TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Introduction Research Center of Transport Planning and Traffic Engineering

Faculty of Civil Engineering

Institute of Transportation

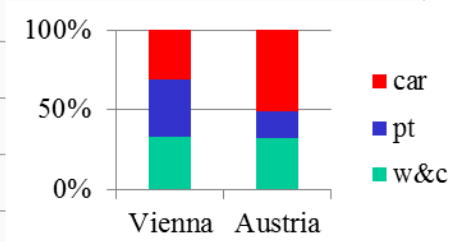
G. Emberger

Vienna, 2018

Where is Austria?

Basic facts Austria - Vienna

Capital and largest city		**Vienna (1,8 mio inhabitants)**
Official language		**German**
Ethnic groups (2011)		**•81.1% Austrians[2]** **•7.0% ex-Yugoslavs** **•4.0% Turks** **•7.9% other**
Area		**83,855 km^2 (115th)**
Population	**2011 estimate**	**8,414,638 (92nd)**
	Density	**100.3/km^2 (107th)**
GDP (nominal) 2012 estimate per capita		**$47,083**
Currency		**Euro (€)**
Motorisation rate	**Vienna** [cars/1000 inh.]	**385**
	Austria [cars/1000 inh.]	**537**
Modal split	**Vienna**	
	Walking & Cycling / pt / car	**33 / 36 / 31**
	Austria	
	Walking & Cycling / pt / car	**32 / 17 / 51**



TU Vienna overview

Vienna University of Technology

- founded 1815
- 4.500 staff
- 27.000 students
- 9 faculties
- 250 mio € turnover
- 70 mio € project funding
- more info at www.tuwien.ac.at

Faculty of civil engineering

- 140 staff
- 2.000 students
- more info at www.bauwesen.tuwien.ac.at

Transportation

IVW

Institute of
Transportation

Head: Univ.Prof. Dipl.-Ing. Dr.techn. Ronald Blab

Research Center of
Railway Engineering, Traffic Economics and Ropeways

Head: Univ.Prof. Dipl.-Ing. Dr.techn. Norbert Ostermann

Research Center of
Road Engineering

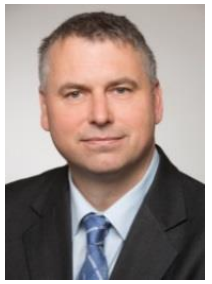
Head: Univ.Prof. Dipl.-Ing. Dr.techn. Ronald Blab

Research Center of
Transport Planning and Traffic Engineering

Head: Univ.Prof. Dipl.-Ing. Dr.techn. Josef Michael Schopf

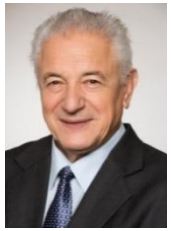
Overview TUW-IVV

Staff



- *Professors:* Guenter Emberger (Head since 2017)
  Thomas Macoun
  Josef Michael Schopf (retired 2017)
  Hermann Knoflacher (em. since 2008)



- *Office:* Angelika Haller
- *Assistants:* Brezina, Dimova, Frey, Lemmerer, Leth, Pfaffenbichler, Ripka, Shibayama, Winder









- *Ph.D. Students: Wejwithan, Aminian, Validi*


Mission Statement

FVV stands for interdisciplinary mobility research for a human development towards sustainability

- People and their environment are the basis of our work
- We aim for a broad understanding of transport planning, including
  - ecological,
  - social,
  - psychological,
  - economical and
  - technical aspects,

  and taking into account **interrelations** and **feedbacks**

We combine

teaching ⇆ research ⇆ planning ⇆ training

Introduction – projects at TUW-IVV

- Since 2008 the Research Center has worked on
  - more than 50 international projects and
  - more than 160 national projects
  - more than 90 transport master plans since the 1970ies.
  - memberships in more than 15 national and international research networks
- An overview and links to further information could be found on our webpage:
  - www.ivv.tuwien.ac.at/forschung/projekte/international-projects.html
  - www.ivv.tuwien.ac.at/forschung/projekte/nationale-projekte.html

Research Topics

- E- mobility,
- sustainable transport,
- cycling, active mobility, public transport,
- travel behaviour studies - surveys,
- land use and transport interaction modelling,
- 4-stage-transport-modelling,
- GHG- modelling,
- transport master plans and assessment,
- freight transport, E-delivery concepts
- barrier free public spaces
- etc.

