	A mapping service generated with the iGUESS WPS Client.
01_tiny_solarirra	Mapping	2014-09-19	<input type="checkbox"/> Publish	Available	A mapping service generated with the iGUESS WPS Client.
PV costs (amorph) (Euro/kWh)	Solar Energy, Mapping	2014-06-20	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV costs (mono) (Euro/kWh)	Solar Energy, Mapping	2014-06-20	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV costs (multi) (Euro/kWh)	Solar Energy, Area of Interest, Mapping	2014-05-02	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV potential (amorph) (kWh/a)	Solar Energy, Mapping	2014-06-20	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV potential in the Lijnbaan neighbourhood	Solar Energy, aggregate_basemap, Mapping	2013-08-21	<input checked="" type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV potential (mono) (kWh/a)	Solar Energy, Mapping	2014-06-20	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV potential (multi) (kWh/a)	Solar Energy, Mapping	2013-11-15	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
PV_potential_training	Solar Energy, Mapping	2014-06-20	<input type="checkbox"/> Publish	Available	A mapping service generated with the iGUESS WPS Client.
Solar irradiation (RO-centre) (kWh/m ² a)	Solar Energy, aggregate_basemap, Mapping, solar_irradiation	2013-11-11	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
Solar irradiation (RO-Lijnbaan) (kWh/m ² a)	Solar Energy, aggregate_basemap, Mapping, solar_irradiation	2013-11-11	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
Solar irradiation (RO-public buildings) (kWh/m ² a)	Mapping, solar_irradiation	2014-06-19	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site
Solar irradiation (RO-west) (kWh/m ² a)	Mapping, solar_irradiation	2014-05-28	<input type="checkbox"/> Publish	Available	Web-Service Demo with data stored at TUDOR site

[Register New Datasets](#)

Retrieve information on data set

tudor  iGUESS  Integrated Geospatial Urban Energy Information and Support System

Signed in as Ulrich (Luxembourg) [Account | Logout] Rotterdam

PV potential (multi) (kWh/a)

Server Name:	Web-Service Demo with data stored at TUDOR site				
Data Services:	WMS WFS Show Data				
Mapping Tags:	<input checked="" type="checkbox"/> Solar Energy	Add Mapping Tag	<input type="button" value="X"/>		
Processing Tags:	<input checked="" type="checkbox"/> Mapping	Add Processing Ta	<input type="button" value="X"/>		
When registered:	November 15, 2013 16:55 (UTC)				
Configurations:	Not used in any configurations				
ACTIONS:	Unregister Dataset				
Technical details >>					
PV potential (mono) (kWh/a)	Solar Energy	Mapping	2014-06-20		
PV potential (multi) (kWh/a)	Solar Energy	Mapping	2013-11-15		
PV_potential_training	Solar Energy	Mapping	2014-06-20		
Solar irradiation (RO-centre) (kWh/m ² a)	aggregate_basemap	Mapping	solar_irradiation	2013-11-11	
Solar irradiation (RO-Lijnbaan) (kWh/m ² a)	Solar Energy	aggregate_basemap	Mapping	solar_irradiation	2013-11-11
Solar irradiation (RO-public buildings) (kWh/m ² a)	Mapping	solar_irradiation		2014-06-19	
Solar irradiation (RO-west) (kWh/m ² a)	Mapping	solar_irradiation		2014-05-28	

[Register New Datasets](#)



Published?	Status	Server
<input type="checkbox"/>	Available	A mapping service generated with the iGUESS WPS Client.
<input type="checkbox"/>	Available	A mapping service generated with the iGUESS WPS Client.
<input type="checkbox"/>	Available	A mapping service generated with the iGUESS WPS Client.
<input type="checkbox"/>	Available	Web-Service Demo with data stored at TUDOR site
<input type="checkbox"/>	Available	Web-Service Demo with data stored at TUDOR site
<input type="checkbox"/>	Available	Web-Service Demo with data stored at TUDOR site
<input type="checkbox"/>	Available	Web-Service Demo with data stored at TUDOR site
<input checked="" type="checkbox"/>	Available	Web-Service Demo with data stored at TUDOR site

Register new Data Sets in iGUESS

tudor PUBLIC BUILDING CAMPUS HAMBURG

iGUESS

Integrated Geospatial Urban Energy Information and Support System

Home Data Manager Modules Scenarios Maps About Signed in as Ulrich (Luxembourg) [Account | Logout] Ludwigsburg

Register Datasets

iGUESS uses datasets stored on remote servers. To register datasets with the system, enter a server URL in the box below. iGUESS will probe the remote server and present you a list of datasets you can register. In order to use a dataset with a module, you will need to tag it with the appropriate tags. If you want to use the dataset for mapping purposes, use the Mapping tag.

iGUESS will probe for WFS, WCS, and WMS servers at the URL provided below. Layers offered by the WMS will be available for mapping, and layers offered by the WFS/WCS will be available for using as inputs to web processes.

Server: Web-Service with data stored at TUDOR premises for the city of Ludwigsburg
This installation serves different Web-Service types (WMS, WFS, WCS) for testing

Server has 3 layers. SRS required for processing: EPSG:31467; SRS required for mapping: EPSG:3857.

LB_Thermalbild LB_Thermalbild <input checked="" type="checkbox"/> available for mapping yes <input checked="" type="checkbox"/> available for processing yes REGISTERED Services: WMS, WCS Used in 0 configurations <input checked="" type="checkbox"/> Mapping <input type="button" value="Add Mapping Tag"/> <input type="button" value="Add Processing Tag"/> Mapping Projections: EPSG:31467; EPSG:3857; EPSG:4326 Processing Projections: EPSG:31467	 Identifier: LB_Thermalbild	City boundary Demo data set of city boundary in Ludwigsburg <input checked="" type="checkbox"/> available for mapping yes <input checked="" type="checkbox"/> available for processing yes UNREGISTERED Services: WMS, WFS <input type="button" value="Add Mapping Tag"/> <input type="button" value="Add Processing Tag"/> Mapping Projections: EPSG:31467; EPSG:3857; EPSG:4326 Processing Projections: EPSG:31467
--	---	--

Choosing a Renewable Potential Calculator

tudor
PUBLIC RESEARCH CENTER RENEWABLE ENERGY

iGUESS
Integrated Geospatial Urban Energy Information and Support System

Signed in as Ulrich (Luxembourg) [Account | Logout] Rotterdam

Modules

Info ■ Users can create Module Configurations from a Module Template by specifying all inputs and outputs that template requires.
■ A list of Module Templates can be found in the Module Catalog.

