

Workshop: Regional Energy Analysing Model (REAM)

Endre Ottosen, NEPAS

„Upgrading the education level at territorial (local) self-governments in the scope of sustainable energy management and Earth climate protection”



norway
grants 

Supported by a grant from Norway through the Norwegian Financial Mechanism
Project co-financed by Poland

NEPAS

Agenda

Local and regional energy planning

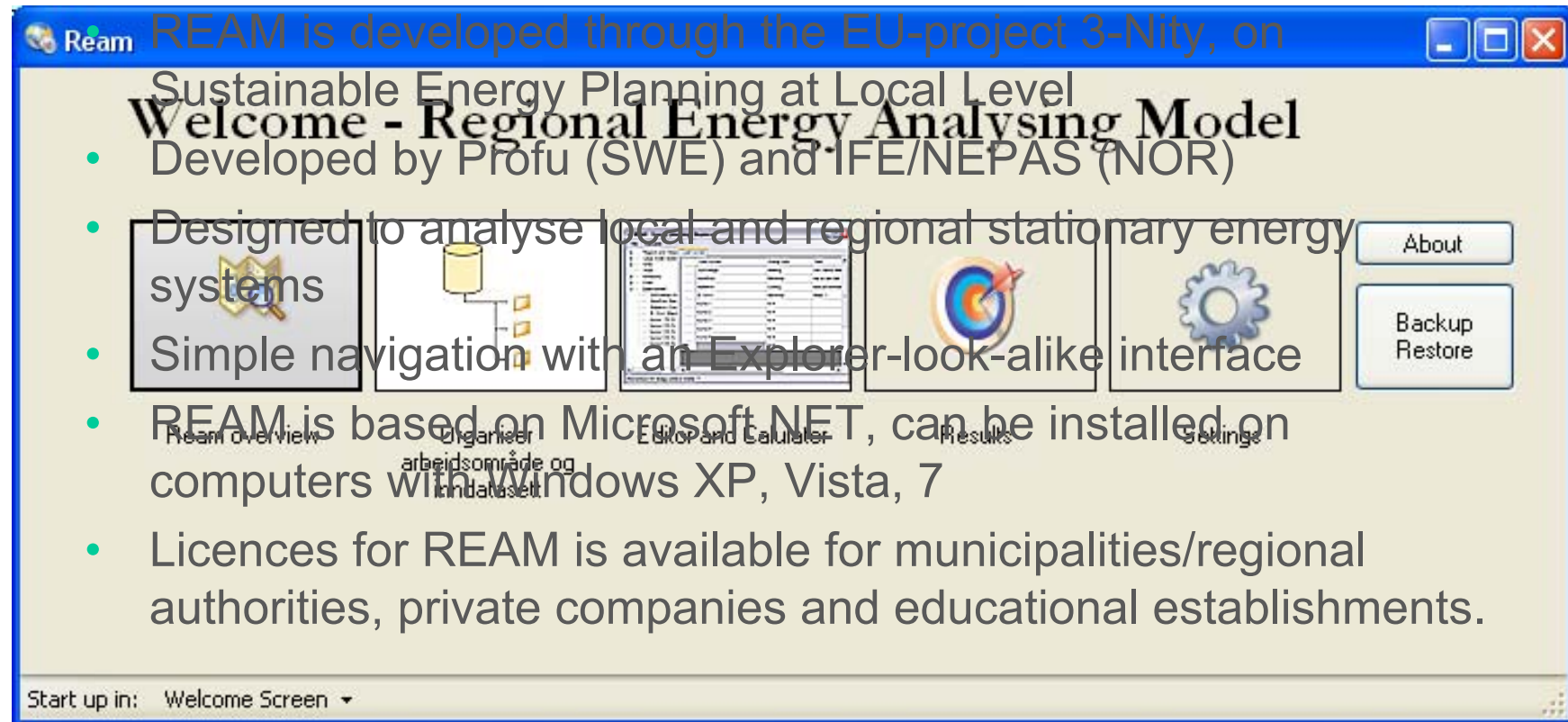
- Methodology and procedure
- Facts and statistics
- Measures and goals

Regional Energy Analysing Model (REAM)

- Model structure
- Calculation algorithm
- Result presentation

REAM

Regional Energy Analysing Model



REAM is developed through the EU-project 3-Nity, on Sustainable Energy Planning at Local Level

Welcome - Regional Energy Analysing Model

- Developed by Profu (SWE) and IFE/NEPAS (NOR)
- Designed to analyse local and regional stationary energy systems
- Simple navigation with an Explorer-look-alike interface
- REAM is based on Microsoft .NET, can be installed on computers with Windows XP, Vista, 7
- Licences for REAM is available for municipalities/regional authorities, private companies and educational establishments.

Start up in: Welcome Screen ▾

Navigation icons: Ream overview, Organiser arbeidsområde og inndatasett, Editor and Calculator, Results, Settings

Buttons: About, Backup Restore

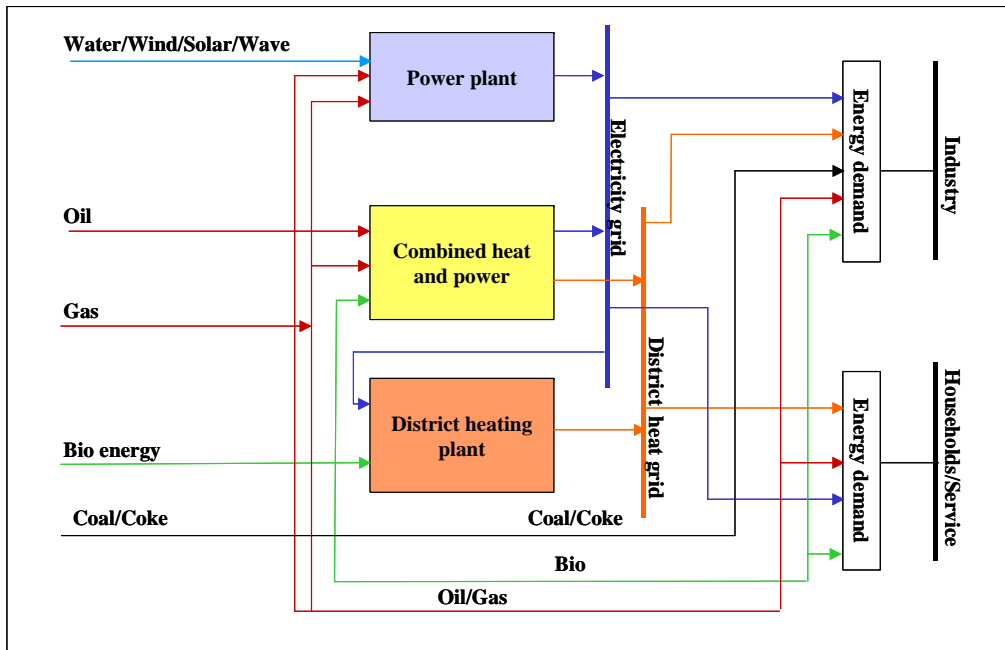
General description

- REAM includes:
 - Local energy production, small and large scale facilities
 - Infrastructure for transmission of electricity, heating and cooling
 - End use of energy
 - Energy efficiency measures
- Analyses the development on a least cost basis
- REAM is easy to handle; the user chooses level of detail
- REAM can analyse the energy system in an entire municipality/region, or selected sectors or geographic areas
- Language flexibility, partly unit flexibility

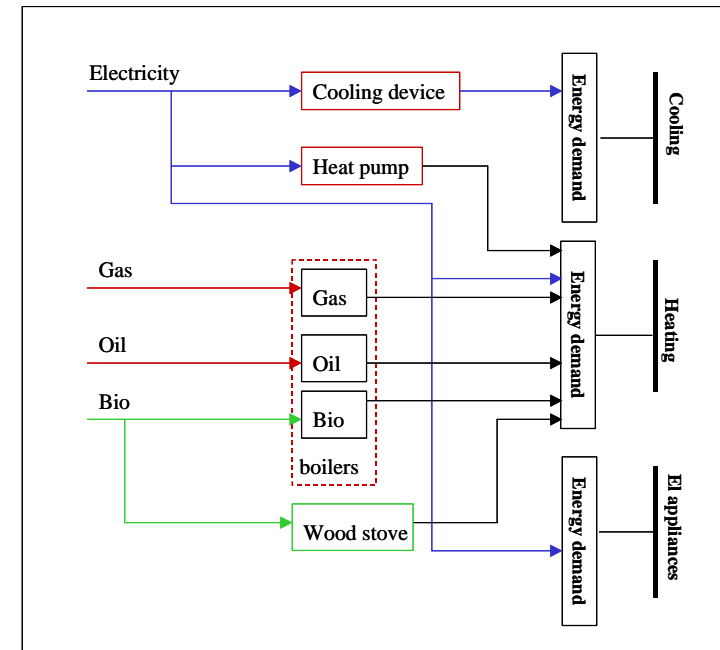
REAM is a tool for local and regional energy planning

Principal RES

Overview level

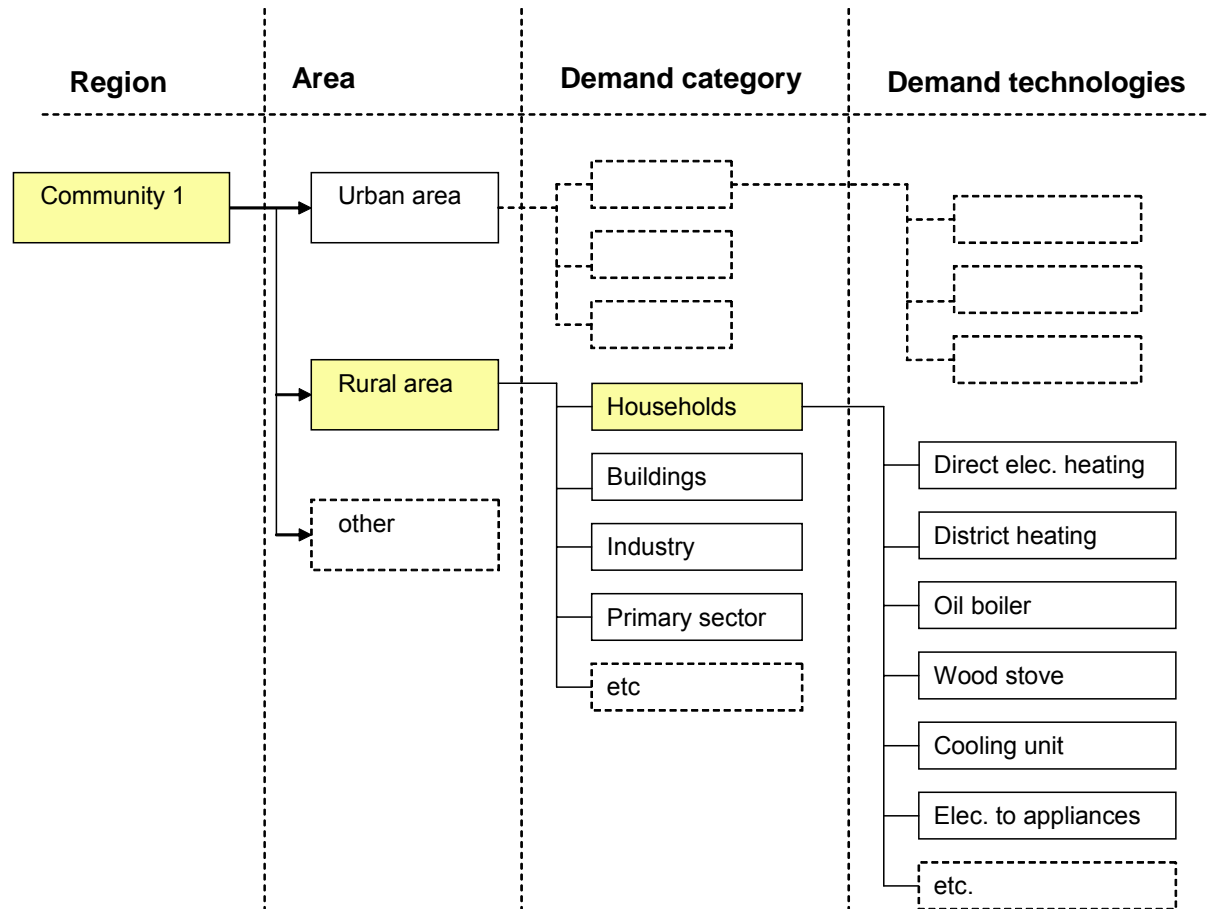


Demand category level



John Johnsson, Profu

Model Structure



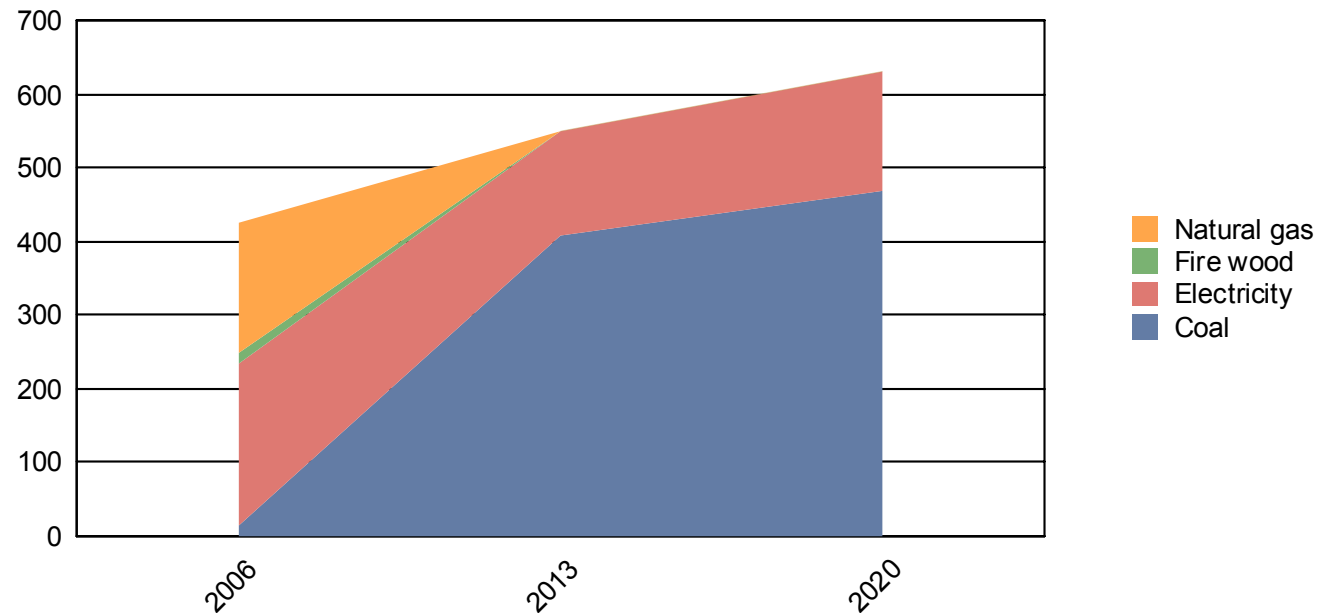
Kari Espegren, IFE

Example: Scenario calculations

- Municipality of Dobrich used as an example
- Three scenarios will be presented
 - Basic scenario
 - Business As Usual Scenario
 - Low Emission Scenario
- Data for energy consumption in Dobrich for 2006 (residential, industry, services, municipal buildings)
- Today's energy prices and cost estimates for Bulgaria
- **Take notice:** A number of general assumptions have been made. The value of this example is not the results of the calculations, only how to show how REAM may be used to simulate different scenarios

