

Energy models as tools for an integrated assessment of energy use in cities

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Integrated Energy Planning representing supply and demand side

The purpose is to find different paths towards an economic and ecological sustainable municipal energy system while also taking into account limited financial and human resources as well as incomplete insight into the future development of economic, technical and social conditions.

The planning approach to achieve these goals follows three basic principles:

- Utilize system analysis methods and computerized energy system models
- Combine integrated long-term strategic planning of the whole energy system (= comprehensive analysis) with detailed planning of concrete subsystem projects
- Set-up a plan for continuous improvement and monitoring

Integrated Energy Planning representing supply and demand side

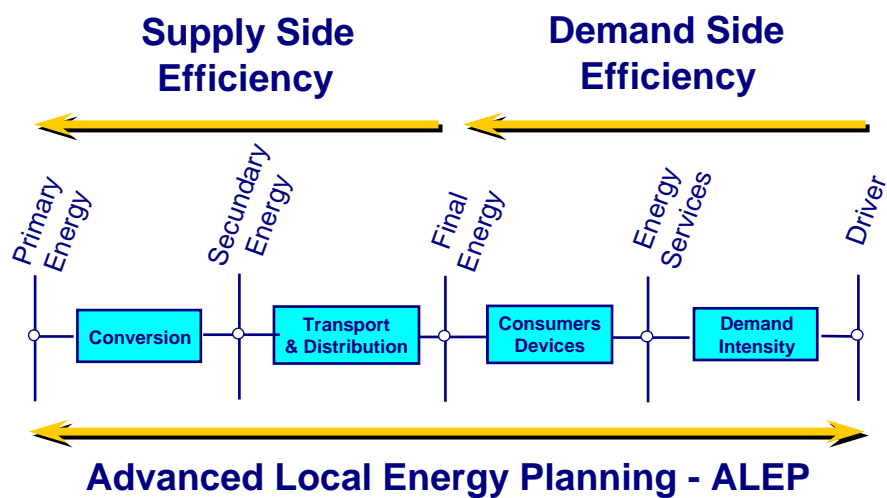
The traditional approach is to study and plan each subsystem of an energy system individually, neglecting the possible interdependencies between the system components. In general, this will lead to a sub-optimal system.

In **EnerKey**, comprehensive and detailed subsystem analysis can complement each other to provide an integrated and consistent long-term sustainable energy plan that analyses the behaviour of the entire energy system.

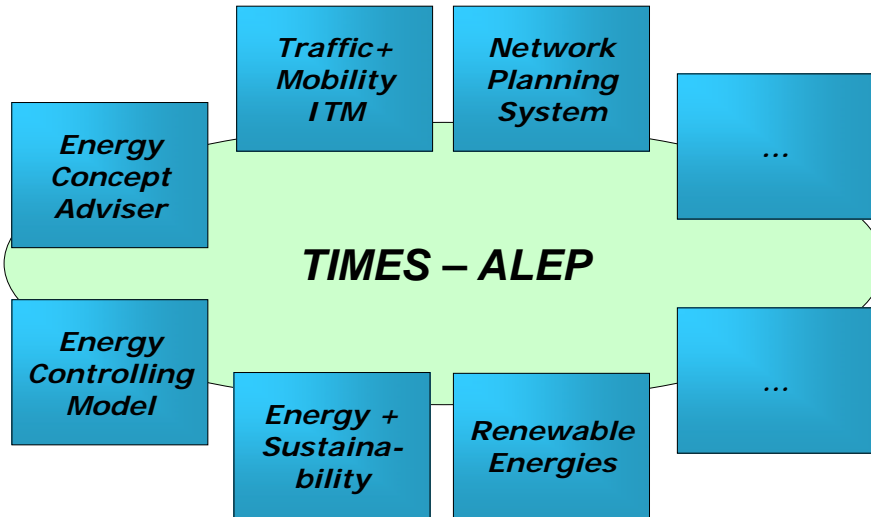
The goal of the integrated analysis is to reveal the strengths and weakness of the present energy system and to identify needs, threats and opportunities for the future.

The Reference Energy System (RES) is a scheme which models the structure of a municipal energy system today and in the future.

