**RESYS-Tool** – A calculator for the energy turnaround for municipalities as well as for large cities and regions

RESYS is a web-based tool for the regional development of a regional energy strategy. Focus is on renewable energies. Resys helps to estimate quickly:

- a city’s energy demand and the according development in time (temporal resolution of one hour). This is provided for the following demand sectors: residential sector, industry, infrastructure and mobility.
- the potential for the energy supply from renewables (achievable yields, time curve, investment cost).
- in how far supply matches demand taking account of any available buffering (energy storage).
- a good energy strategy for the examined region relying on a smart benchmarking system.

Resys, in particular, provides answers to the following questions (relying on scenario analysis where appropriate):

- How does the energy demand develop over time in my city/region in different sectors (residential sector, industry, infrastructure, mobility)? Refuting the common argument "Renewables are fine but the energy is not available at times when needed."
- Detailed analysis of the demand sector (lighting, process heat for steam etc.)
- Which is the region’s potential in renewables in terms of "technically available potential"?
- Which part of this technical potential may be realistically tapped? What are the related investment costs?
- Which renewables are to be preferably used? (interactions between the sectors are taken into account)
- Which are the consequences of trends and actions in energy efficiency and city development regarding the various demand sectors?
- In how far do curves resulting from the energy demand simulation match the supply curve? Can the system cope with demand peaks, for instance during the morning and evening hours?
- When would excess energy be available? What is the effect of buffers on the rate of energy use from local renewable sources and on required grid extension?
- Scenario analysis of future projects, estimation of the related major effects.
- Which are weak and which are strong points of the energy supply?

Examples for the application of the tool: Development of regional energy concepts, Regional projects, Research.
The RESYS tool - its usage, the basic approach

**Basic approach:**
Resys relies on benchmark figures linked to city categories and on databases on energy potentials and on climate.

1. Energy demand simulation
2. Estimate renewable energy potentials
3. Match demand and supply work out future developments and targets
4. Substantiate targets: Across energy sources and with time steps down to one hour
5. Monitoring, Controlling

Thereby the need for primary data in your project is minimised!

**Results:** A simulation of demand and supply curves including the auxiliary electricity demand ...

... shown in various tables and charts.

10 hours for your first useful results:
- Category Assessment: 3h
- Current state: 2h
- Target planning: 5h

**Energy concepts more favourable** – less time for data collection – more time for focusing on conceptual work.
RESYS-Tool: A survey on the most relevant steps and functions

The tool consists of the following 6 steps:

1 **Assessment of the category of your city**
Based on few figures the category of your city is assessed. Assigning the city a category allows for a quick and sound assessment of the city's figures of demand and supply in the following steps:

2 **Current energy demand**
Based on the category of your city and according benchmark data a few further inputs lead to a first estimate of the total energy demand of the residential sector, of industry and of the mobility sector. The according parameters may be readjusted once more fine-grained data is available. Partly this assessment relies on internal calculations on heat and cooling demand which are based on regional climate data.

3 **Current energy supply**
The current supply situation based on renewables is assessed and, in particular, the theoretical potential of renewables from local resources.

4 **Analysis of the current state**
Outline of the energy demand by sectors and type of useful energy. A graphical representation of supply and demand curves over time is available with timesteps down to one hour. This step in the entire cycle provides first ideas for the following step of action planning.

5 **Action planning**
The user specifies targets for the local supply from renewable energy and for reducing the energy demand by taking action on efficiency efficiency, however, taking into account trends (baseline).

6 **Output of results**
Demand and supply are compared by annual figures as well as by according time curves spanning a year or a single day. Benchmark data, degrees by which potentials are exploited, eventual limitations in energy imports and exports as well as cost data are used to evaluate the scenarios and to plan further optimisations.
RESYS-Tool – Selected insights

Step 1: Assessment of the city category

The model in the background:

<table>
<thead>
<tr>
<th>City</th>
<th>Agrarian city, livestock</th>
</tr>
</thead>
<tbody>
<tr>
<td>City with industry</td>
<td>Small city with infrastructure</td>
</tr>
<tr>
<td>Tourism destination</td>
<td>City with a high percentage of commuters</td>
</tr>
<tr>
<td>Agrarian city, agriculture</td>
<td></td>
</tr>
</tbody>
</table>

Basic structural data (e.g. inhabitants, and employees, areas, working population) on the city leads to assigning the city one of the predefined categories by an internal algorithm. The categories and the algorithm use benchmark data on specific energy demand and energy demand time curves which are based on the energy balance data of 168 Austrian and 20 European large cities.

Hier fehlen noch Symbole Großstadt und Metropole!

How all this translates for the user of the tool:

First, only basic structural data on the city so the city may be classified according to one of the preset type categories or be attributed to a combination of such categories.
Step 2: Current energy demand

Once the user has access to more accurate data at a later stage they may be added thereby increasing the accuracy of the results ("auto refining systems")

The only necessary input in order to identify the energy demand for housing

Default values based on the city category

Precise value - if needed, click on the exclamation mark to reload the default value
Exemplary results for the current energy demand

Relevant energy demand categories are heat demand, electricity demand, and mobility. Furthermore, there is an analysis by categories and by end-user sectors such as the transport of persons and goods or households, by industry sectors and by energy carriers:
Step 3: Current energy production

The current use of renewable energy is assessed by energy carrier and by type of energy conversion unit:

- Solar energy (photovoltaics and solar thermal energy)
- Geothermal energy (converted to heat and electricity)
- Biomass
  - *Plants with a CHP*: biogas CHP (centralised and decentralised), biogas plant feeding into the gas network and producing fuel, large and small CHPs, BTL (biomass to liquid) plants, biofuel CHPs, methane/bio methane CHPs
  - *Plants without a CHP*: biomass boiler, biofuel boiler, natural gas/bio methane boiler
- Heat pumps (heat sources: air, soil or groundwater)
- Wind power
- Hydropower
- District heating networks

Example regarding biomass plants

Parameters of the plant largely come with the software as presets but may be overruled by more specific data by the user.