Energy supply

For Dobrich - Basic Scenario

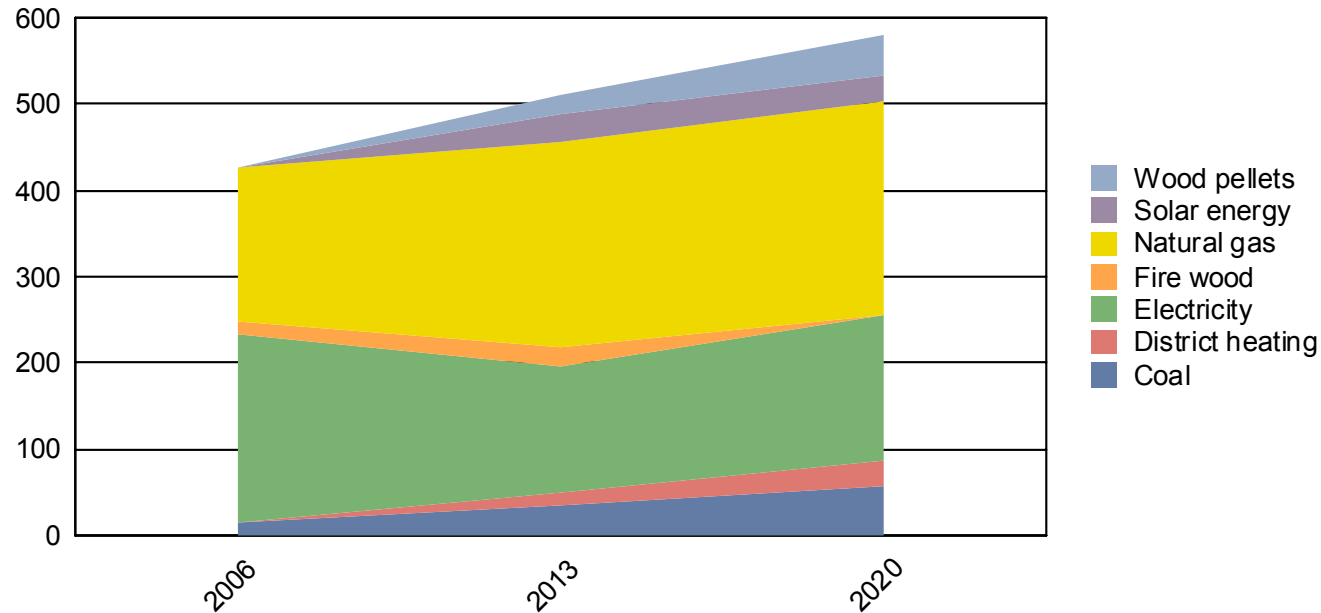


“Basic” Scenario

- The development is solely based on least cost calculation
- No additional assumptions or restrictions introduced (such as resources limitation or other barriers)
- No cost adjustments, general price increase on all fuels

Energy supply

For Dobrich - Business As Usual Scenario

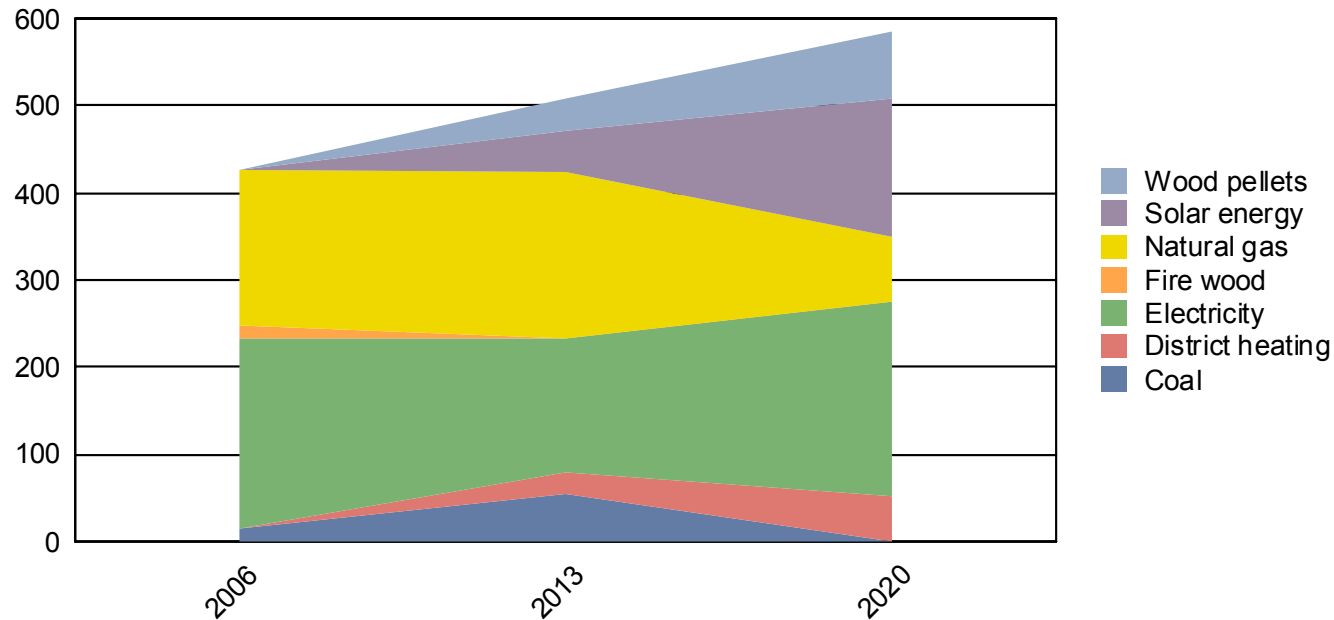


“Business As Usual” Scenario

- Restrictions introduced due to technical barriers, resource limitations and human behaviour (based on assumptions)
- Still no cost adjustments

Energy supply

For Dobrich - Low Emission Scenario



“Low emission” Scenario

- Restrictions introduced due to technical limitations and human behaviour (based on assumptions)
- Increased taxes on fossil fuels
- Reduced investment cost on solar collectors (e.g. due to subsidies)

Calculation algorithm

Small Scale Technologies

- The model is driven by the changes in the demand categories (market changes)
- Replacing phased-out capacity, alternative
- Replacing technologies with variable cost $>$ new total cost
- The substitution is made on the basis of lowest total cost
- Alternatively is the development specified by the user
- The calculation of the total cost in a specific period is based on the assumptions **only** in this period → sequential calculations

Calculation algorithm

$$AC = IC + FC + OMC + \frac{FuC + TC + EC}{\eta}$$

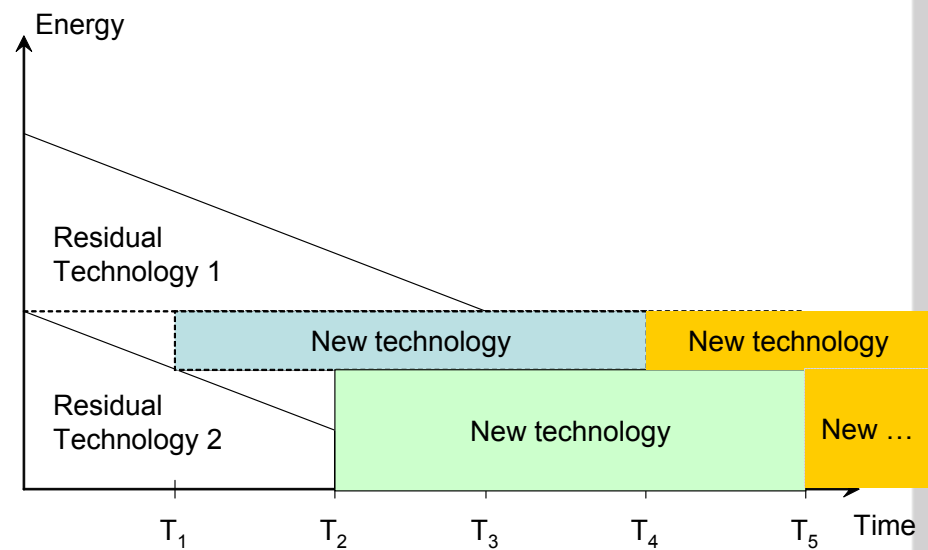
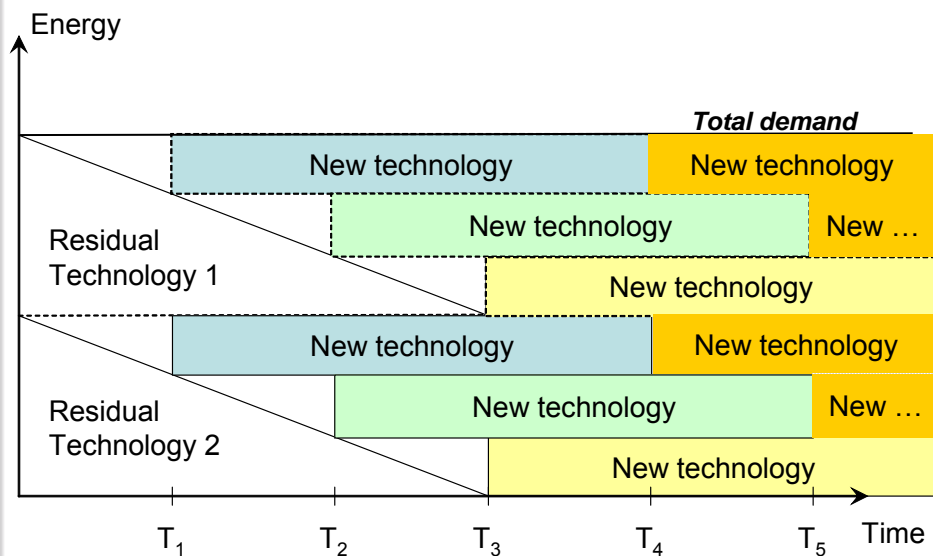
- AC = Average cost
- IC = Investment cost, (fixed annual installment)
- FC = Fixed cost
- OMC = Operation and maintenance costs
- FuC = Fuels cost
- TC = Tax costs
- EC = Emissions costs
- η = The technology efficiency

Calculation algorithm

Small Scale Technologies

Substituting phased-out technology

Existing variable cost > new total cost



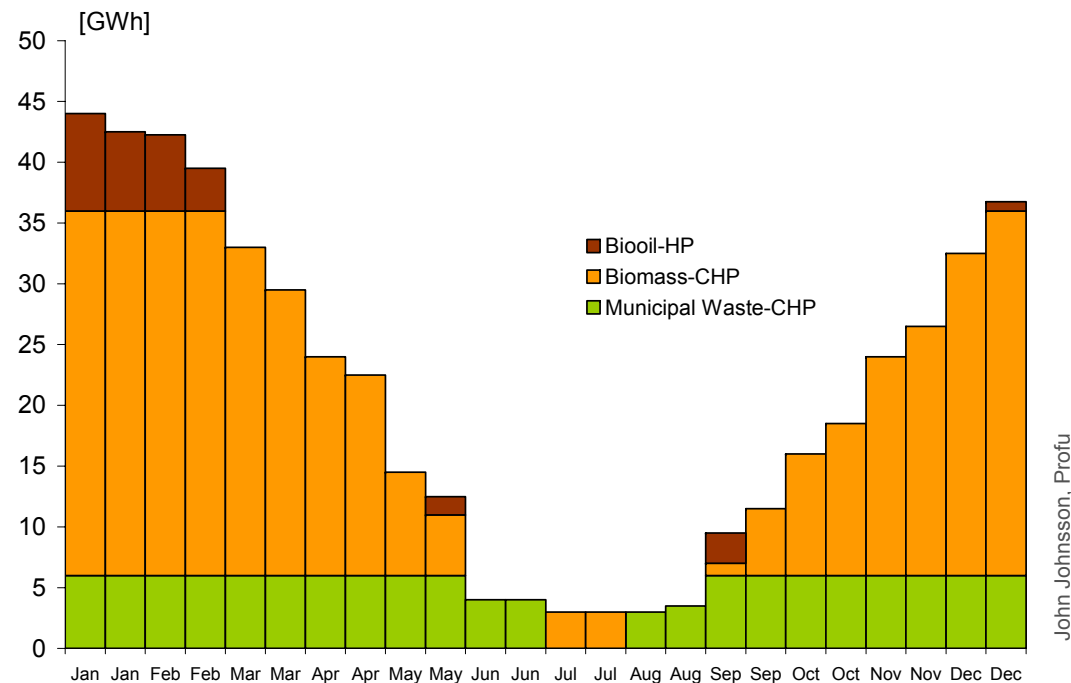
John Johnsson, Profu

Calculation algorithm

Large Scale Technologies

- Dispatch model (total variable cost ranking)
- Alternatively user specified production schedule