Integrated Planning with RES Approach



Integrated Energy Planning System - *EnerKey*



The Integrated **MARKAL** **EFOM** System

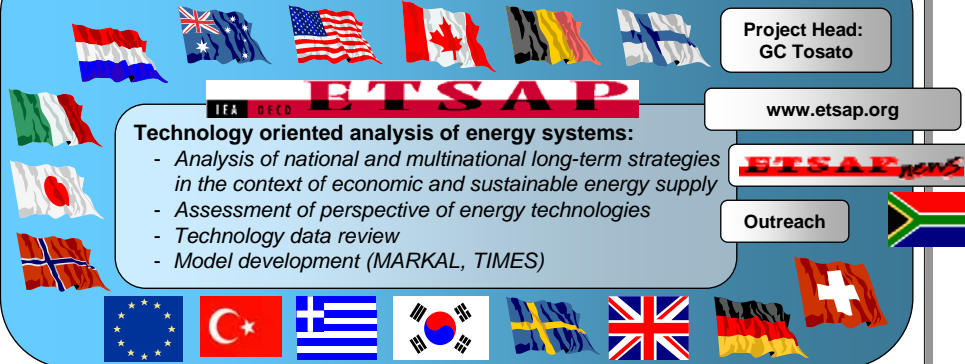
Developed by the partners of the Energy
Technology Systems Analysis Programme
(ETSAP)

ETSAP

IEA (International Energy Agency)

Implementing Agreements

Energy Technology Systems Analysis Programme (ETSAP)



Goals of the TIMES development

EFOM-ENV

- Limited subannual resolution
- Changing time horizon
- + Flexible process description

LEAP

MARKAL

- Many processes
- Changing time horizon

TIMES

- + Flexible RES description
Subdivisions of the year
Regions
- + Modularity
- + Expanding application areas
- + Prepare for ongoing research

Development

- By ETSAP
- Implementation in GAMS

Applications of the model

- IER:
 - Ostfildern
 - Baden-Württemberg
 - Bavaria
 - Saxonia
 - Hessen
 - Germany
 - European electricity and gas sector
 - World
- Other places:
 - Finland (VTT, Helsinki)
 - Belgium (KUL, Leuven)
 - Italy (Turin)
 - EU-NEEDS project
 - Global model (IPP, Munich; GERAD, Canada)
 - South Africa model, Village model (ERC, Cape Town)

Methodology

- Bottom-up Model
- Perfect competition
- Perfect foresight
- Optimisation (LP/MIP)

Min/Max Objective function
 s.t.
 Equations, Constraints
 Decision Variables \Leftrightarrow Solution
 Input parameters

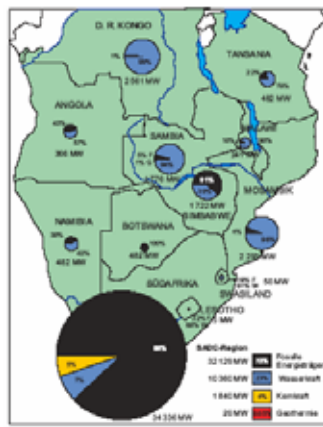
TIMES
 (The Integrated MARKAL
 EFOM System)

Features

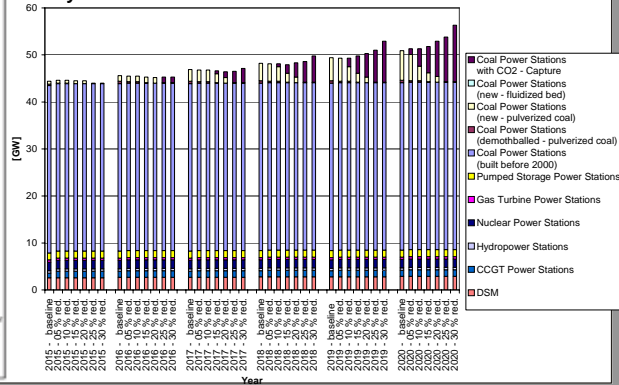
- Inter-temporal / Long-term
- Flexibility
- Vintaging
- Load curve
- Multi-region
- Elastic demands
- Endogeneous learning
- Macroeconomic linkage
- Climate extension