Configured Modules **Module Catalog**

- Aggregation service with support for slider tool
- Building stock energy consumption and savings
- PV Potential with user based input
- Solar irradiation

This process calculates the sum of yearly irradiation (in kWh/m²) on a roof surface, taking into account cloud cover and other local conditions. This process uses the r.sun GRASS module and is described in detail in the CRTE Internal report "Development of a Solar Energy Cadastre using a GIS-based Solar Radiation Model". Identifier: solar_irradiation

Hosted by: MUSIC PyWPS Server 

Model Inputs

Parameter Name	Identifier	Description
Building footprints	[building_footprints]	A vector polygon data set which represents the building footprints. Except of feature geometries no other additional information is needed. If attribute data is attached it will be ignored during import process.
Cloud cover measured in octa averaged over the last 30 years	[meteo_octa]	A vector point data set which represents the daily cloud cover measured in octa.
Column name used for classification of features used in training area dataset	[training_roof_classification_column]	Field of type INTEGER which specifies the classification attribute of the four existing training classes (e.g. 1,2,3,4)
Digital Surface Model	[dsm]	A raster data set representing a Digital Surface Model of the city. The resolution should be as small as possible (~1m) to have roof objects detected. The data set should not have wholes (NULL values). They should be filled by preprocessing. Units should be

Linking in a Calculator across the Web

tudor  **iGUESS** 
INSTITUTE FOR ENERGY AND THE ENVIRONMENT

Integrated Geospatial Urban Energy Information and Support System

Signed in as Ulrich (Luxembourg) [Account | Logout] Rotterdam

Home Data Manager Modules Scenarios Maps About

Register WPS Server

 Sample: <http://wps.iguess.tudor.lu/cgi-bin/pywps.cgi>

Server: MUSIC PyWPS Server
This is the WPS Server of the MUSIC project. It is powered by PyWPS, see <http://pywps.wald.intevation.org> and <http://www.opengeospatial.org/standards/wps>
Owner: CRP Henri Tudor

Solar irradiation
 PV Potential with user based input
 Aggregation service with support for slider tool
 Urban Heat Island characterisation
 Green roofs
 Geothermal cadastre
 Building stock energy consumption and savings
 Building stock energy savings



Registering the new Remote Calculator

Owner: CRP Henri Tudor

- Solar irradiation
- PV Potential with user based input
- Aggregation service with support for slider tool
- Urban Heat Island characterisation
- Green roofs

This module classifies roof patches that are suitable for different types of green roof installations.

Identifier: `green_roofs`

Model Inputs

Parameter Name	Identifier	Description
Roof patches with suitable area for green roof installations	<code>[roof_patches]</code>	A vector data set which delineates the suitable roof patches for a green roof installation. This input is an output of the solar irradiation module of iGUESS.
Maximum roof slope where green can be built	<code>[max_roof_slope]</code>	Maximum slope angle of the roof where a green roof can be installed. The default is set to 10 degrees which is usually a threshold where green roofs are not too expensive to be built. Above 10 degrees measures to prevent growing medium movement and erosion must be taken.

Model Outputs

Parameter Name	Identifier	Description
Classification of possible green roof installations	<code>[green_roofs_locations]</code>	Possible locations of green roof installations. All patches with higher than the given <code>max_slope</code> are skipped (usually 10 degrees). According to different sources cultivation is then very expensive because of soil erosion and water issues. If a flat roof top is found a kind of horticulture should be placed where people could grow food. Intensive or extensive green roofs are classified if the third quartile of slope of the roof patch is not higher than <code>max_slope</code> .



UNREGISTERED

- Geothermal cadastre
- Building stock energy consumption and savings
- Building stock energy savings
[guess.tudor.lu/wps_servers/new#](http://tudor.lu/wps_servers/new#)

Configuring a Renewable Calculator – Irradiation

Name solar_UL [Click to edit]

Based on Solar Irradiation

Details This process calculates the sum of yearly irradiation (in kWh/m²) on a roof surface, taking into account cloud cover and other local conditions. This process uses the r.sun GRASS module and is described in detail in the CRTE internal report "Development of a Solar Energy Cadastre using a GIS-based Solar Radiation Model".

Note - [Click to edit]

Area of Interest Tiny test region clipping

Inputs	Parameter Name	Parameter Tag	Selected Dataset or Value
Column name used for classification of features used in training area dataset Field of type INTEGER which specifies the classifi... More >	[training_roof_classification_column]	type	
Building footprints A vector polygon data set which represents the bul... More >	[building_footprints]	Building footprints subset	
Cloud cover measured in octa averaged over the last 30 years A vector point data set which represents the daily... More >	[meteo_octa]	Cloud cover for Lijnbaan	
Digital Surface Model A raster data set representing a Digital Surface M... More >	[dsm]	DSM subset	
Linke turbidity A vector point data set which represents the month... More >	[meteo_linke]	Linke factor for Lijnbaan	
Ratio of diffuse to global irradiation A vector point data set which represents the month... More >	[meteo_ratio]	Ratio diffuse/global irradiation for Lijnbaan	
Training areas for roof top classification A vector data set that contains four classes of ro... More >	[training_roof_classification]	Training Features subset	
Outputs	Parameter Name	Output Dataset Identifier	
Solar irradiation A raster data set which contains the solar irradia... More >	00_solar_irradiation_UL_1		
Suitable roof patches A vector data set which delineates the suitable roo... More >	00_roof_patches_UL_1		

[View Configuration List](#) [Run Module Again >>](#) [Delete This Configuration](#)

Configuring a Renewable Calculator – PV potential

 This module has been successfully run. You can now view the outputs in the Data Manager.