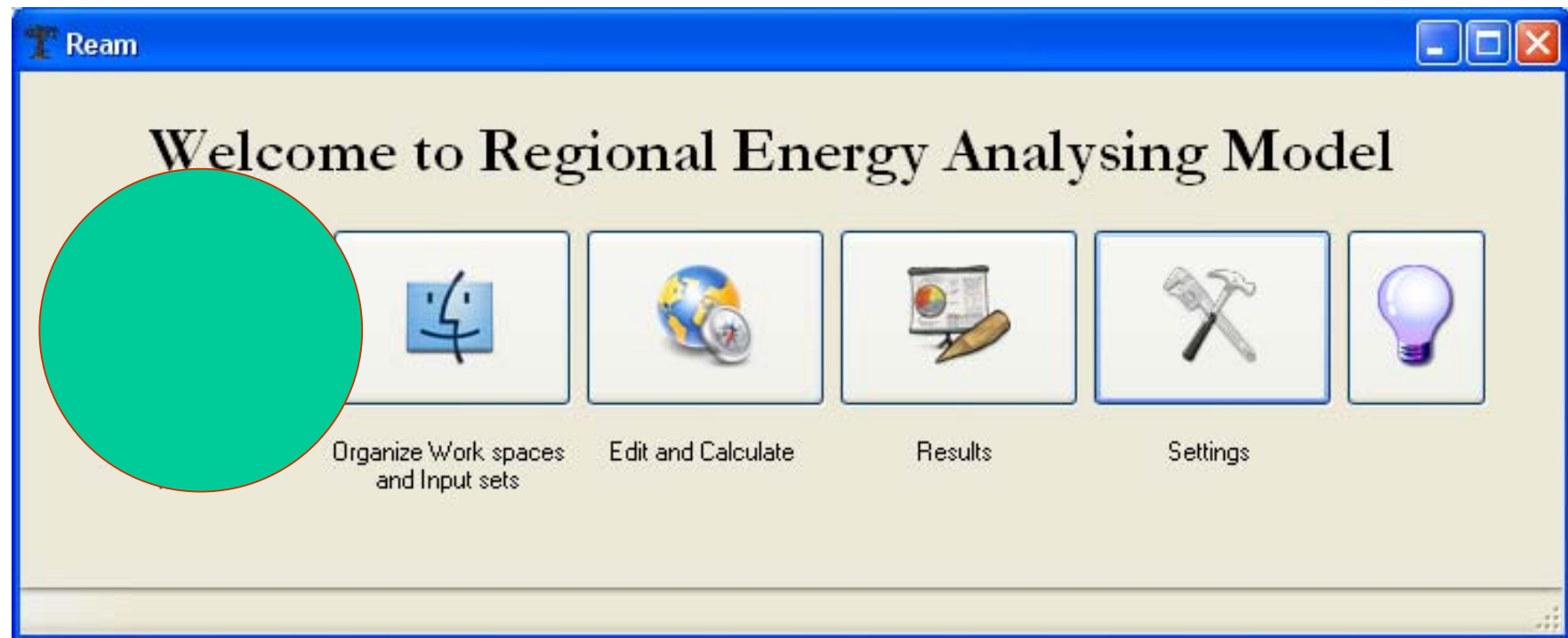
Example - District heating production



John Johnsson, Profu

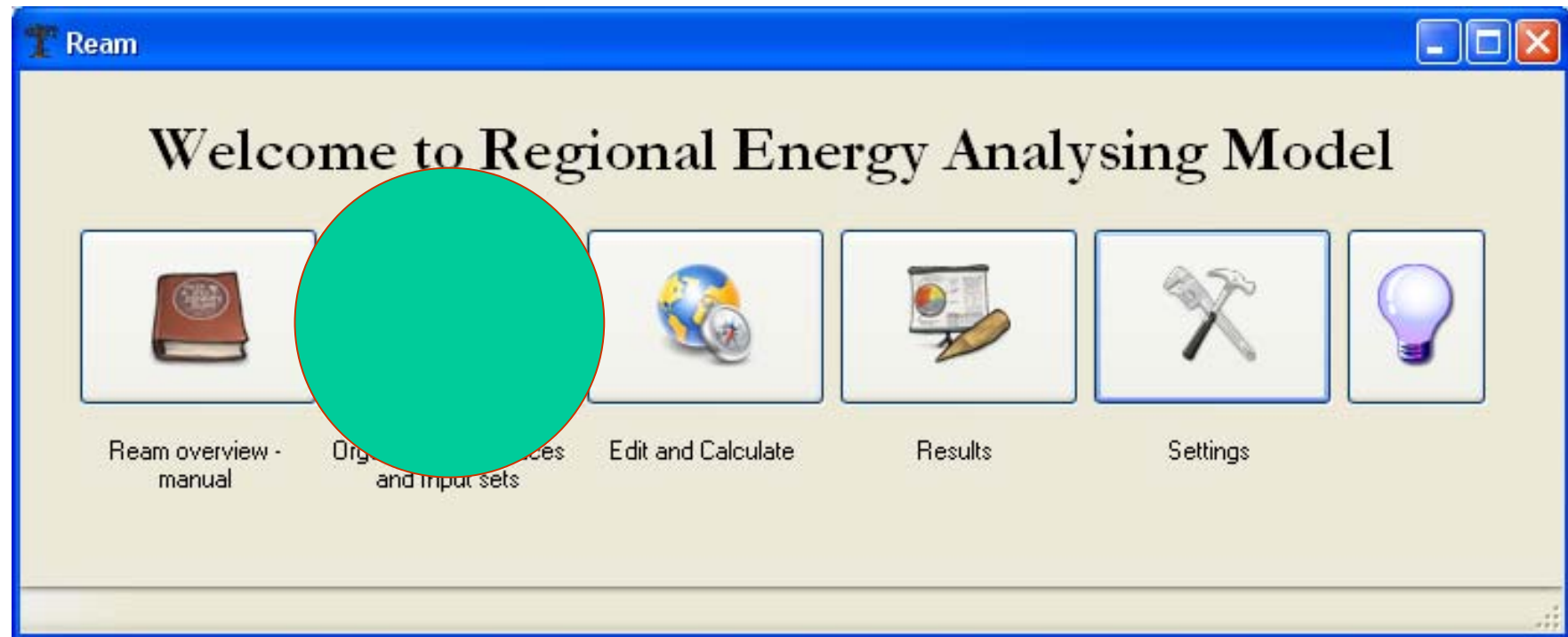
Getting started

REAM Overview: Provides the REAM manual



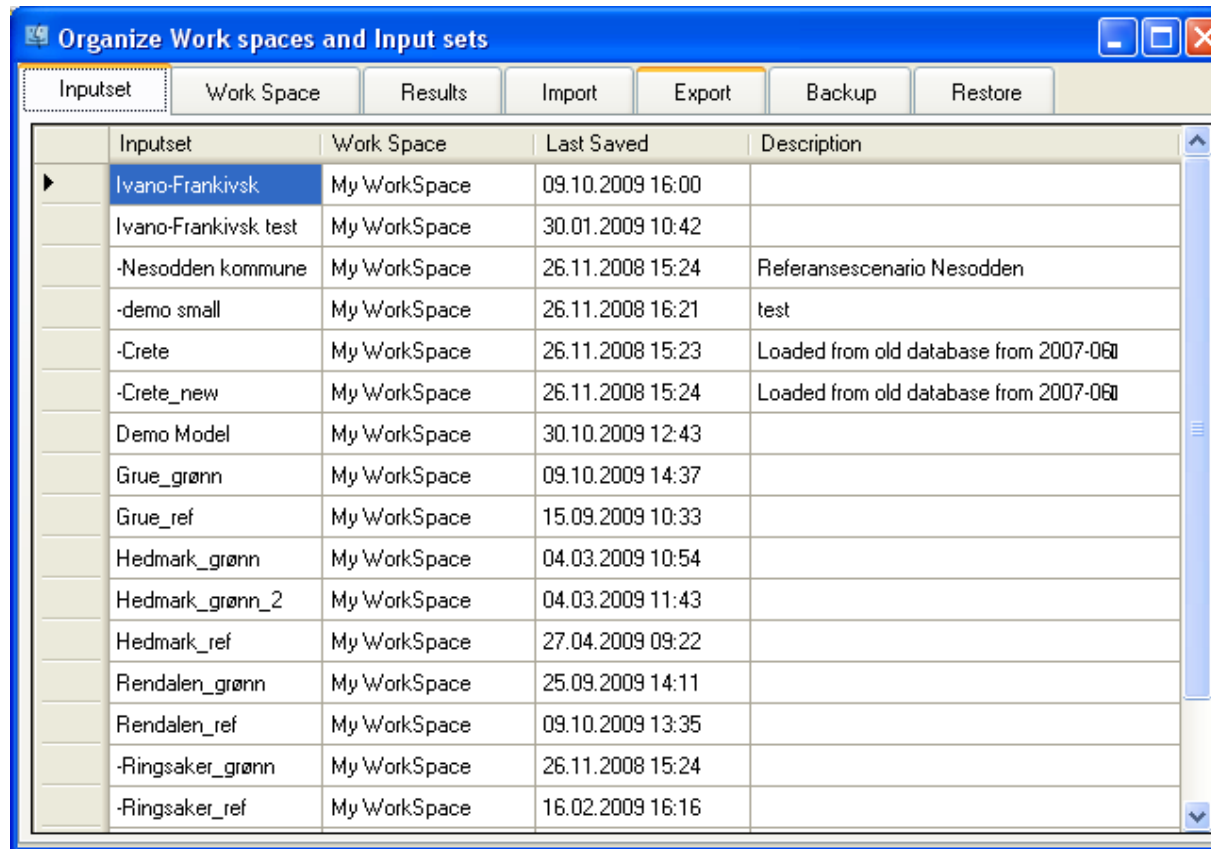
Getting started

Organizer: Manage input sets, results, export, backup



Getting started

Organizer: Manage input sets

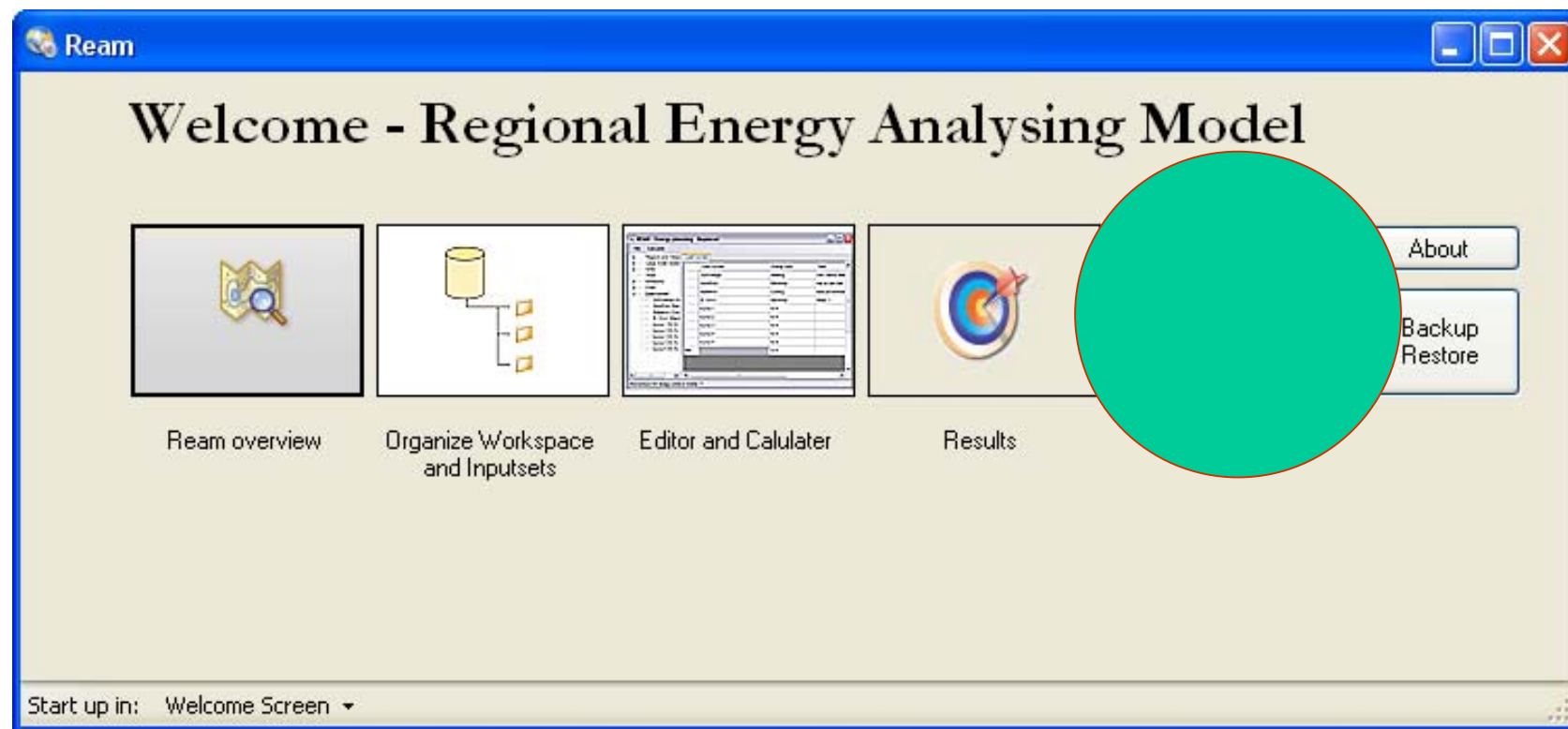


The screenshot shows a software window titled "Organize Work spaces and Input sets". It has a menu bar with "Inputset", "Work Space", "Results", "Import", "Export", "Backup", and "Restore". Below the menu bar is a table with the following columns: "Inputset", "Work Space", "Last Saved", and "Description". The table contains 16 rows of data, with the first row selected.

Inputset	Work Space	Last Saved	Description
Ivano-Frankivsk	My Workspace	09.10.2009 16:00	
Ivano-Frankivsk test	My Workspace	30.01.2009 10:42	
-Nesodden kommune	My Workspace	26.11.2008 15:24	Referansescenario Nesodden
-demo small	My Workspace	26.11.2008 16:21	test
-Crete	My Workspace	26.11.2008 15:23	Loaded from old database from 2007-06
-Crete_new	My Workspace	26.11.2008 15:24	Loaded from old database from 2007-06
Demo Model	My Workspace	30.10.2009 12:43	
Grue_grønn	My Workspace	09.10.2009 14:37	
Grue_ref	My Workspace	15.09.2009 10:33	
Hedmark_grønn	My Workspace	04.03.2009 10:54	
Hedmark_grønn_2	My Workspace	04.03.2009 11:43	
Hedmark_ref	My Workspace	27.04.2009 09:22	
Rendalen_grønn	My Workspace	25.09.2009 14:11	
Rendalen_ref	My Workspace	09.10.2009 13:35	
-Ringsaker_grønn	My Workspace	26.11.2008 15:24	
-Ringsaker_ref	My Workspace	16.02.2009 16:16	

Getting started

Settings: Global settings for the model



Getting started

Settings: Global settings for the model

Ream - Other Settings

Definition of fuel taxes

<input checked="" type="checkbox"/> CO2 Tax	CO2 Tax
<input checked="" type="checkbox"/> Energy Tax	Energy Tax
<input type="checkbox"/> Not in use	Not in use
<input type="checkbox"/> Not in use	Not in use
<input type="checkbox"/> Not in use	Not in use

Language: English

Monetary unit: €

Energy Description Model: Wh (GWh)

For large scale and grid calculation

Calc. Rate, [%]: 6

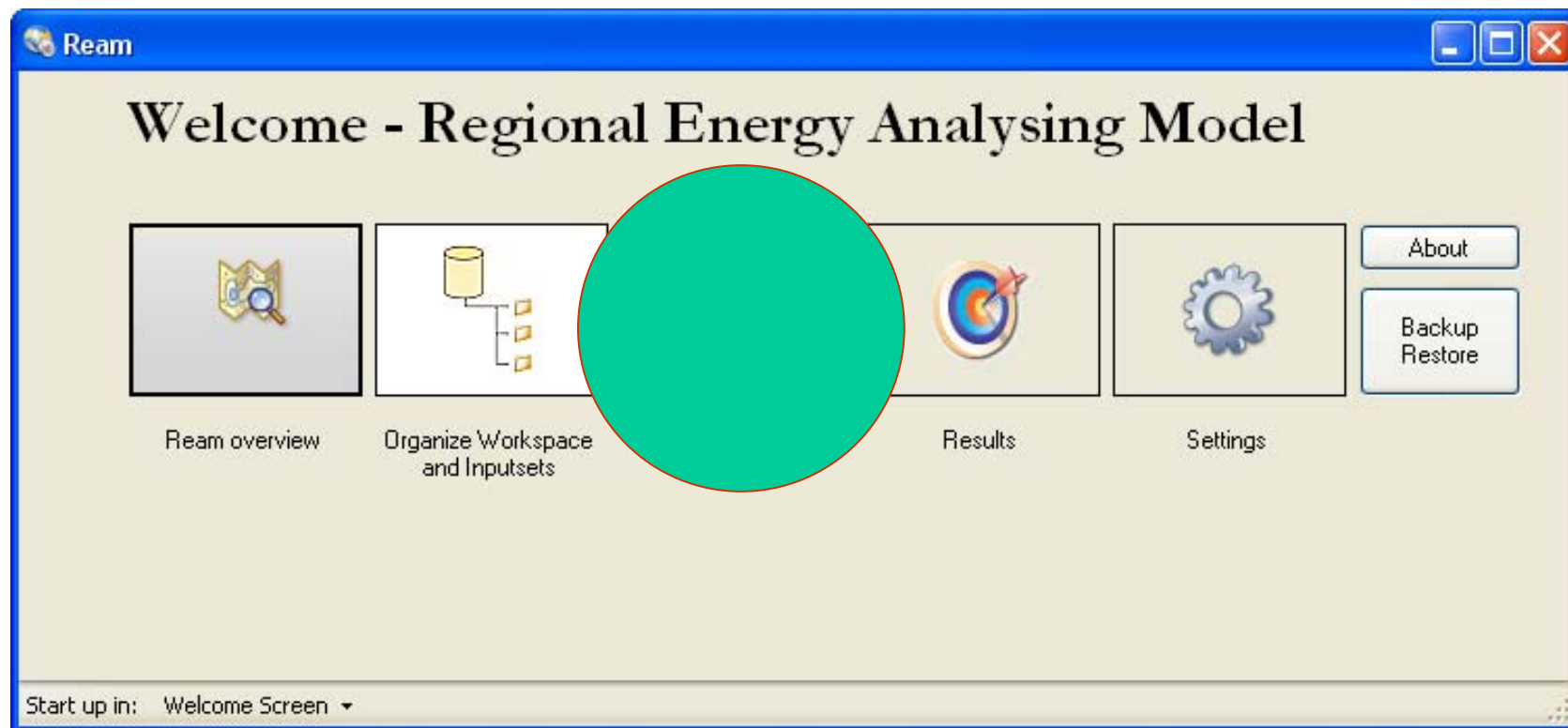
Vat, [%]: 10

Reset databases read documentation.