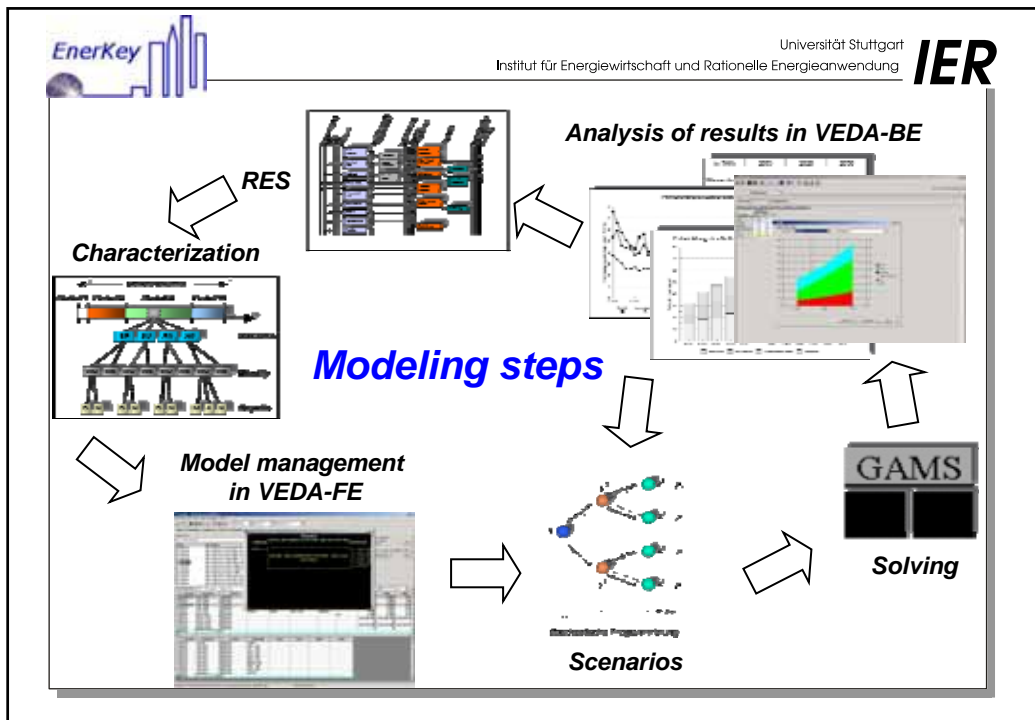
Integrated Environmental and Climatic Strategies for South Africa
 (T. Schulz, diploma thesis, 2003)

Analysis of economically optimal strategies to reduce *greenhouse gases* CO_2 , CH_4 and N_2O as well as *flue gases* NO_x and SO_2 in the South African electricity sector for the time horizon 2001 - 2020