Name 02_lijn_pv_potential [Click to edit]
Based on PV Potential with user based input
Details This process calculates the electrical potential on roof tops based on different inputs of economical parameters of PV panel technologies. Inputs are spatial data sets from solar irradiation module and economic parameters given by the user.
Note - [Click to edit]

MODULE STATUS: Run Completed

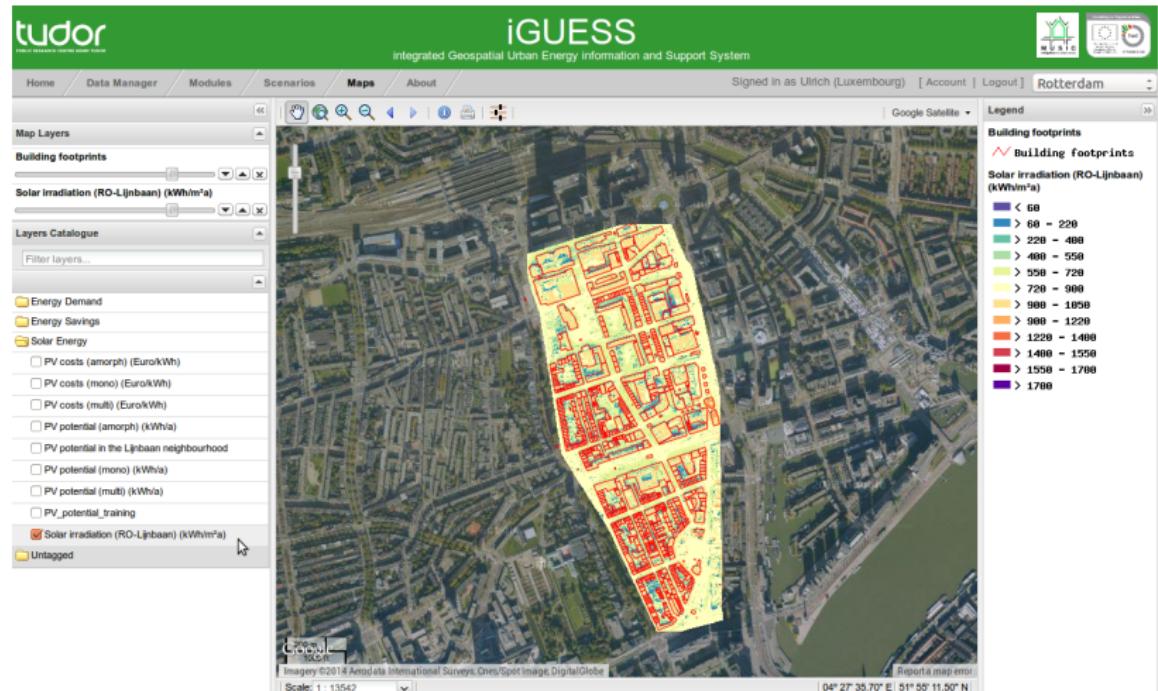
Area of Interest Do not use an Area of Interest

Inputs	Parameter Name	Parameter Tag	Selected Dataset or Value
	Economic panel life time in years <i>Envisioned economic panel life time in years [a]. ...</i> More >	[econ_lifetime]	20
	Panel cost in Euro <i>Panel costs in Euro per square meter of installati...</i> More >	[panel_cost]	1500
	Payback price <i>Guaranteed payback price over the economic panel l...</i> More >	[payback_price]	0.249
	Panel efficiency <i>Panel efficiency in percent defined by the user. U...</i> More >	[panel_efficiency]	14
	Building footprints <i>A vector polygon data set which represents the bu...</i> More >	[building_footprints]	Building footprints
	Roof patches with suitable area for PV installations <i>A vector data set which delineates the suitable roo...</i> More >	[roof_patches]	01_lijn_roof_patches
	Solar Irradiation <i>A raster data set representing solar irradiation o...</i> More >	[solar_irradiation]	01_lijn_solarirra

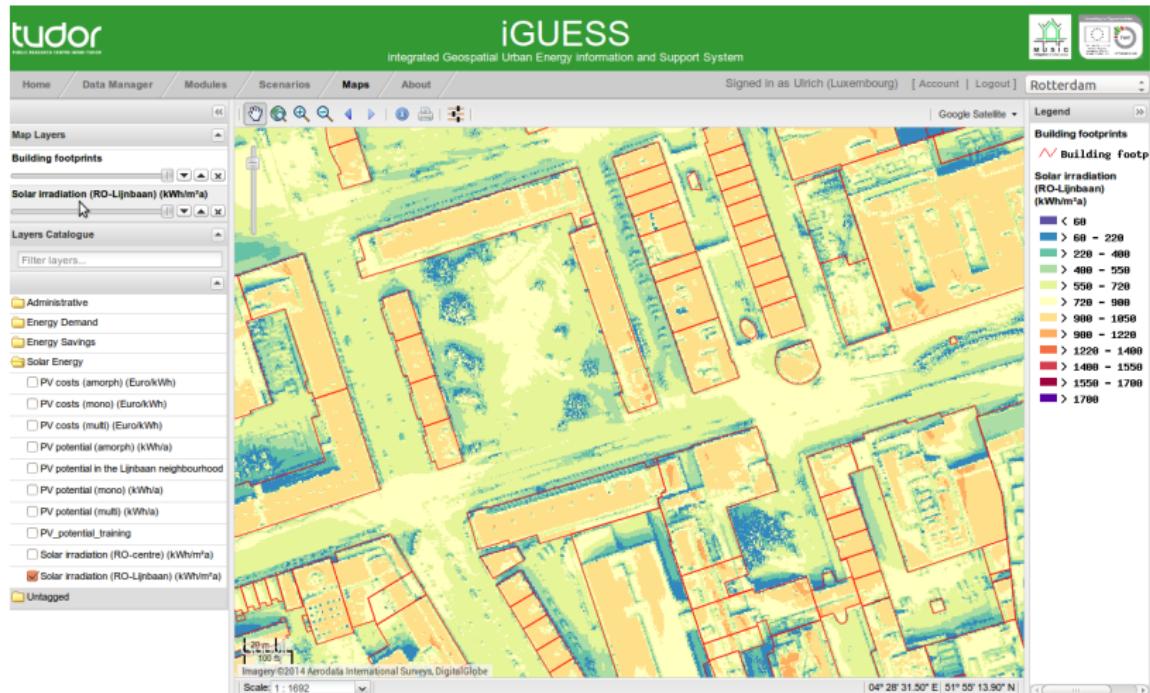
Outputs	Parameter Name	Output Dataset Identifier
	PV potential <i>PV potential generated for roof patches given as i...</i> More >	02_lijn_pv_potential

[View Configuration List](#) [Run Module Again >>>](#) [Delete This Configuration](#)