Save Cancel

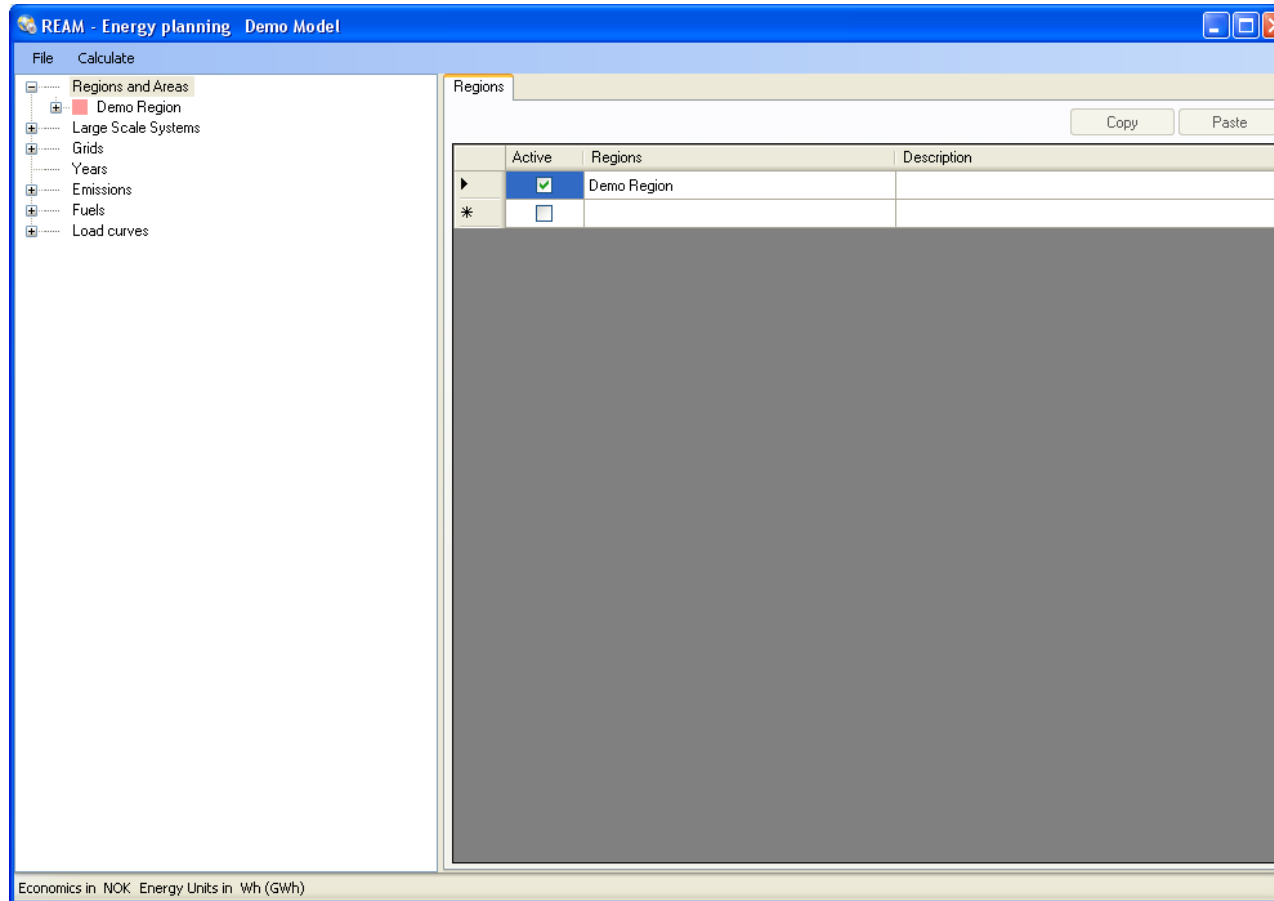
Getting started

Editor & Calculator: Editing input sets and make calculations



Getting started

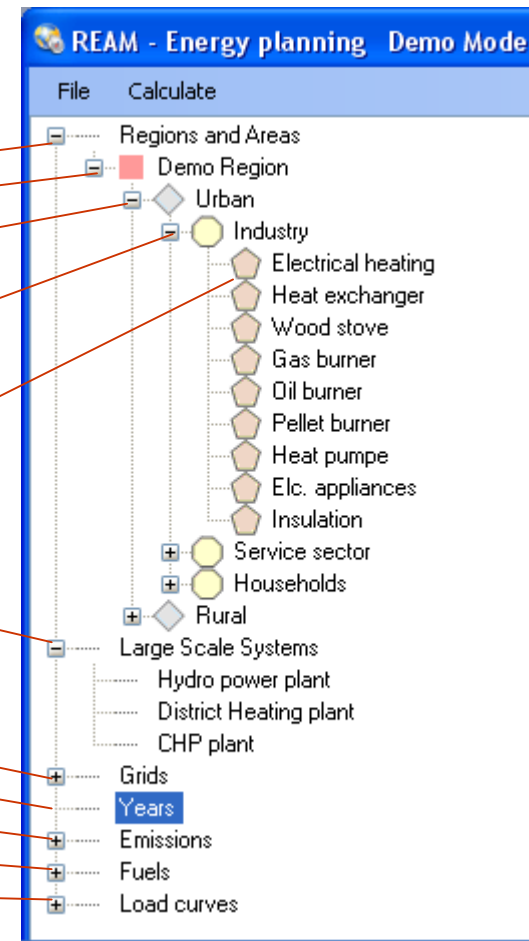
Editor & Calculator: Editing input sets and make calculations



Model structure

Main structure components

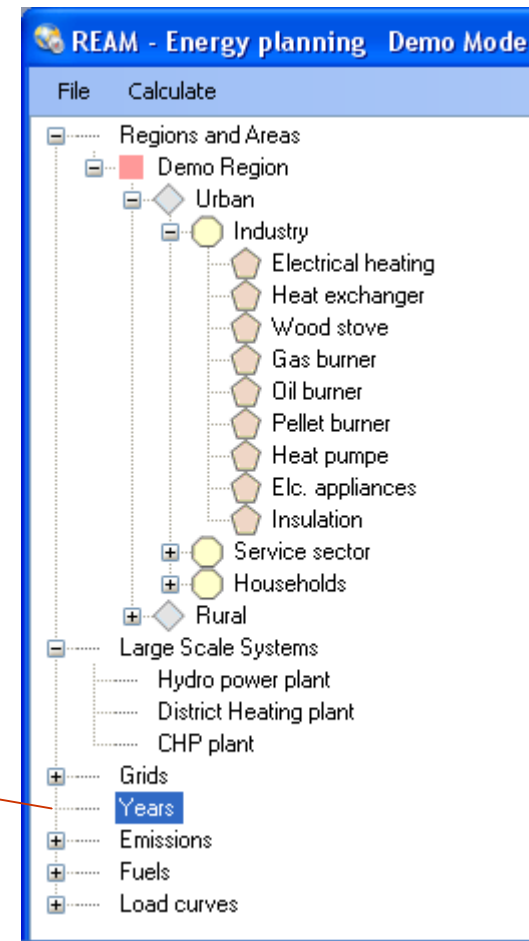
- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves



Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- Large scale systems
- Grids
- **Years**
- Emissions
- Fuels
- Load curves

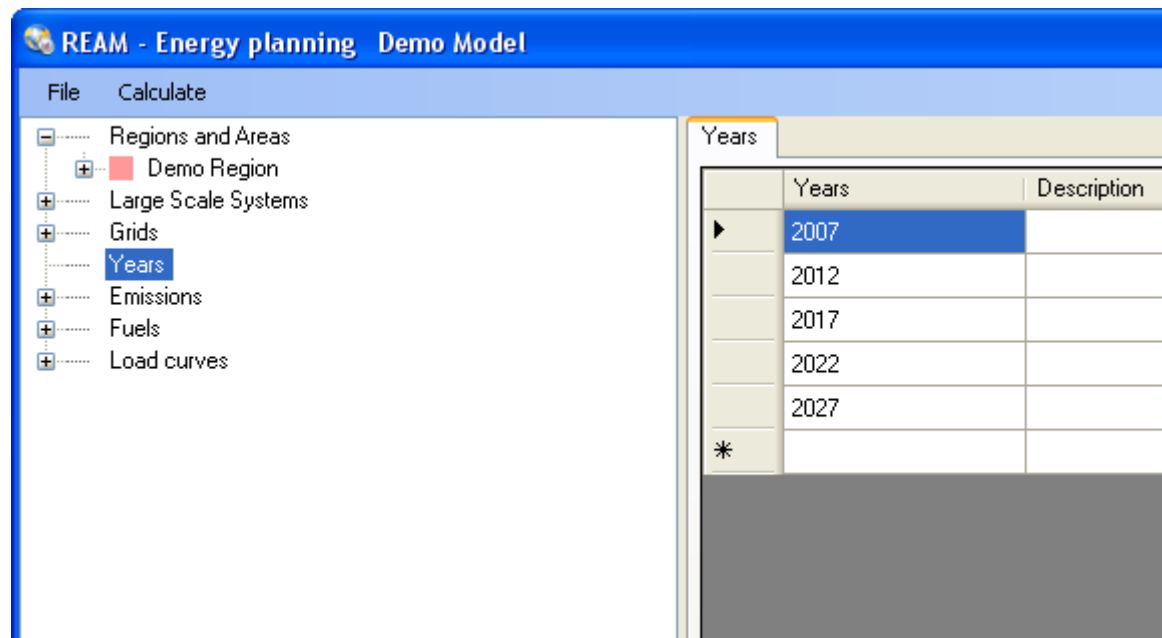


Years

Define the years for which you will make the predictions and simulations

Must be

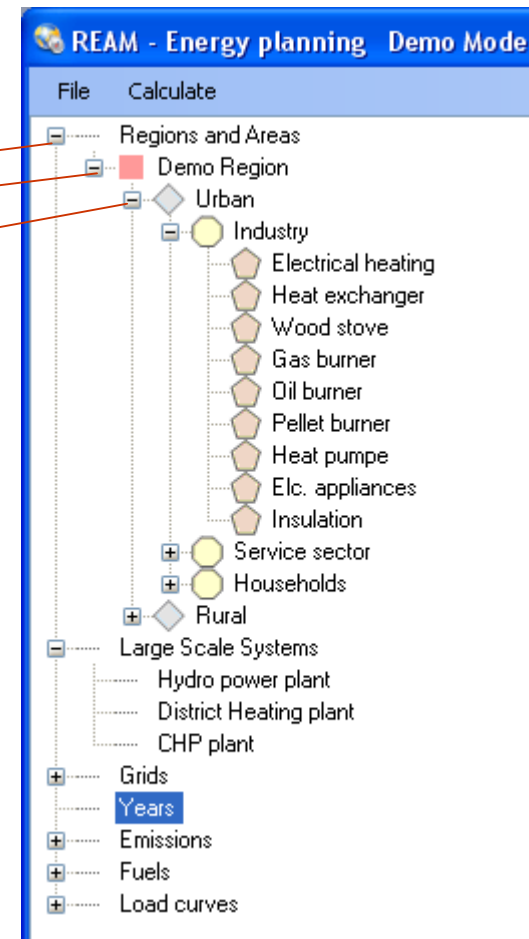
- Numerical
- Chronological
- not necessarily equal in intervals



Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves



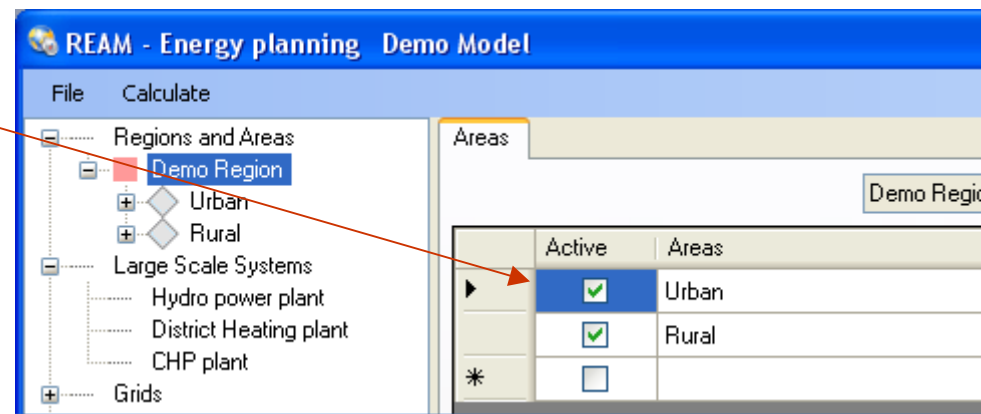
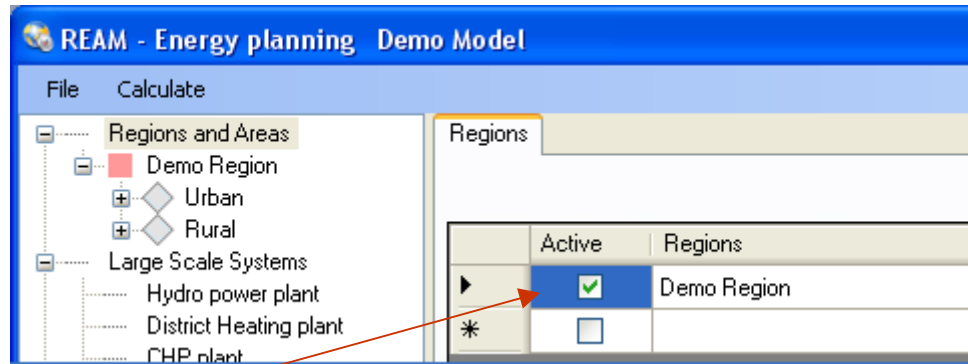
Regions and Areas