<table>
<thead>
<tr>
<th>Name</th>
<th>Heizlast.-abdeckung wärmegeführter Anteil</th>
<th>Heizlast.-abdeckung strom/BTL-geführter Anteil</th>
<th>eta.-elektrisch</th>
<th>eta.-thermisch</th>
<th>eta.-Produkt (BTL, Biogas)</th>
<th>Hilfsstrombedarf</th>
<th>Biogas.-Netzeinspeisung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomasse Vorrangkessel</td>
<td>0,86</td>
<td>0</td>
<td>0</td>
<td>0.08</td>
<td>0</td>
<td>0.015</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>elektrische Leistung bzw. Treibstoff-Leistung</th>
<th>Inputleistung</th>
<th>Wärmeleistung</th>
<th>Anteil Sommerbetrieb 0 … 1</th>
<th>Anteil wärmegeführt 0…1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomasse Vorrangkessel</td>
<td>0</td>
<td>2.397.72</td>
<td>2.110</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Based on these parameters the yields that may be achieved, fuel demand and demand in auxiliary electricity are calculated:
Example photovoltaics
In addition to assessing the yields, the use of the entire electricity of the city is compared with the locally available potentials from photovoltaic production as resulting from the simulation;

- Bisherige Nutzung
  - Anteil PV - Dach
    - 125 m²
  - Anteil PV - Wand
    - 5 m²
  - Anteil PV - freistehend
    - 5 m²

- Vorgabewerte - Gemeindetyp abhängig
- Vorgabewerte - Gemeindetyp unabhängig

- Ergebnisse
  - Ertrag - Dach
    - 10.70 MWh
  - Ertrag - Wand
    - 0.54 MWh
  - Ertrag - freistehend
    - 0.75 MWh
  - PV - Flächen gesamt
    - 135 m²

- Diagramme

Potentials in m²

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Step 4: Analysis of the current state

The comparison of the energy demand as resulting from the tool simulation and the current use of energy in the city shows the deficiencies when trying to satisfy the demand with renewables (the more you may cover the local demand by locally produced energy the less you have to import). This, for instance, results in less required investment into the electricity grid capacity:

You may also analyse by demand sector what drives the energy demand in order to visualize promising approaches for actions to reduce demand:
Step 5: Target setting

In step 5 you may model demand side trends as well as potentials for energy saving:

**Raumheizung**

| durchschnittliche Energiekennzahl bisher | 210 | 11 [%] | 136,9 |

Otherwise the usage of renewable energy can be expanded:

**Solar** | **Geothermie** | **Biomasse** | **Restwärme** | **Wind** | **Wasser**

| Strom aus Windkraft – bisherige Nutzung | 0 [MWh] | 72,6416 [%] | 688,2815249266 [MWh] | 3,125 [%] | 16,000 [MWh] |

| Gesamt-Ertrag aus Neuanlagen Windkraft | 500 [MWh] | | | |

| Gesätzte Investsumme | 500,000 [€] |

Diagramme

**Stromerzeugung aus Windenergie**

Summen
Step 6: Output of results

The ultimate goal is to match the time curves of demand and supply as much as possible:

(Comparison on the current heat generation is done in step 4)

Thereby the "classic" argument of "... yeah, but renewables are supplied always at the wrong time" may be counteracted because the chart relies on a realistic estimate of the demand and of the potential for supply!
Example for further evaluations:

Matching the demand:

Cost:

Benchmarking:

"Energy turnaround" (the safe supply by renewables) is not only about a small region but addresses a global strategy "think global – act local" in order to achieve the turnaround at a global scale. Low density regions with a high energy potential have to produce an excess in energy in order to supply the urban agglomerations to ensure an overall safe supply.

In this sense, regional actions and targets as they result from the Resys tool are compared with the requirements of the region at a higher level which comprises the current region. In a first approach this has been realised in Resys for the larger region of Austria:
Background of the model

Simulation of the energy demand: To provide estimates for missing demand figures, based on empirical data, functional relations are established between framing parameters/input data and demand figures of the analysed city and typical key figures are established.

Potentials of using renewables: They are assessed along a path of staggered refinement starting out from the theoretical potential (determined exclusively by principles of natural science and in particular of physics) -> technical potential (assessed by principles relating to currently available technology) -> economic potential and by taking into account the social acceptance (specified via user input) resulting finally in the realistic potential.

Time curves for supply: The chart of a function (comprising yields and further key data such as excess energy or auxiliary electricity demand) is calculated for each technology according to the technical-physical framing condition of each plant (efficiency, operation parameters etc.)

Example for the use of solar energy: The solar irradiation onto a plane of arbitrary orientation and inclination is assessed by resorting to the global irradiation as it reaches a horizontal plane relying on the radiation models by (Klucher, 1979) and (Reindl, 1989). Thereby passive solar gains achieved via glass facades and active solar gains from photovoltaics (Quaschning, 2011) and from solar thermal plants may be assessed. Plants with various orientations and inclinations (pitch), various user profiles and temperatures for the useful heat (solar thermal plants) are simulated and evaluated.

For details please see for example

Outlook for applications

The RESYS-Tool may be used in education, in research projects and in energy counseling at municipal or regional level.

Project website: www.energiewende-rechner.at
Tool: www.resys-tool.at

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