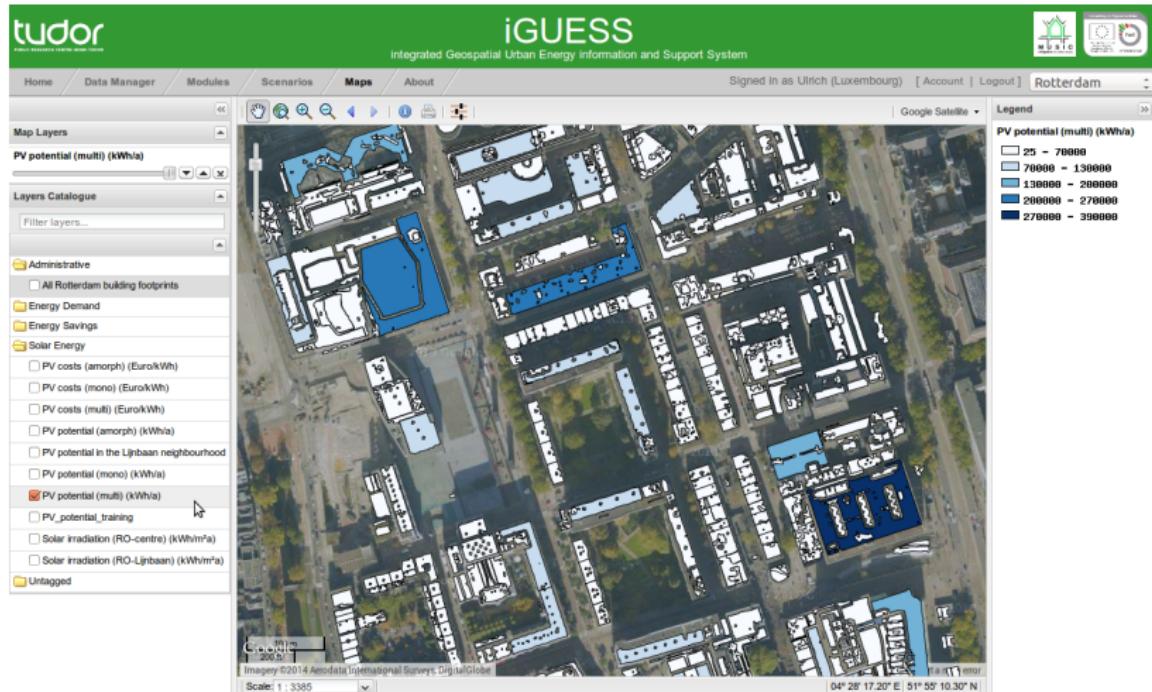
Exploring Solar Energy Potential within the City



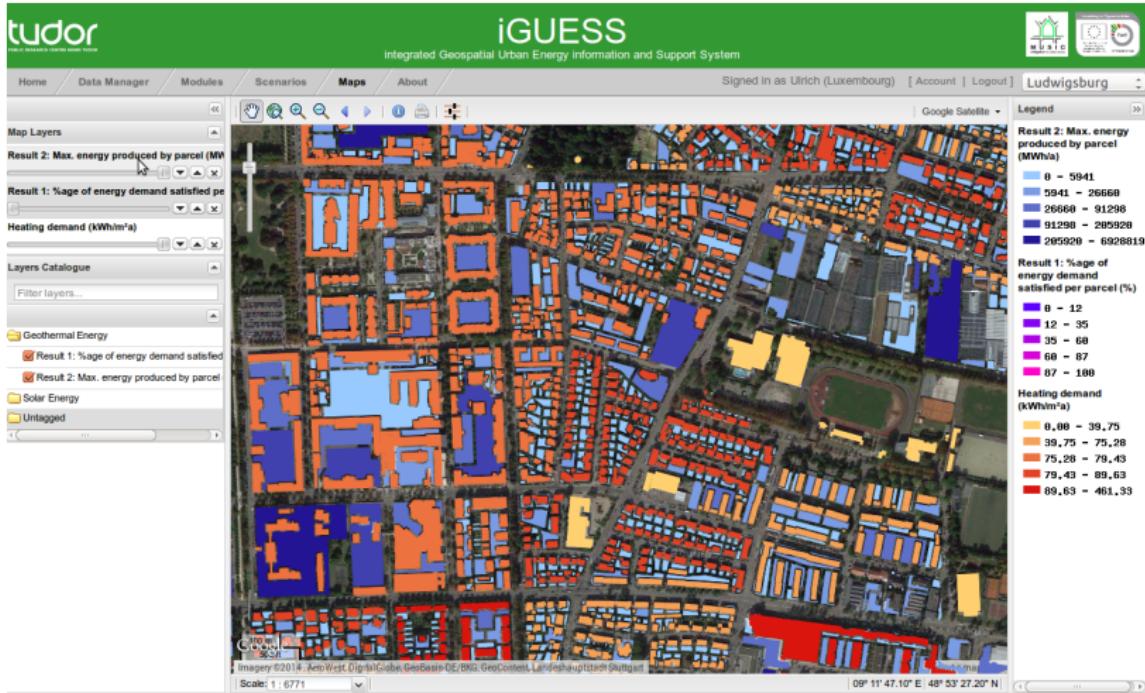
Zooming in to Solar Potential at building level