Regions and Areas

Define:

- Region(s), e.g. county

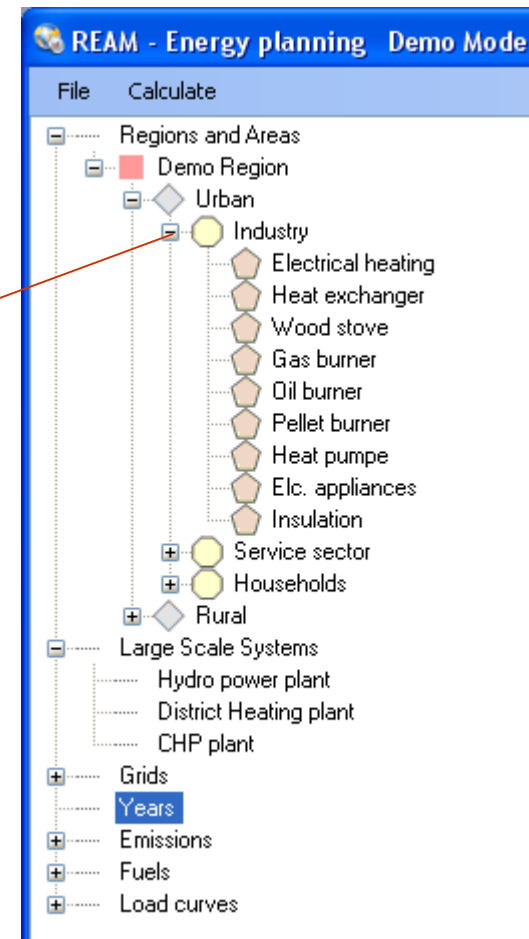
- Area(s), e.g. municipality or urban/rural



Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves



Demand category

Demand category overview

The screenshot shows the REAM - Energy planning Demo Model interface. On the left is a tree view with categories like 'Regions and Areas', 'Demo Region', 'Urban', 'Rural', 'Large Scale Systems', 'Grids', 'Years', 'Emissions', 'Fuels', and 'Load curves'. The main window displays the 'Demand Category Overview' for the 'Urban' region. A table lists demand categories with their respective calculation rates and VAT percentages. Red arrows point from the text 'Define' and its list to the 'Demand Category', 'Calc. Rate, [%]', and 'Vat, [%]' columns of the table.

	Demand Category	Calc. Rate, [%]	Vat, [%]
▶	Industry	15,00	0,00
	Service sector	10,00	0,00
	Households	7,00	25,00
*			

Define

- Demand Categories
- Calculation Rate
- VAT

Demand category

Small Scale Systems Overview

- Define Demand Technologies, Energy Type and Technology Type

The screenshot shows the REAM - Energy planning Demo Model software interface. The left sidebar contains a tree view with categories: Regions and Areas (Demo Region), Urban (Industry, Service sector, Households), Rural, Large Scale Systems, Grids, Years, Emissions, Fuels, and Load curves. The main window displays the 'Small Scale Systems Overview' tab, which includes a table with columns: Demand technology, Energy type, Technology Type, and Description. The table lists various technologies such as Electrical heating, Heat exchanger, Wood stove, Gas burner, Oil burner, Pellet burner, Heat pompe, Etc. appliances, and Insulation. Red arrows point from the text 'Define Demand Technologies, Energy Type and Technology Type' to the corresponding columns in the table.

Demand technology	Energy type	Technology Type	Description
Electrical heating	Heating	Supply	
Heat exchanger	Heating	Supply	
Wood stove	Heating	Supply	
Gas burner	Heating	Supply	
Oil burner	Heating	Supply	
Pellet burner	Heating	Supply	
Heat pompe	Heating	Supply	Ground/Water
Etc. appliances	Electricity	Supply	
Insulation	Heating	Efficiency	

Demand category

Demand

- For each year of simulation, predict demand for Heating, Electricity and Cooling (GWh)

The screenshot shows the REAM - Energy planning software interface. The window title is "REAM - Energy planning Sør-Østerdal_ref". The interface includes a menu bar with "File" and "Calculate", a tree view on the left for "Regions and Areas" (Sør-Østerdal, Elverum, Primary sector, Industry, Public/private services, Single family houses, Trysil, Åmot, Stor-Elvdal, Engerdal, Large Scale Systems, Grids), and a main panel with tabs for "Small Scale Systems Overview", "Demand", "Extra investment", and "Fee share". The "Demand" tab is active, showing a dropdown menu for "Primary sector" and a table with the following data:

Years	Heating, [GWh]	Electricity, [GWh]	Cooling, [GWh]
2007	3,07	2,04	0,00
2012	2,87	1,91	0,00
2017	2,73	1,82	0,00
2022	2,64	1,76	0,00
2027	2,60	1,73	0,00

Demand category

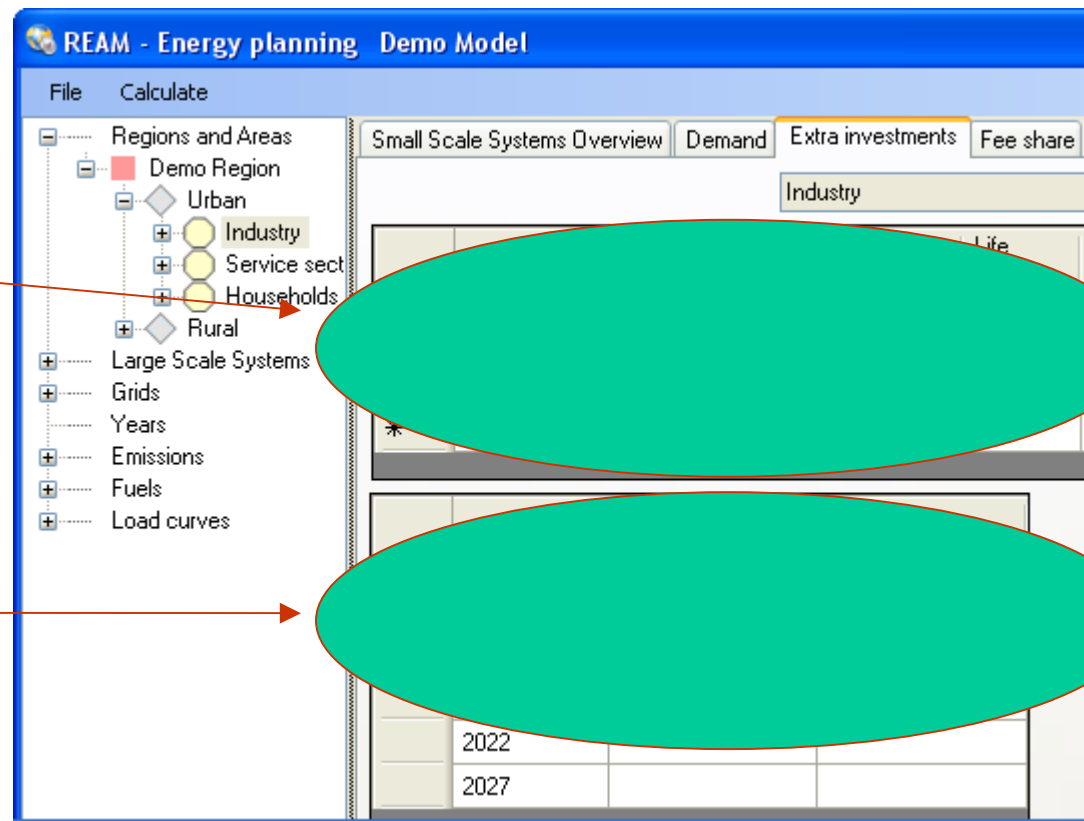
Extra Investments

Define

- Extra investments, Energy type, Investment cost, Life length

and

- Residual and/or Upper capacity for each year



Demand category

Fee share

- Define the Fee Share for each emission gas for each demand category

Small Scale Systems Overview Demand Extra investments **Fee share**

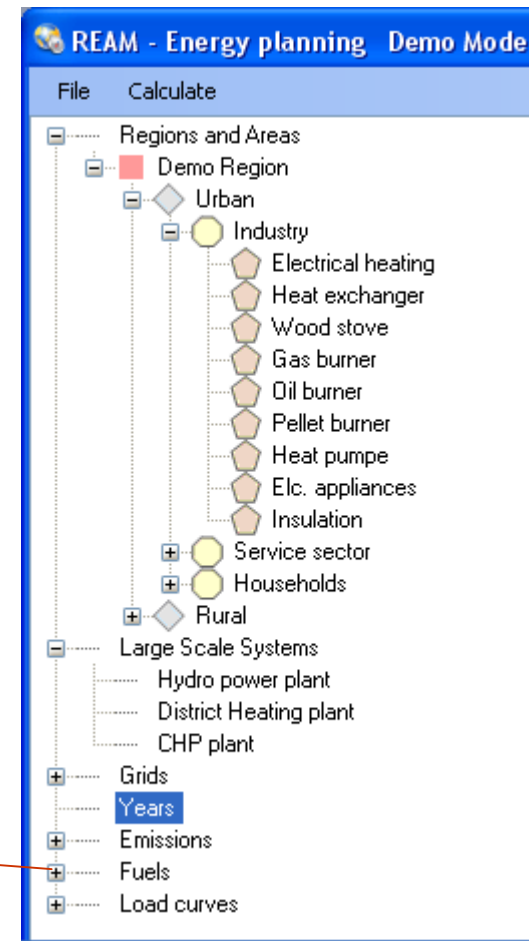
Industry

	Emissions	Fee share, [%]
▶	CO2 [g/MJ]	100,00
	NOX [mg/MJ]	100,00
	Sulfur [mg/MJ]	100,00
*		

Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves



Fuels

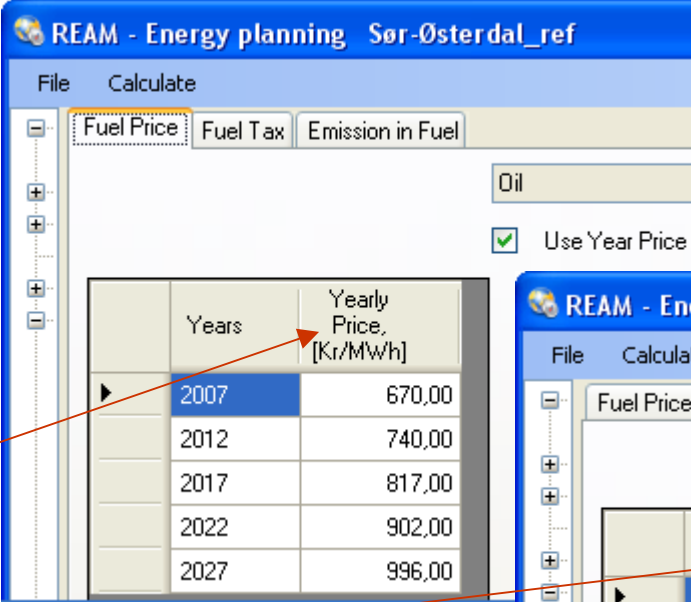
Fuel and electricity

- Define all energy carriers
- Tick off for grid connection, if so

Fuels	Connect to grid	D
Electricity	<input checked="" type="checkbox"/>	
Hot water	<input checked="" type="checkbox"/>	
Log wood	<input type="checkbox"/>	
Gas	<input type="checkbox"/>	
Oil	<input type="checkbox"/>	
Wood pellets	<input type="checkbox"/>	
Kerosene	<input type="checkbox"/>	
Wood chips	<input type="checkbox"/>	
Water	<input type="checkbox"/>	
*	<input type="checkbox"/>	

Fuels

- Define fuel price
 - Year Price or 24 int./yr
- Define fuel tax
 - Up to 5 tax categories
- Define Emissions
 - Global emissions, outside system border



REAM - Energy planning Sør-Østerdal_ref

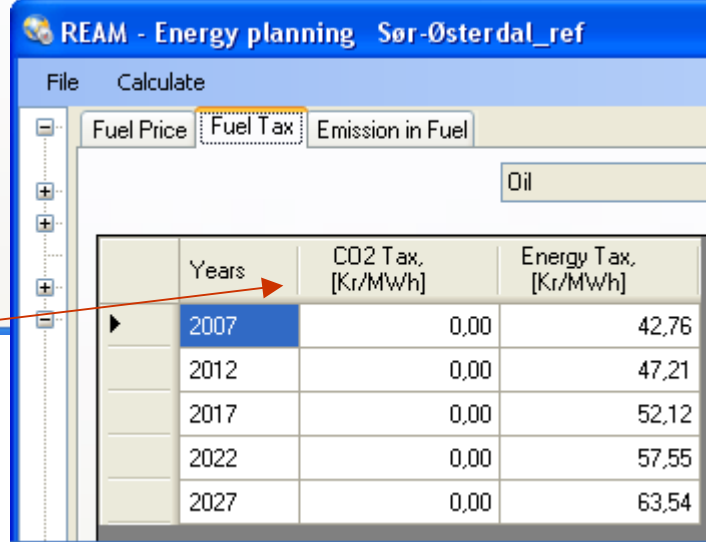
File Calculate

Fuel Price Fuel Tax Emission in Fuel

Oil

Use Year Price

Years	Yearly Price, [Kr/MWh]
2007	670,00
2012	740,00
2017	817,00
2022	902,00
2027	996,00



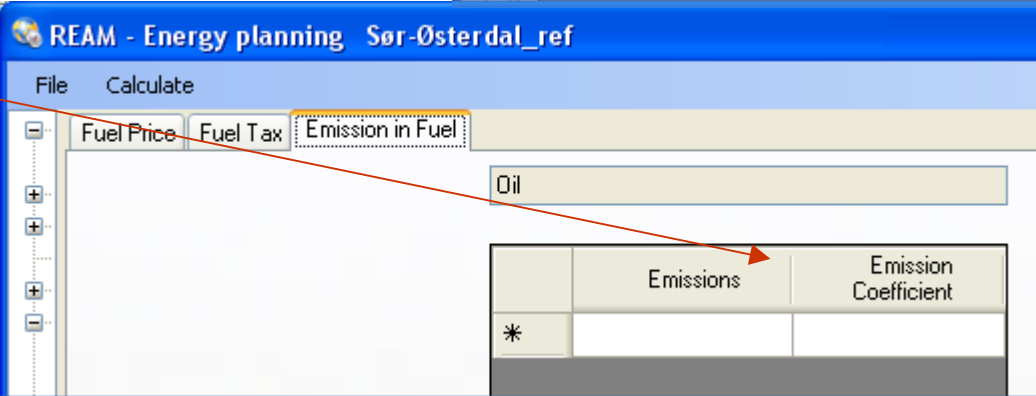
REAM - Energy planning Sør-Østerdal_ref

File Calculate

Fuel Price Fuel Tax Emission in Fuel

Oil

Years	CO2 Tax, [Kr/MWh]	Energy Tax, [Kr/MWh]
2007	0,00	42,76
2012	0,00	47,21
2017	0,00	52,12
2022	0,00	57,55
2027	0,00	63,54