Net installed capacity for different CO_2 -reduction targets in the year 2020

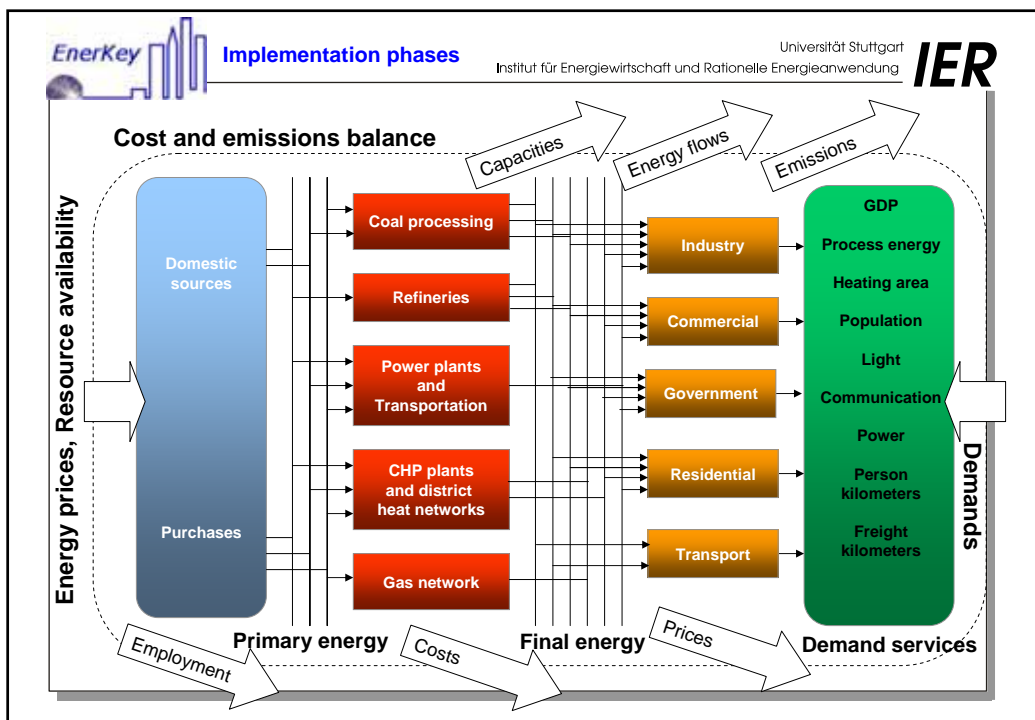
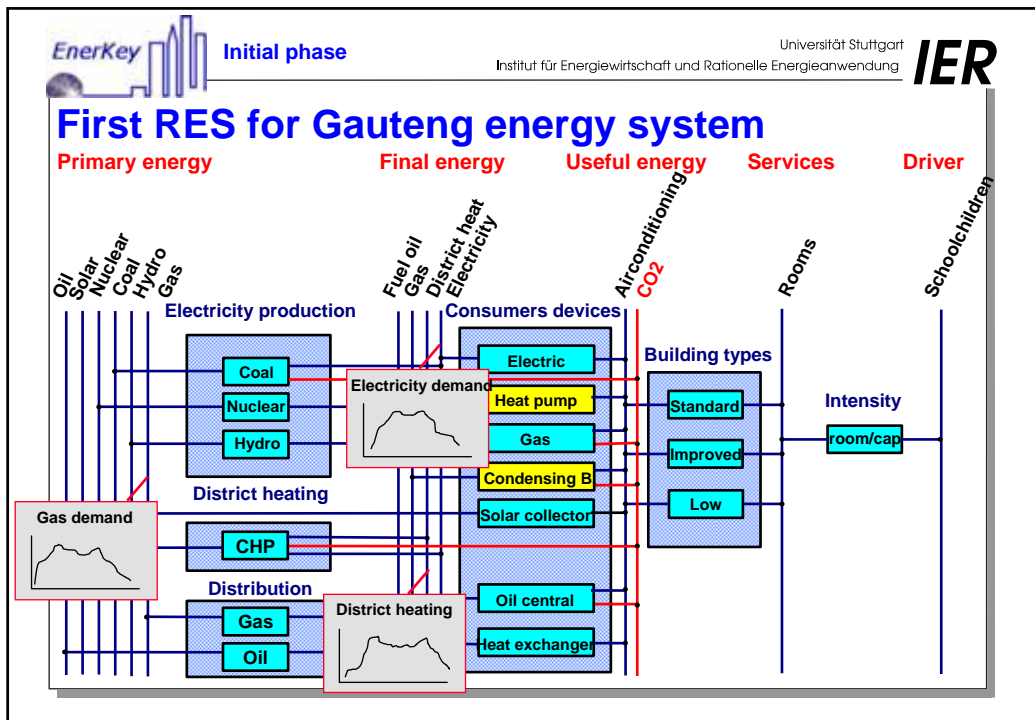




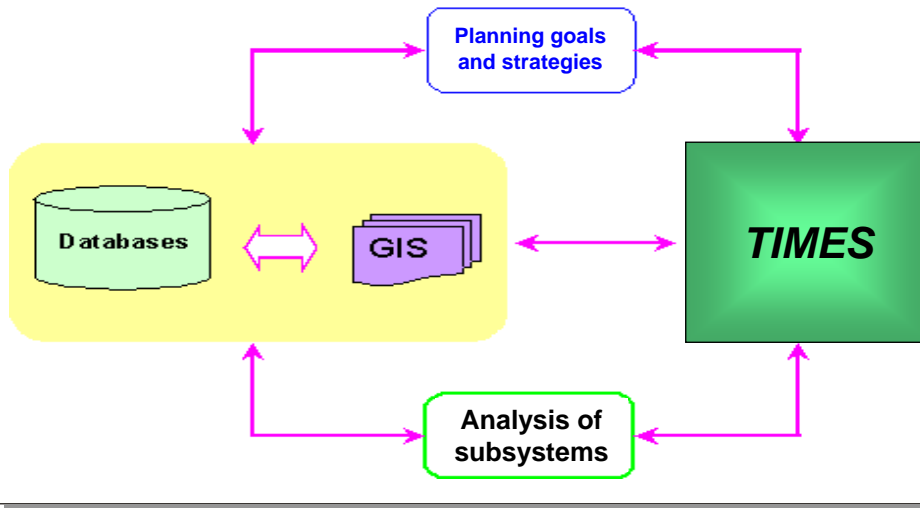
EnerKey **Initial phase** Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung **IER**