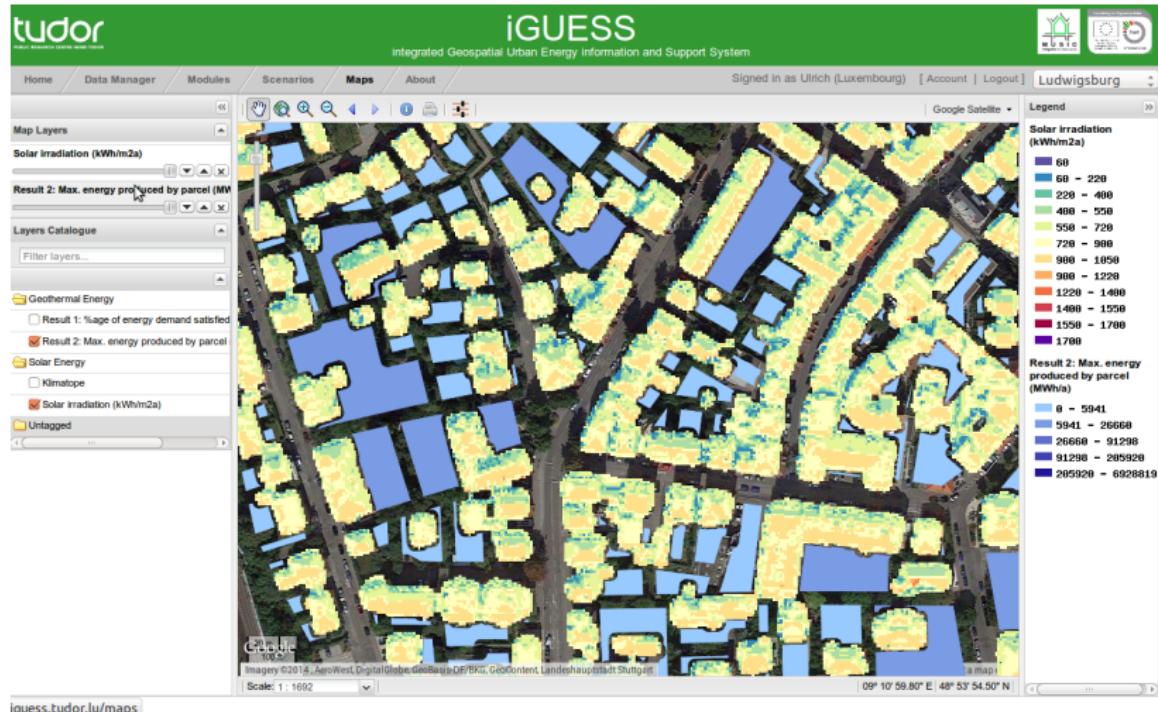
PV Electricity Production Potential



Looking at Geothermal Potential within the City



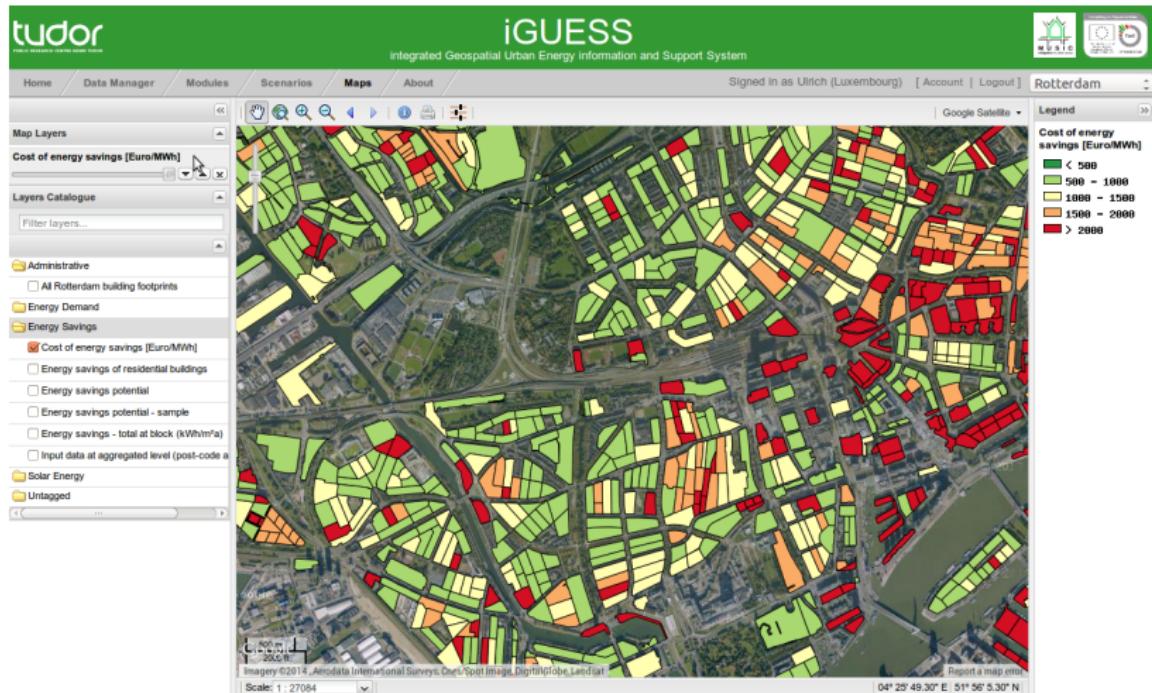
Combining Solar and Geothermal potentials



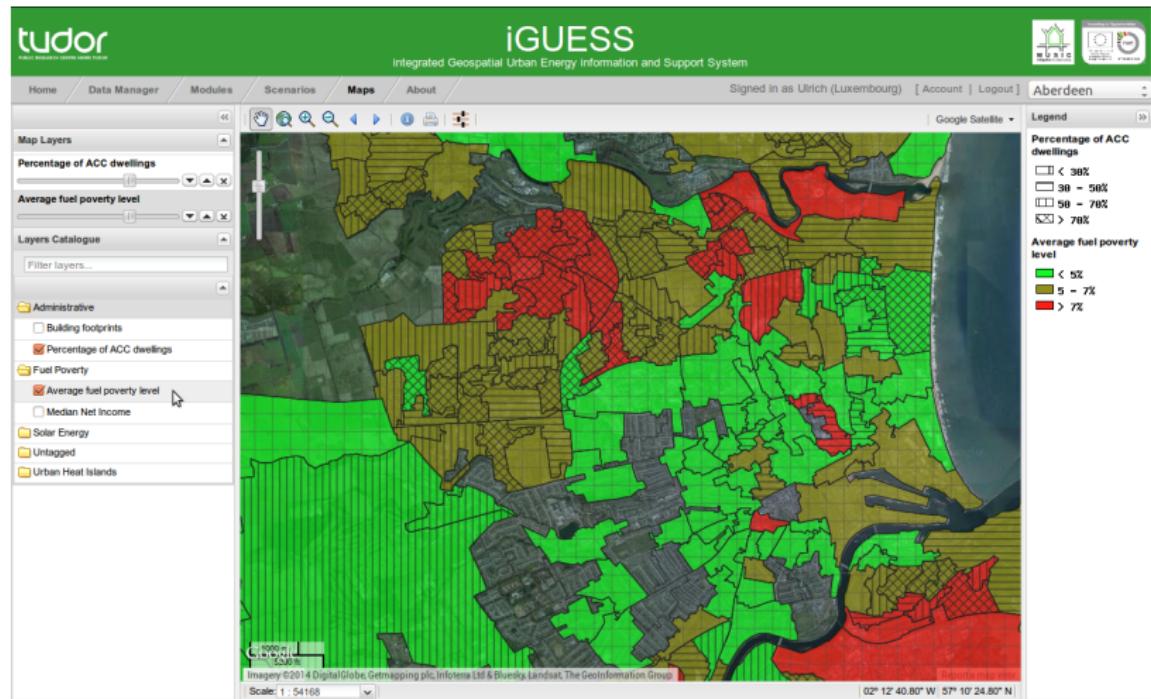
Exploring Energy Saving Potentials across the City