REAM - Energy planning Sør-Østerdal_ref

File Calculate

Fuel Price Fuel Tax Emission in Fuel

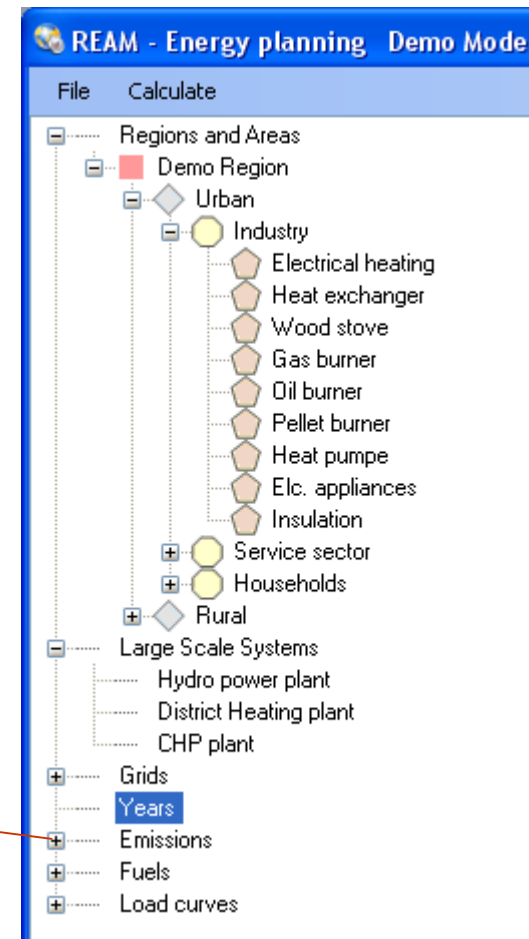
Oil

	Emissions	Emission Coefficient
*		

Model structure

Main structure components

- Regions and areas
 - Region
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 - End use technology
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves

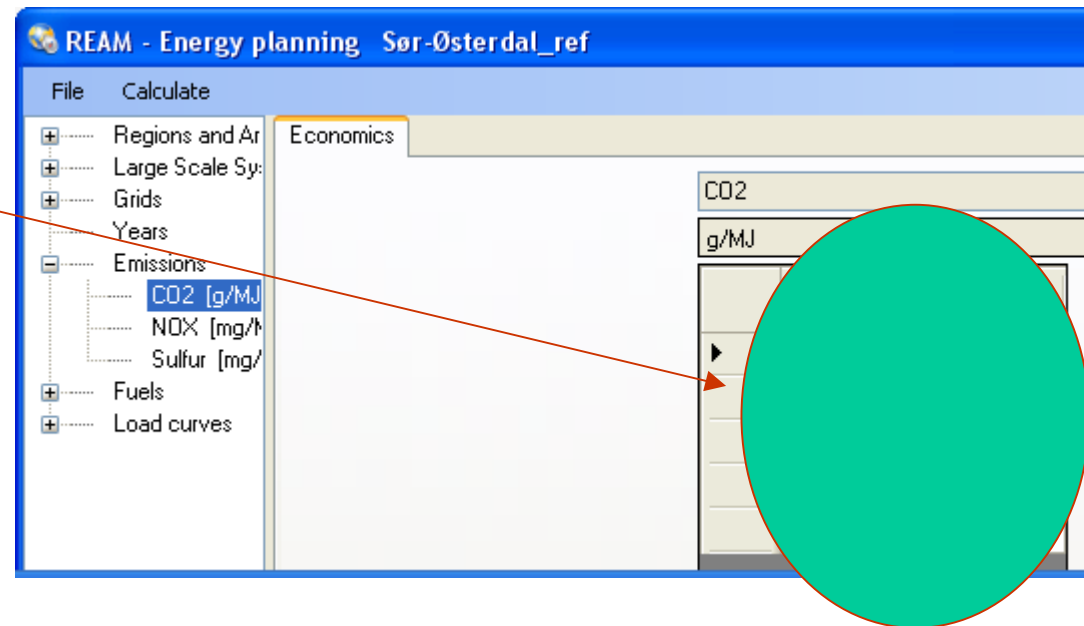
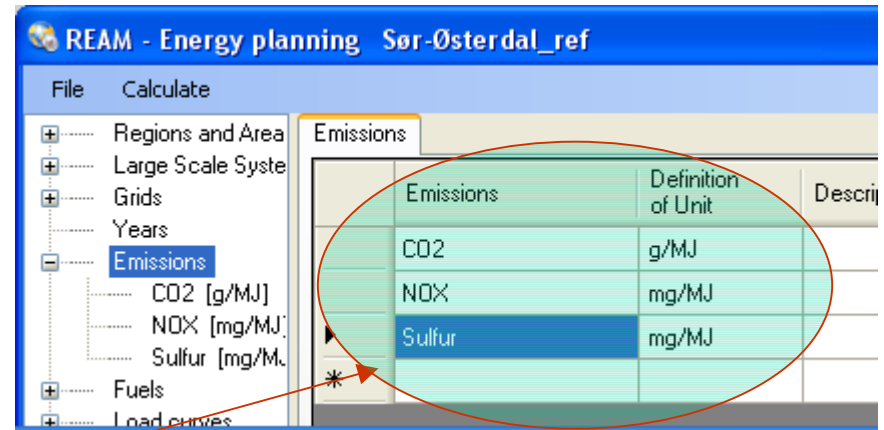


Emissions

Emissions & Economics

- Define Emissions and select Definition of Unit

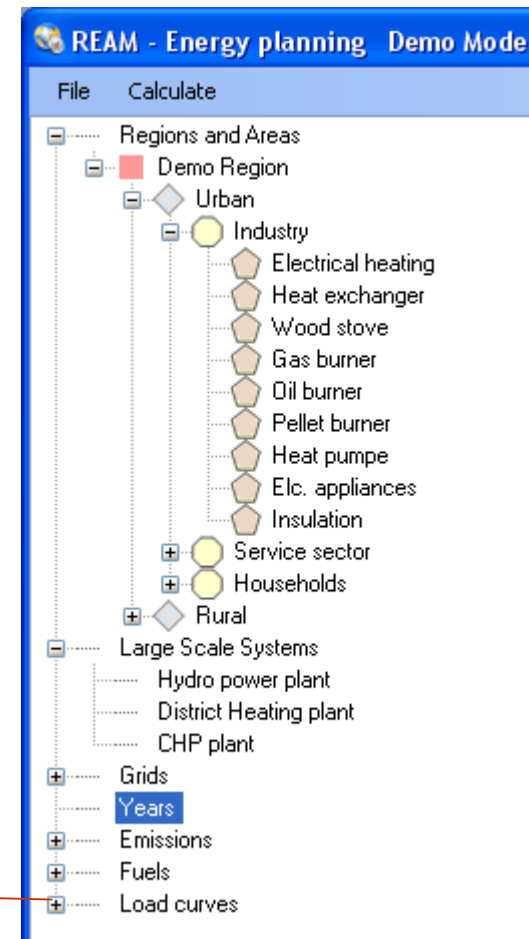
- Define Emission Fee for each year of simulation



Model structure

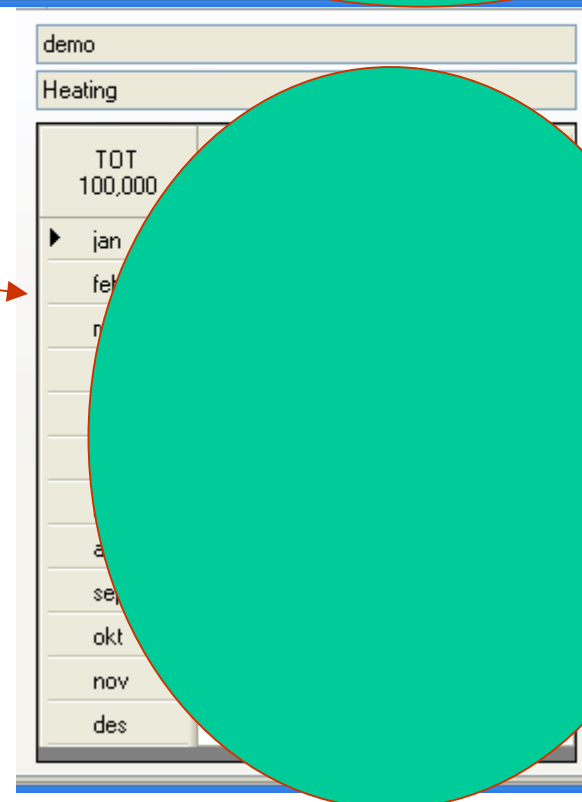
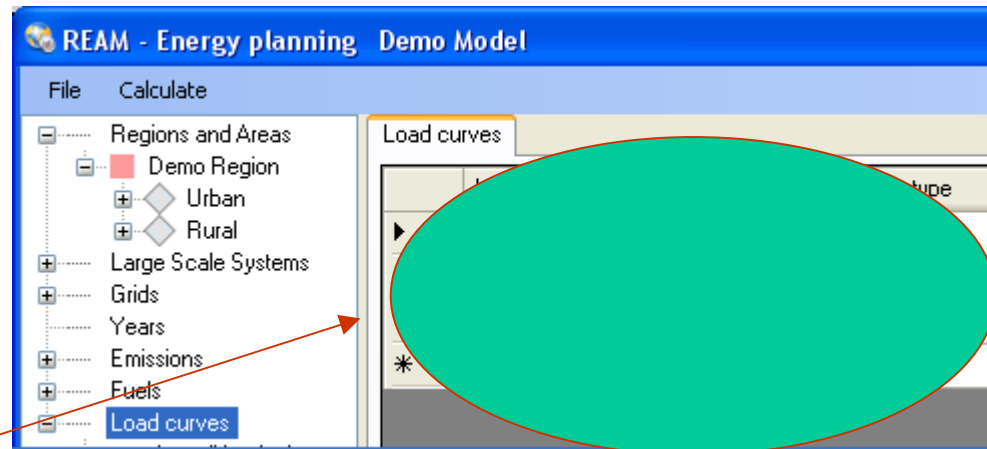
Main structure components

- Regions and areas
 - Region
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- Grids
- Years
- Emissions
- Fuels
- **Load curves**



Load curves

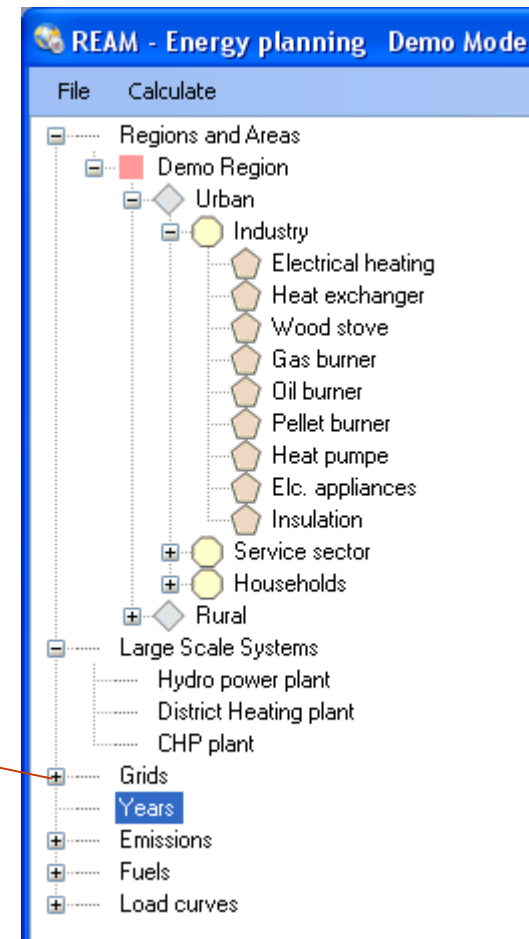
- Define load curves
 - Required for each energy type
- Define load in each 24 intervals during the year
 - Day and night each month
 - Must sum up to 100%!
- Load curves are global
 - available for all input sets



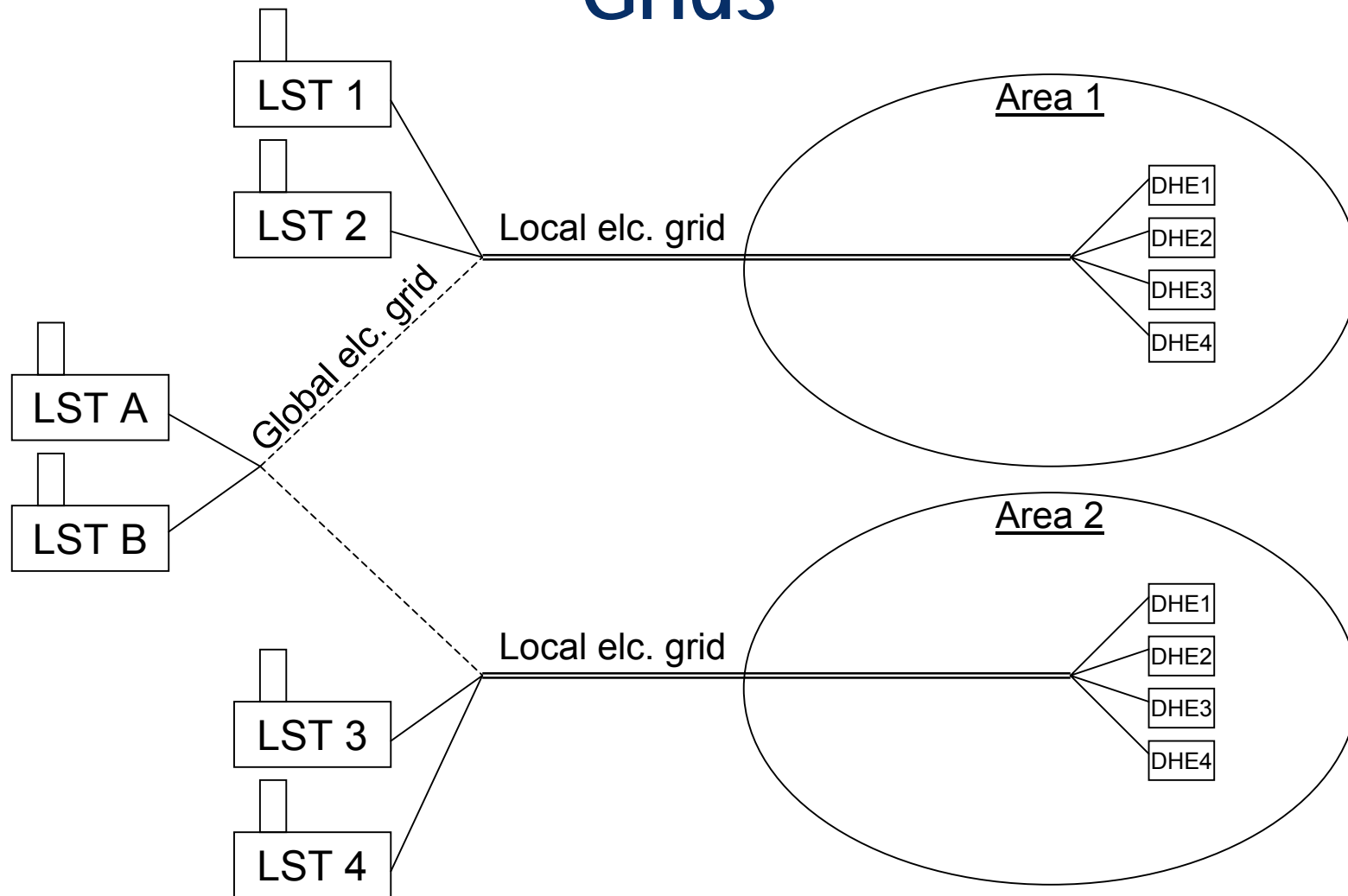
Model structure

Main structure components

- Regions and areas
 - Region
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 - End use technology
- Large scale systems
- **Grids**
- Years
- Emissions
- Fuels
- Load curves