Acquisition and availability of data

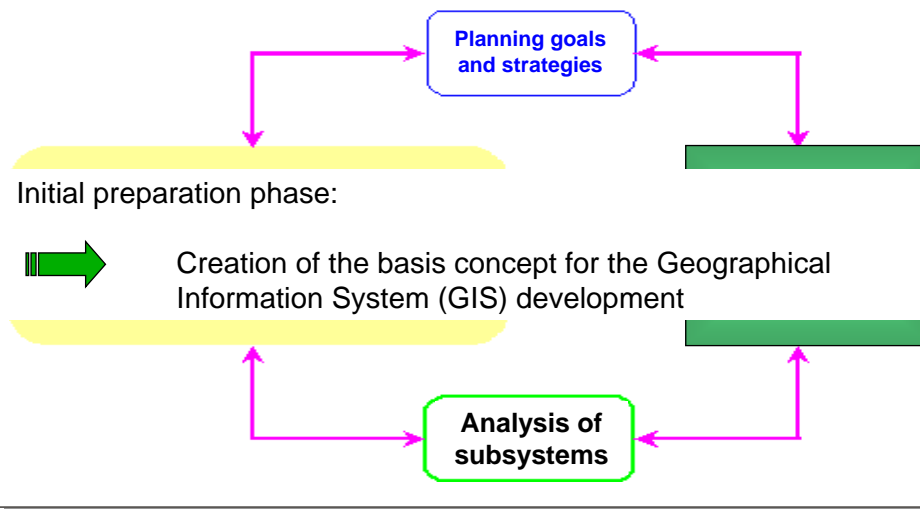
- Collecting statistical data on energy consumption by sectors and technology type, especially in the segment of the pilot project
- Economical and technical data on electricity and heat generation facilities and heat transmission and distribution system
- Data and assumptions for socio economic drivers
- Identification of first technical and environmental data for new energy technologies on the demand and the supply side



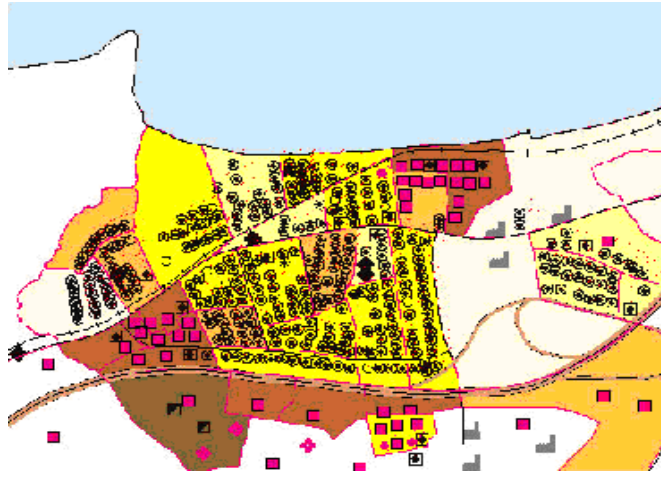
Combination of bottom-up and top-down approach