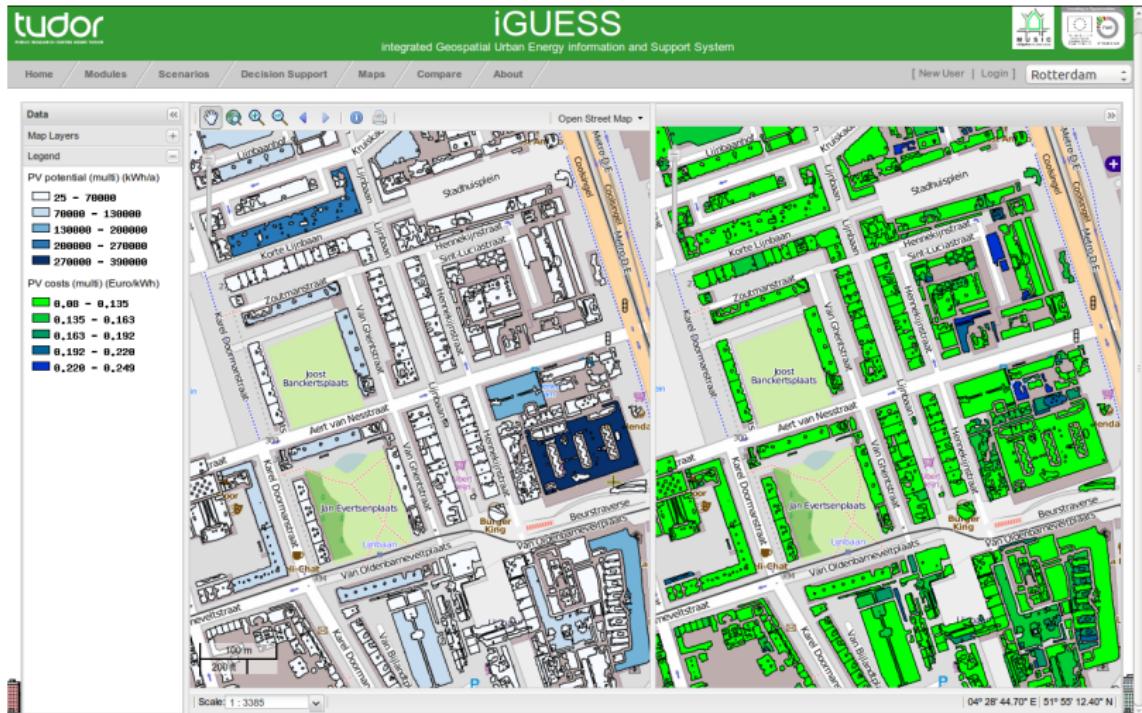
Looking at investment costs across the City



Explore Energy Poverty across the City



Comparing potentials to associated costs



Planning neighbourhoods

tudor PUBLIC RESEARCH CENTER ROTTERDAM

iGUESS
Integrated Geospatial Urban Energy Information and Support System

Signed in as Ulrich (Luxembourg) | Account | Logout | Rotterdam | Google Satellite

Home Data Manager Modules Scenarios Maps About

Map Layers

Energy savings potential

Layers Catalogue Filter layers...

Energy Demand

Cost of energy savings [Euro/MWh]

Energy savings of residential buildings

Energy savings potential

Energy savings potential - sample

Energy savings - total at block (kWh/m²)

Input data at aggregated level (post-code area)

Solar Energy

Untagged

Potential Application

Move the sliders to see in the map where the installation is most efficient. The buildings with lower electricity costs for a 20 years lifetime are ranked first. This is still a prototype.

Cost: 1.335 €/kWh

Investment: 9022 k€

Energy Generation/Savings: 10331 MWh/a

Area: 111568 m²

Close

Report a map error

Imagery ©2014, Aerodata International Surveys, Cnes/Spot Image, DigitalGlobe

Scale: 1: 6771

04° 26' 4.60" E, 51° 54' 31.60" N

The screenshot shows a geospatial map of a residential area in Rotterdam, overlaid with green and yellow dashed polygons representing solar panel installation potential. A modal window in the center provides detailed information about the selected area:

- Cost:** 1.335 €/kWh
- Investment:** 9022 k€
- Energy Generation/Savings:** 10331 MWh/a
- Area:** 111568 m²

The map includes various interface elements such as a legend, zoom controls, and coordinate markers.

Develop CO₂ Scenarios

Home Data Manager Modules **Scenarios** Maps About

Signed In as Ulrich (Luxembourg) | Account | Logout | Ludwigsburg

Energie Klimaschutz in der Schule

Scenario Name Energie Klimaschutz in der Schule

Base Year 2007

Time step (years) 5

Author Rui Martins Save scenario

Last edited by Ulrich Leopold Add period

Last edit 08-11-2014 Remove period

Sector	Demand Growth (%/yr)	Efficiency Gain (%/yr)	Total Demand (GWh)
Industry	0.2	0.4	280.0
Residential	0.2	1.0	1011.0
Tertiary	0.1	0.8	324.0
Road Transport	0.3	0.7	630.0
Agriculture	0.0	0.0	0.0
Rail Transport	0.0	0.0	0.0
Ship Transport	0.0	0.0	0.0

Energy Production (%)

Electricity	District Heating														
Period	Coal	Gas	CHP	Crude Oil	BioGas	Waste	Imports	Other Fossil	Geothermal	Hydraulic	Solar	Wind	Wood	Other renewables	Total
2007	0.0	6.05	0.0	0.0	0.0	0.0	86.93	0.0	0.0	5.22	0.14	1.66	0.0	0.0	100.00
2012	0.0	4.2	0.0	0.0	0.0	0.0	86.11	0.0	0.0	6.08	0.38	3.16	0.0	0.0	99.93
2017	0.0	2.15	0.0	0.0	0.0	0.0	85.27	0.0	0.0	7.03	0.68	4.85	0.0	0.0	99.98
2022	0.0	2.0	0.0	0.0	0.0	0.0	84.0	0.0	0.0	7.0	2.0	5.0	0.0	0.0	100.00
2027	0.0	2.0	0.0	0.0	0.0	0.0	81.0	0.0	0.0	7.0	5.0	5.0	0.0	0.0	100.00
2032	0.0	2.0	0.0	0.0	0.0	0.0	56.0	0.0	0.0	7.0	30.0	5.0	0.0	0.0	100.00

Develop CO₂ Scenarios

Energy Production (%)