Grids



Grids

Define Grids, select Area, Global connection (if so) and Energy type

Grids	Areas	Global connected	Energy type
District heatin grid	Urban	<input type="checkbox"/>	Heating
Power transmission	Urban	<input checked="" type="checkbox"/>	Electricity
Power transmission	Rural	<input checked="" type="checkbox"/>	Electricity
*		<input type="checkbox"/>	

Grids

Technical

- Distribution Efficiency
- Capacity Residual (MW)

Demo Model

Technical Economics Producer Consumer

District heatin grid - Urban

Energy type Heating

Distribution efficiency, [%] 95

▶	

Economics

- Investment Cost
- Life length
- Variable Cost

Demo Model

Technical Economics Producer Consumer

District heatin grid - Urban

Energy type Heating

Investment (in), [NOK/kW] 2000

Life Length, [years] 20

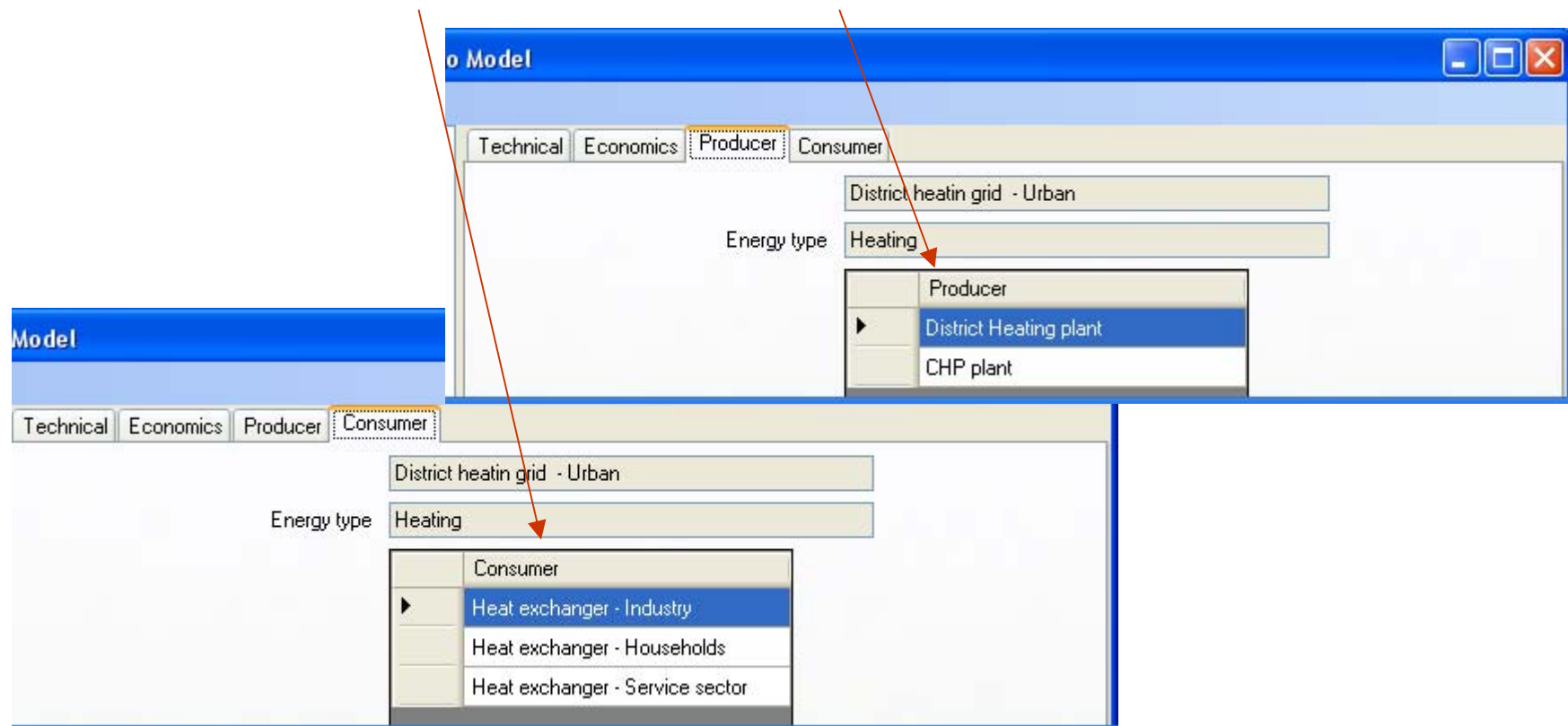
Variable cost, [NOK/MWh] 0

Description

Grids

Producer & Consumer

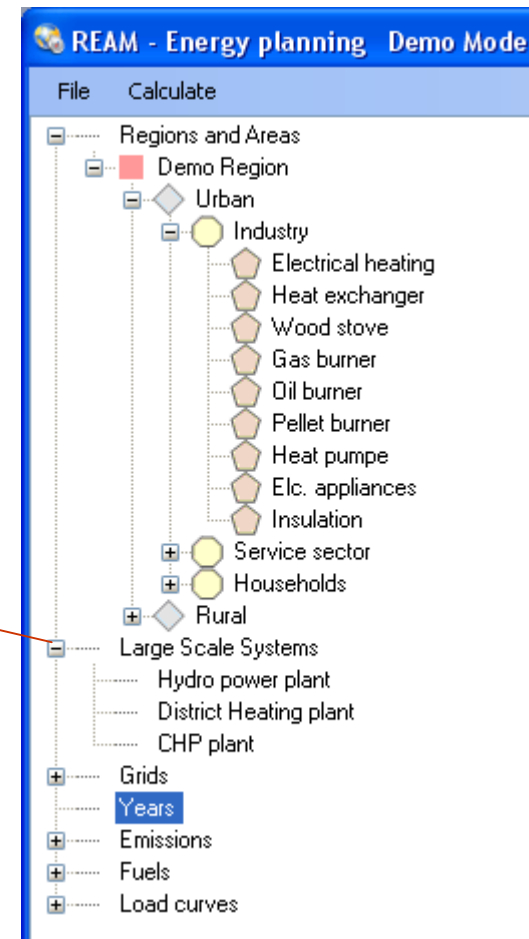
- Shows which Consumers (SST) and Producers (LST) are connected to the Grid



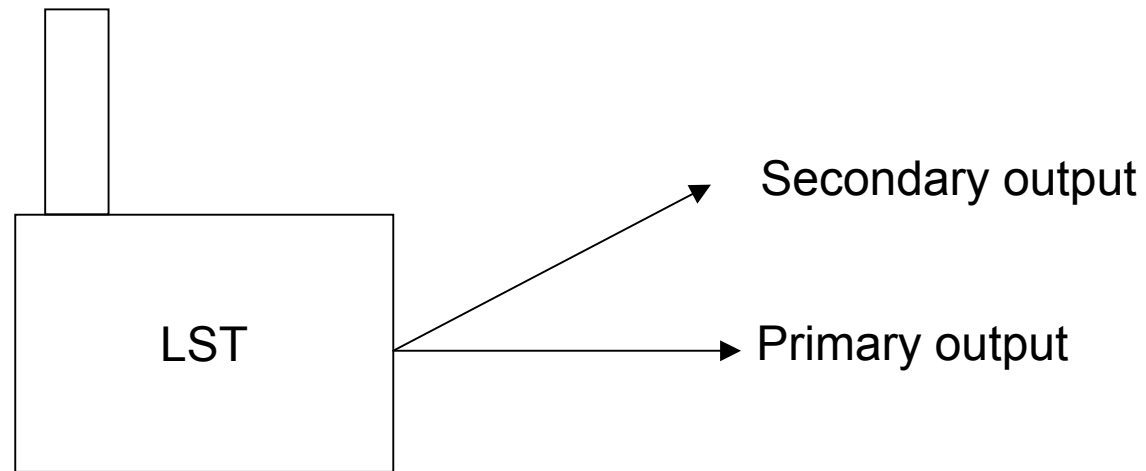
Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - End use technology
- **Large scale systems**
- Grids
- Years
- Emissions
- Fuels
- Load curves



Large Scale Systems



$$\text{Quota} = \text{Primary} / \text{Secondary}$$

Large Scale Systems

Large Scale Systems Overview

- Define Large Scale Systems, Energy type(s) and Priority

The screenshot shows the REAM - Energy planning Demo Model software interface. The left sidebar displays a tree view of the model structure, including 'Regions and Areas', 'Demo Region', 'Urban', 'Rural', 'Large Scale Systems', 'Grids', 'Years', and 'Emissions'. The 'Large Scale Systems' folder is expanded, showing 'Hydro power plant', 'District Heating plant', and 'CHP plant'. The main window displays the 'Large Scale Systems Overview' table, which lists the systems, their energy types, secondary energy types, and priorities. Red arrows point from the text 'Define Large Scale Systems, Energy type(s) and Priority' to the corresponding columns in the table.

Large Scale Systems	Energy type	Secondary Energy Type	Priority	Description
▶ Hydro power plant	Electricity	N/A	*	
District Heating plant	Heating	N/A	*	
CHP plant	Heating	Electricity	*	
*				

Large Scale Systems

Technical Define

- Capacity Residual (MW)
- Available capacity
- Efficiency (per fuel)

The screenshot shows a software window with tabs for 'Economics', 'Emissions', and 'Grids'. The 'Grids' tab is active, showing a 'District Heating plant' configuration. The 'Energy type' is set to 'Heating'. Below this, there are two tables. The first table shows 'Capacity Residual (primary output), [MW]' for various years. The second table shows 'Efficiency, [%]' for different fuels. A large green oval highlights the right side of the interface, including the 'Capacity Residual' table and the 'Efficiency' table.

Years	Capacity Residual (primary output), [MW]
2007	14
2012	14
2017	18
2022	18
2027	18

Fuels	Efficiency, [%]
Oil	90,00
Wood chips	85,00
*	

Large Scale Systems

Economics

Define

- Investment cost
- Life length
- Fixed cost
- Variable cost (per fuel)
- Fee Share (per emission)

District Heating plant

Investment (out), [NOK/kW] 1000

Life Length, [years] 20

Fixed cost (out), [NOK/kW] 0

Fuels	Variable cost, [NOK/MWh]
Oil	0,00
Wood chips	0,00

Emissions	Fee share, [%]
CO2 [g/MJ]	100,00
NOX [mg/MJ]	100,00

Large Scale Systems

Emissions

Define Emission Coefficient for each emission, for each fuel respectively



Grids

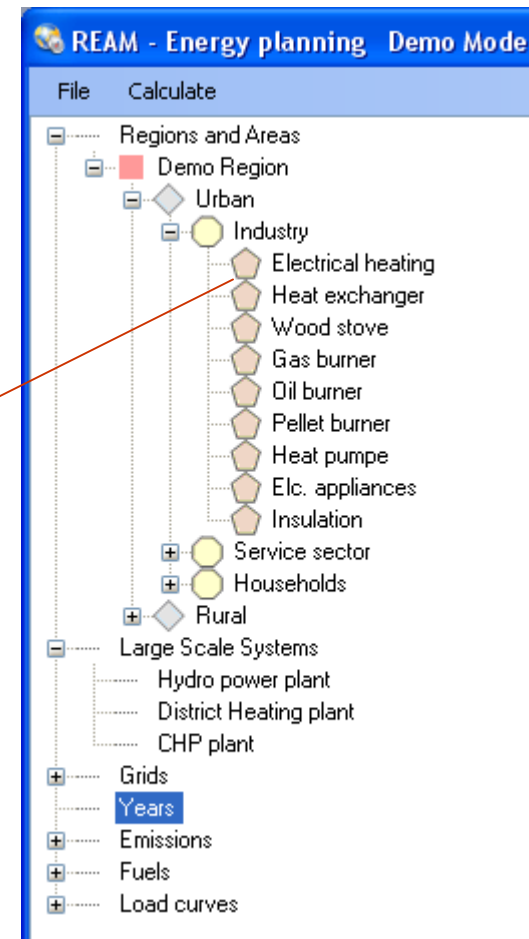
Choose Global grid connection, or a local grid from menu



Model structure

Main structure components

- Regions and areas
 - Region
 - Area
 - Demand category
 - **End use technology**
- Large scale systems
- Grids
- Years
- Emissions
- Fuels
- Load curves



Demand technology

Technical Define

- Capacities for each year (GWh): residual, fixed, upper, lower
- Fuels, Grids, Efficiency, Maximum share
- Extra Investments

The screenshot shows the REAM - Energy planning software interface. The window title is "REAM - Energy planning Sør-Østerdal_ref". The interface has a menu bar with "File" and "Calculate". Below the menu bar are three tabs: "Technical", "Economics", and "Emissions". The "Technical" tab is active. The main area contains several input fields: "Oil burner" (text), "Energy type" (Heating), and "Technology Type" (Supply). Below these fields is a table with columns for "Year" and "Capacity Lower, #1". The table has one row for the year 2027 with a value of 0,15. Below the table is another section with a dropdown menu for "Extra investment" showing options: "Chimney" (selected), "Hot water distribution", and an asterisk (*). The "Description" field is empty. Two large green ovals highlight the table and the "Extra investment" dropdown menu. Red arrows point from the text in the "Technical Define" section to these elements in the software interface.