Combination of bottom-up and top-down approach

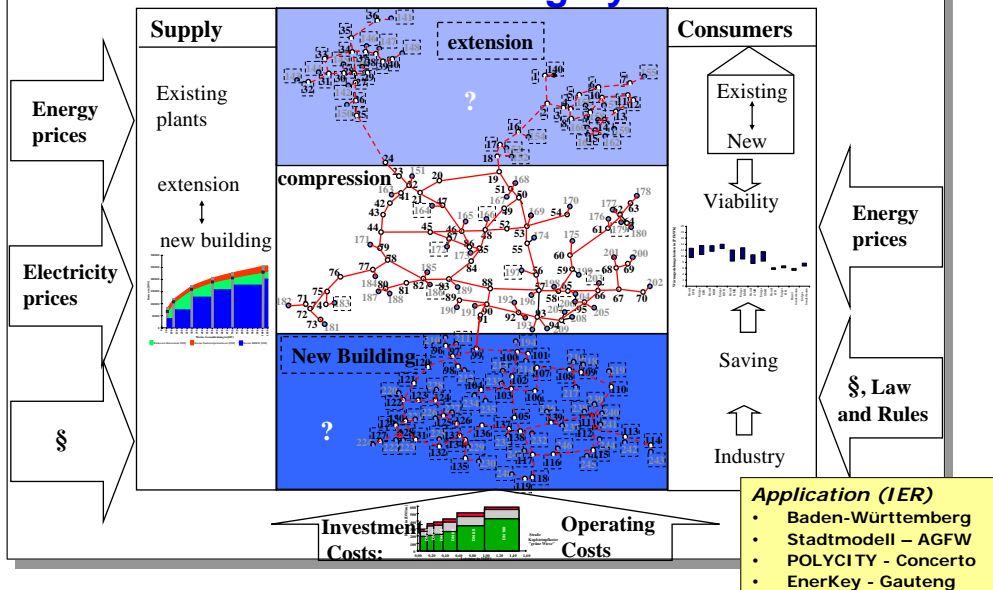


Geographical Information System (GIS)



Demand for air conditioning and cooling, heat map, road traffic etc.

Network Planning System



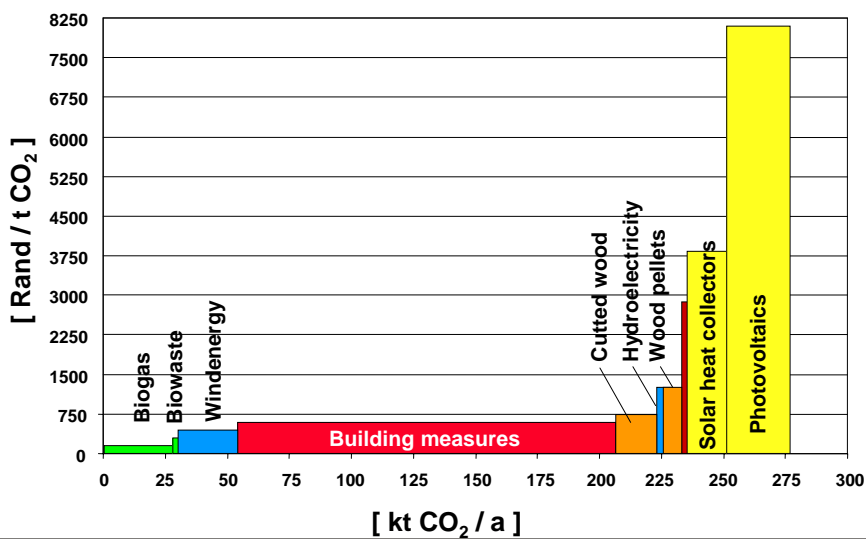
Policies and Measures

- Demand Side Efficiency
- Supply Side Efficiency
- Renewable Energy Sources
- Fuel switching
- Electrification and other infrastructure
- Energy-conscious behaviour




Result: Potentials and costs of different measures calculated with the integrated energy modeling system (Consistency !)

Cost-Potential-Curve of different measures



Scenario analysis => What happens, if ...

- Measures oriented scenarios
- Objective oriented szenarios
- Sensitivities (floor space, economic growth, energy prices, ...)
- Comparison of sustainability indicators

 Result: Integrated concept of an economic and ecological sustainable municipal energy system with robust steps to provide affordable, accessible and reliable energy services while recognising equitable distribution in meeting those needs

Why energy system modeling ?

Energy system models are an essential tool to enable policy makers to see the implications of current decisions on energy sustainability in the future.

The models are designed to find, among different alternatives, the one which satisfies the best market allocation of limited resources, e.g. biomass, natural gas, taking into account different exogenous constraints, e.g. emission limits, and decision criteria.

In **EnerKey**, the integrated model approach can be adopted to assess the overall energetic, economic and environmental effects and results for the different municipalities, the Gauteng region in total and for developing an overall energy and sustainability strategy.

The models can show the conflict potential of different planning goals and objectives.

the end