Electricity		District Heating													
Period	Coal	Gas	CHP	Crude Oil	Biogas	Waste	Imports	Other Fossil	Geothermal	Hydroelectric	Solar	Wind	Wood	Other renewables	Total
2007	0.0	6.05	0.0	0.0	0.0	0.0	86.93	0.0	0.0	5.22	0.14	1.66	0.0	0.0	100.00
2012	0.0	4.2	0.0	0.0	0.0	0.0	86.11	0.0	0.0	6.08	0.38	3.16	0.0	0.0	99.93
2017	0.0	2.15	0.0	0.0	0.0	0.0	85.27	0.0	0.0	7.03	0.68	4.85	0.0	0.0	99.98
2022	0.0	2.0	0.0	0.0	0.0	0.0	84.0	0.0	0.0	7.0	2.0	5.0	0.0	0.0	100.00
2027	0.0	2.0	0.0	0.0	0.0	0.0	81.0	0.0	0.0	7.0	5.0	5.0	0.0	0.0	100.00
2032	0.0	2.0	0.0	0.0	0.0	0.0	56.0	0.0	0.0	7.0	30.0	5.0	0.0	0.0	100.00

Energy Consumption per Sector (%)

Toggle units to MWh

Industry		Residential		Tertiary		Road Transport		Agriculture		Rail Transport		Ship Transport		Total	
Period	Coal	Gas	CHP	Crude Oil	Diesel	Gasoline	LPG	Biogas	District Heating	Electricity	Other Fossil	Geothermal	Wood	Other renewables	Total
2007	0.0	18.0	0.0	41.2	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	99.20
2012	0.0	18.5	0.0	41.1	0.0	0.0	0.0	0.0	0.0	40.3	0.0	0.0	0.0	0.0	99.90
2017	0.0	18.5	0.0	41.2	0.0	0.0	0.0	0.0	0.0	40.3	0.0	0.0	0.0	0.0	100.00
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

+ Emission Factors



CO₂ Emissions by Sector



Develop CO₂ Scenarios

Energy Production (%)

Electricity		District Heating														
Period	Coal	Gas	CHP	Crude Oil	Biogas	Waste	Imports	Other Fossil	Geothermal	Hydraulic	Solar	Wind	Wood	Other renewables	Total	
2007	0.0	6.05	0.0	0.0	0.0	0.0	86.93	0.0	0.0	5.22	0.14	1.66	0.0	0.0	100.00	
2012	0.0	4.2	0.0	0.0	0.0	0.0	86.11	0.0	0.0	6.08	0.38	3.16	0.0	0.0	99.93	
2017	0.0	2.15	0.0	0.0	0.0	0.0	85.27	0.0	0.0	7.03	0.68	4.85	0.0	0.0	99.98	
2022	0.0	2.0	0.0	0.0	0.0	0.0	84.0	0.0	0.0	7.0	2.0	5.0	0.0	0.0	100.00	
2027	0.0	2.0	0.0	0.0	0.0	0.0	81.0	0.0	0.0	7.0	5.0	5.0	0.0	0.0	100.00	
2032	0.0	2.0	0.0	0.0	0.0	0.0	56.0	0.0	0.0	7.0	30.0	5.0	0.0	0.0	100.00	

Energy Consumption per Sector (%)

[Toggle units to MWh](#)

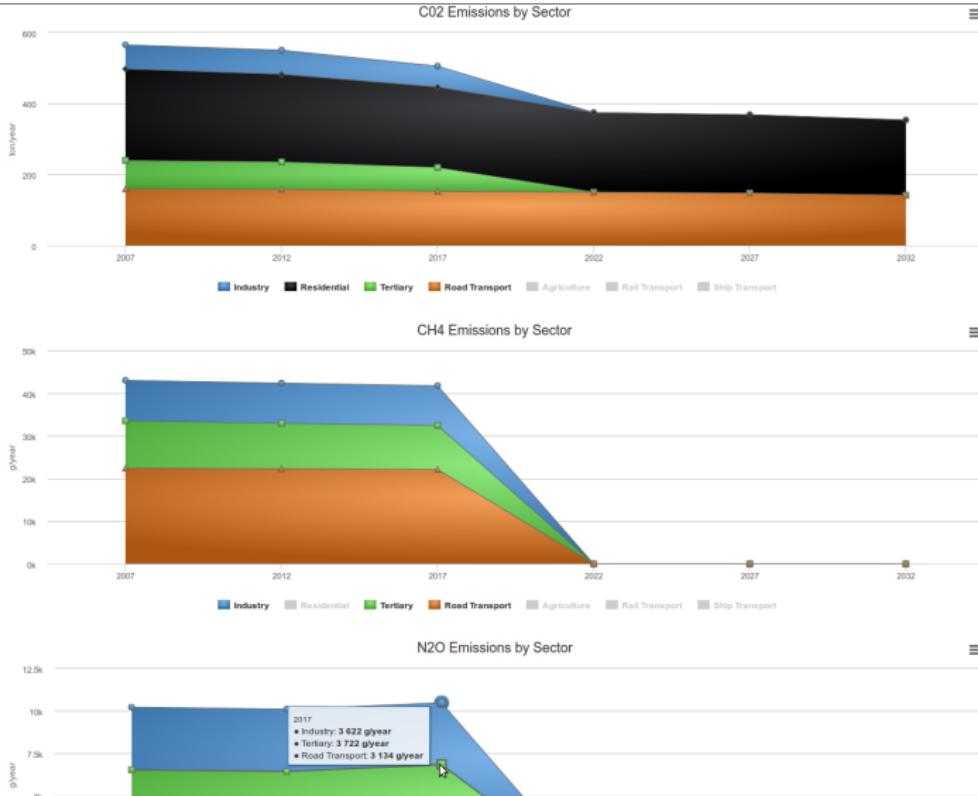
Industry		Residential		Tertiary		Road Transport		Agriculture		Rail Transport		Ship Transport			
Period	Coal	Gas	CHP	Crude Oil	Diesel	Gasoline	LPG	Biogas	District Heating	Electricity	Other Fossil	Geothermal	Wood	Other renewables	Total
2007	0.0	18.0	0.0	41.2	0.0	0.0	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	79.20
2012	0.0	18.5	0.0	41.1	0.0	0.0	0.0	0.0	0.0	40.3	0.0	0.0	0.0	0.0	79.90
2017	0.0	18.5	0.0	41.2	0.0	0.0	0.0	0.0	0.0	40.3	0.0	0.0	0.0	0.0	100.00
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00