Demand technology

Economics

- Define Investment cost (MU/MWh!), Life Length and Variable cost for each fuel

Investment, [NDK/MWh] 400

Life Length, [years] 15

Fuels	Variable cost, [NDK/Mw]
Oil	10,00

Demand technology

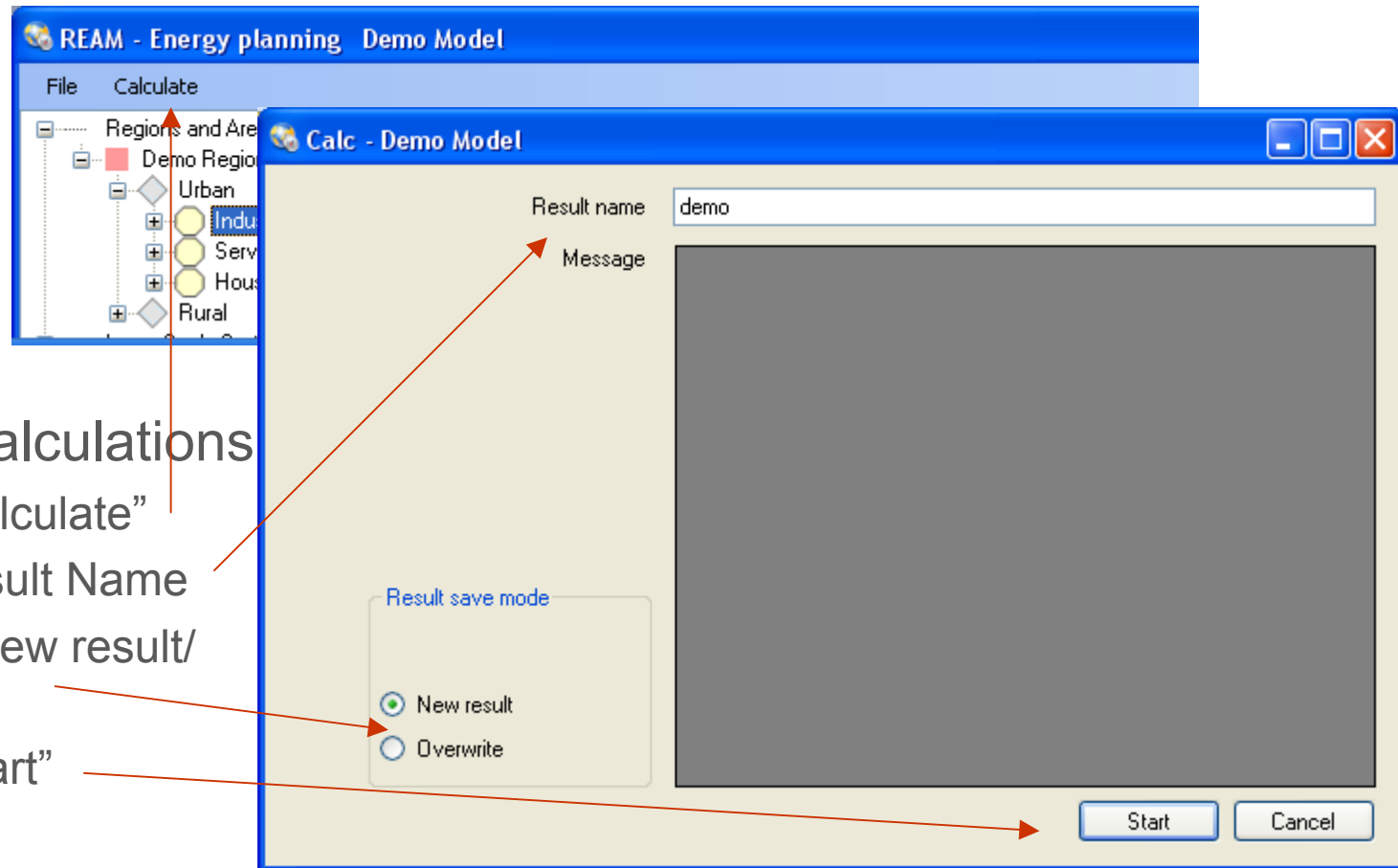
Emissions

- Define the Emission Coefficient for each gas, and for each fuel (in this case only one)

The screenshot shows the REAM - Energy planning Demo Model interface. The 'Emissions' tab is selected, and the 'Oil burner' technology is highlighted in the tree view. The table below shows the emission coefficients for this technology.

Fuels	Emissions	Emission Coefficient
Oil	CO2 [g/MJ]	78,00
	NOX [mg/MJ]	40,00
	Sulfur [mg/MJ]	23,00
	*	

Calculation

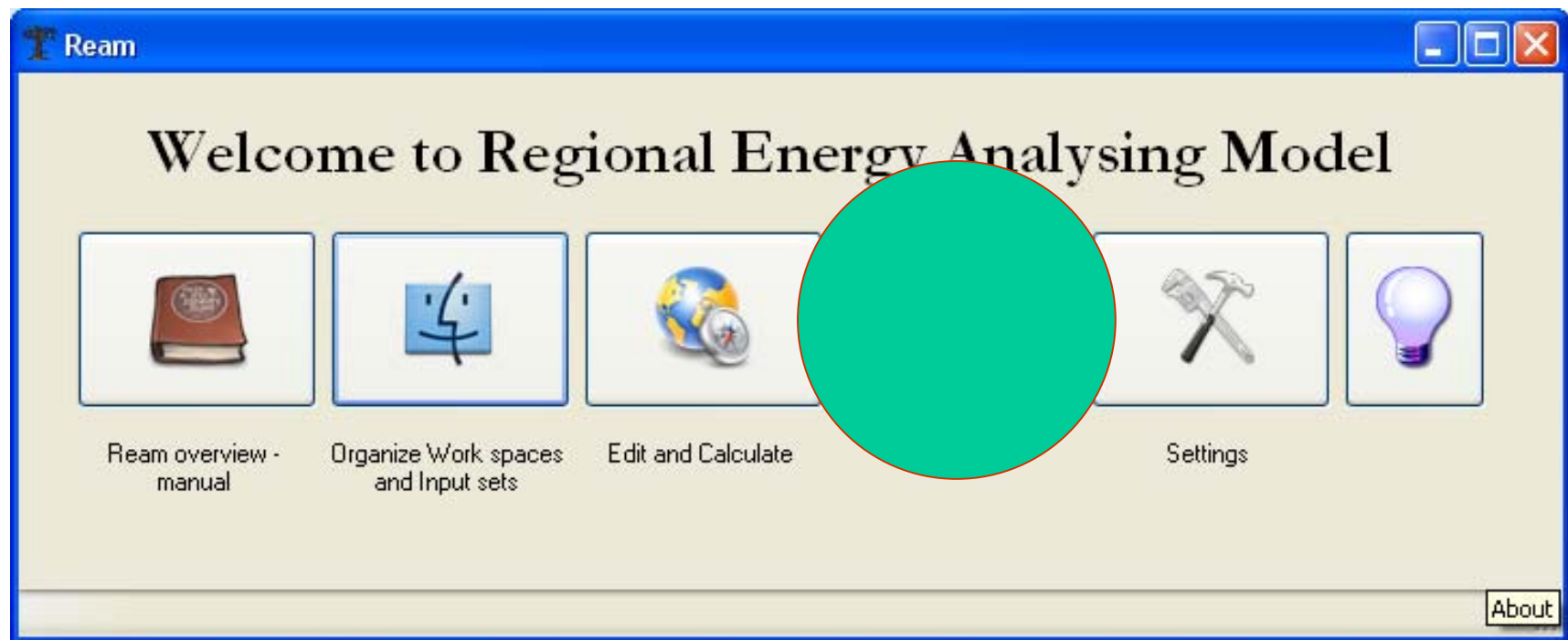


To make calculations

- Press "Calculate"
- Insert Result Name
- Choose New result/
Overwrite
- Press "Start"

REAM Opening

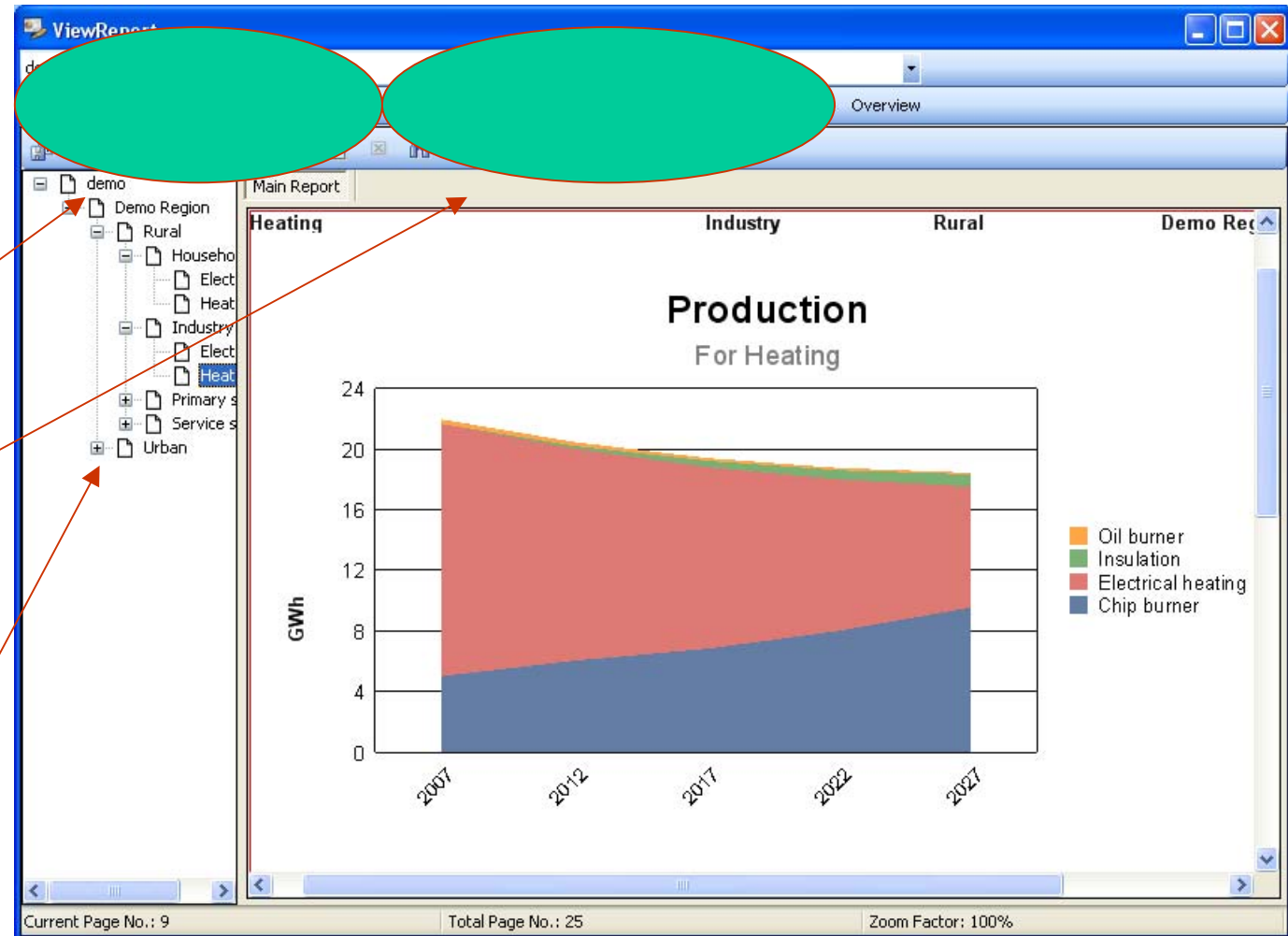
Results: Presentation of results from calculations



Result presentation

Structure

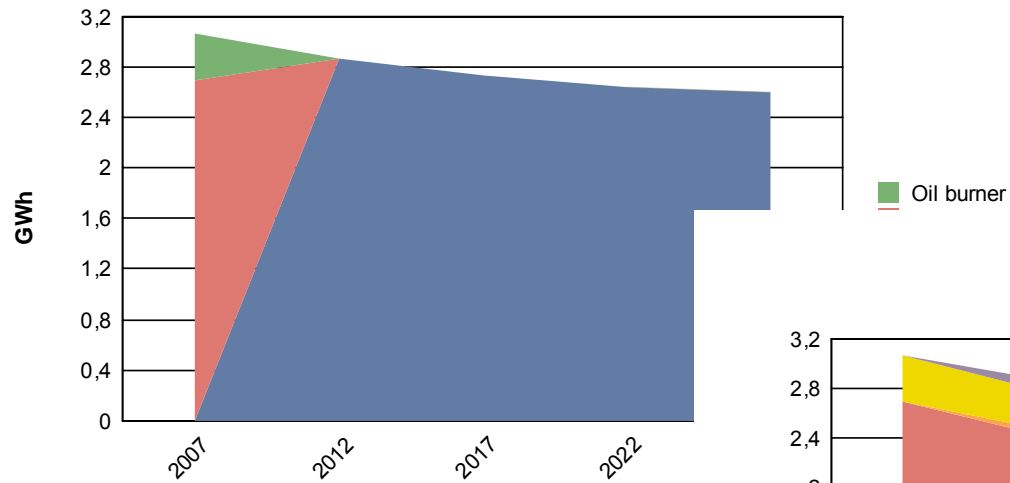
- Small Scale Systems
- Large Scale Systems
- Same Explorer look-alike



Result presentation

Production

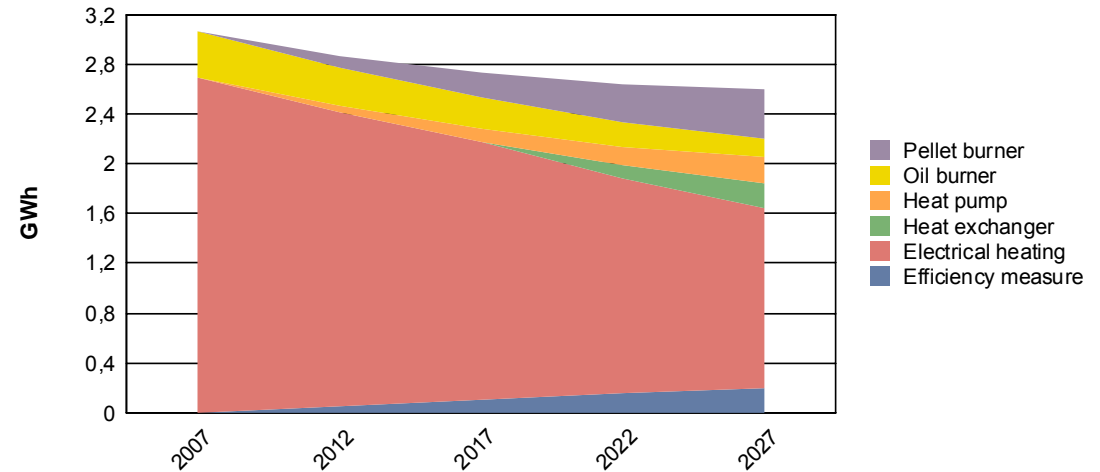
For Heating



← Without restrictions

Production

For Heating



With restrictions →

Where to find relevant data?

- Municipal administration
 - Technical administration
 - Municipal real estate companies
 - Energy advisor
- The local energy companies
 - Electricity grid statistics
 - District heating statistics
 - Gas grid statistics
 - Key persons
 - Local investigations

Where to find relevant data?

- National Statistics
 - Energy prices, national level
 - Energy consumption in end use sectors, community level
 - Energy consumption divided on energy carriers
 - Building statistics
- National and international surveys of structure of energy system
- Large industrial companies
- Large building societies
- Equipment vendors
 - Supply technologies
 - Efficiency measures
- Trade Organisations

Thank you for your attention!

Questions?

Endre Ottosen

www.nepas.no

ottosen@nepas.no