- Emission Factors

CO ₂ (t/MWh)		CH ₄ (g/MWh)		N ₂ O (g/MWh)														
Period	Coal	Gas	CHP	Crude Oil	Diesel	Gasoline	LPG	Biogas	Excess Heat	Waste	Imports	Other Fossil	Geothermal	Hydraulic	Solar	Wind	Wood	Other renewables
2007	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2017	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2022	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2027	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2032	0.3406	0.266	0.0	0.263	0.266	0.249	0.227	0.196	0.0	0.33	0.16	0.0	0.0	0.0	0.0	0.0	0.0	0.0

test.iguess.tudor.ly/co₂_scenarios/113/edit#tabs-fact-5

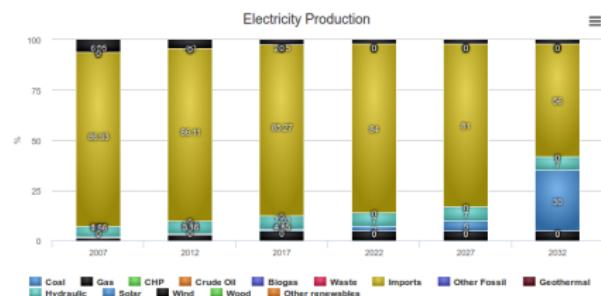
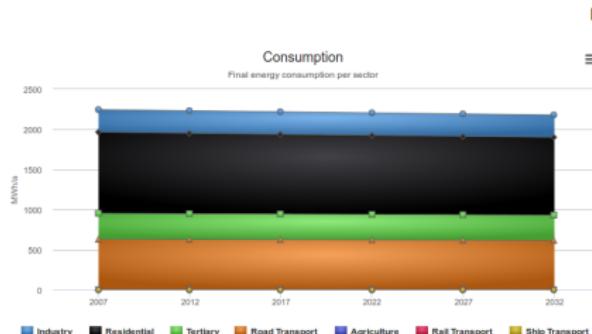
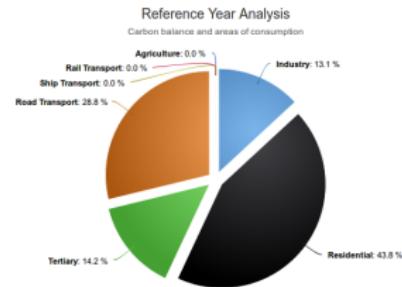
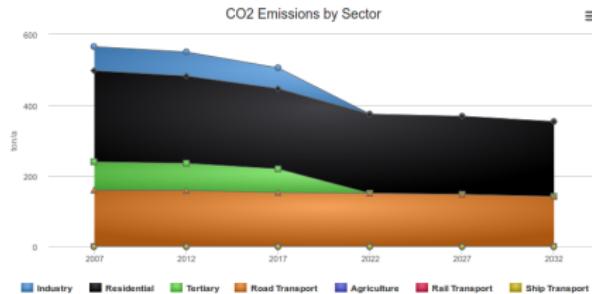
Develop CO₂ Scenarios



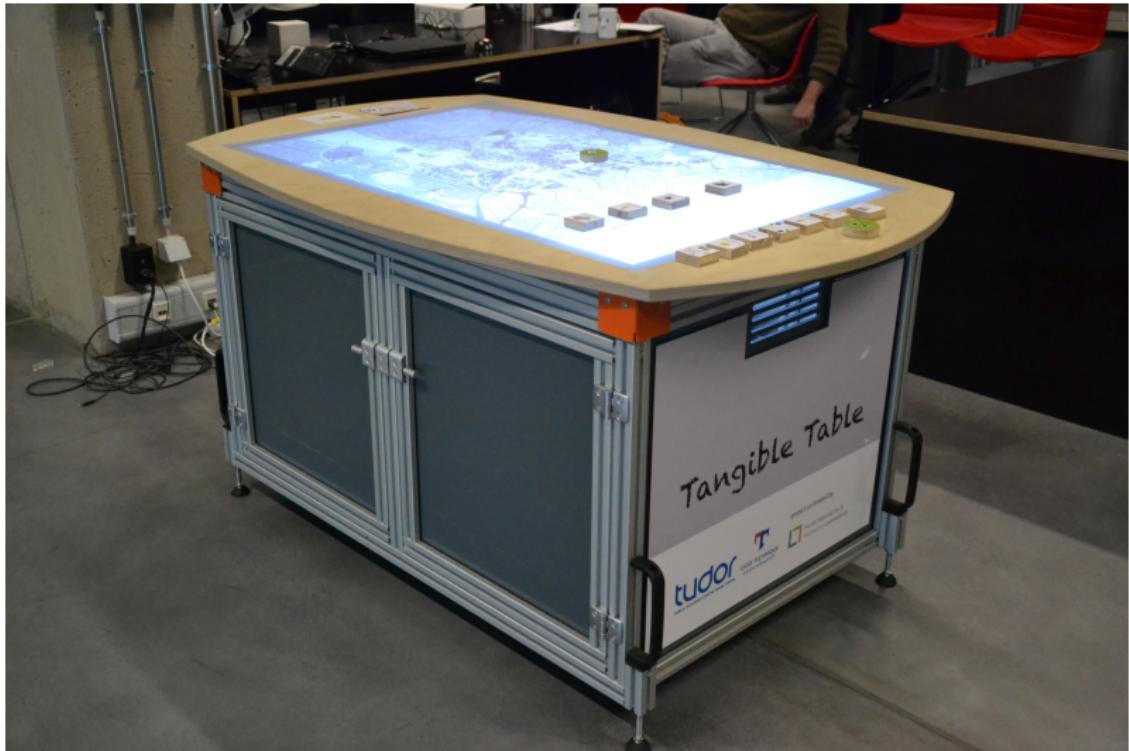
Assess Scenarios

Energie Klimaschutz in der Schule

2007 - 2037



iGUESS for Tangible Tables



iGUESS for Tangible Tables – Maps and Objects



iGUESS for Tangible Tables – Objects



iGUESS for Tangible Tables – Zoom to map



iGUESS impacts

- ▶ iGUESS can help finding answers to complex questions;
- ▶ iGUESS helps cities to develop innovative strategies, e.g. open data access, mobile app developments, Solar PV for social housing, strategic CO₂ emission reduction scenarios, link fuel poverty with renewables and energy savings;
- ▶ iGUESS provides a flexible framework for integration of other topics, e.g. water management, air quality, transportation;
- ▶ iGUESS is looking for new cities and new opportunities.

Thank you for your attention!



search ID: rion1304

© Original Artist
Reproduction rights obtainable from
www.CartoonStock.com

CONTACT US AT:

Ulrich.Leopold@Tudor.lu

www.theMUSICProject.eu