Research international

Co-operation with more than 230 research institutions in Europe and worldwide through international research

Why did we start doing SD?

- 1992 - 1994 work together with Dennis Meadows (Club of Rome, Limits to Growth)
- 1993 - started to learn SD modelling on my own, using STELLA/ITHINK
- 1996 - first SD lecture for students
- 1998 – training course to become a System Thinker (Dennis Meadow, Fish banks trainer in Bonn (GER))
- 1997 – first prototype of LUTI model (this time sketch planning model in Excel/VB (Igor Ripka/ Paul Pfaffenbichler)

Why did we start doing SD?

- 1998 - met and made an liaison with Guenther Ossimitz (1958 – 2013) – SD Mega Link List (http://archive.is/FcjU)
- 1998 – 2002 Irregular meetings to exchange ideas/knowledge
  - founding of www.systemdenken.at – not existing anymore
  - Just for fun we organised beer games – Ottokringer Brewery 2001, Schleppe Brewery 2002 (biggest beer game in the world ~ 100 gamers simultaneously) http://beergame.uni-klu.ac.at/event.htm
  - Peak of the Austrian System Thinking group in 2002 the group dissolved (reasons Guenther Ossimitz became serious ill, I was in UK, the others were either students or not involved enough)

- 1995 -1999 - made the underlying modelling work for SPM/MARS in my thesis, finished 1999, using CLD
  - developed some methodology to asses CLDs such as:

    path number analyses, path length analyses, path orientation analyses, Path time duration/delay analyses, some attempt of identification of dominating loops
- 1998 – 2001 - together with Paul Pfaffenbichler improved existing VBA SPM (OPTIMA,FATIMA, PROSPECTS)
- 2002- 2004 guest researcher at ITS Leeds, convincing PP, SS to switch from VBA to VENSIM + need for Acronym →**MARS was born**

since 2004 till today

- series of MARS applications worldwide
- MARS improvements (more means of transport, intra zonal traffic handling, dynamic GIS mapping tool, utilization of VENSIM in-built optimizer for calibration, policy optimization, etc)
- more modelling work and new model developments, mainly from PP – more info on following slides

SD activities at IVV

- **Education / lectures**

  Since 1996 regular student lectures – “Computer aided methods for solving complex problems – Causal loop diagramming, SD-modelling using Stella and Vensim”

  - to introduce the concept of “sytems thinking”
  - to be able depict mental models and make them discussable
  - to show the difference of qualitative and quantitative system modelling
  - to develop own SD-models

  More info could be found at http://www.ivv.tuwien.ac.at/lehre/archiv-studentenarbeiten/ue-computerunterstuetzte-loesungen-in-komplexen-systemen/ and http://www.ivv.tuwien.ac.at/lehre/archiv-studentenarbeiten/ue-regelkreisbasierte-simulationsmethoden/

- **Academic and real world modelling case studies**

  more details later

Why Vensim

We are using VENSIM for our research because of:

- STELLA/ITHINK were not able to handle more dimensional data (arrays –needed in transport planning (OD-matix, trip purpose, time of the day, means of transport)
- There is a free VENSIM version available for students
- It is relatively easy to learn (lot of examples, good handbook, intuitive understandable, own experience at IVV)
- Has an in-build optimizer tool (can be used for parameter estimation, calibration, optimization, etc…)
- Interface to Excel – easy data holding for underlying models

- More information can be found at http://vensim.com/

Portfolio of System Dynamics models at TUW-FVV

Topic	Acronym
Land use and transport interaction	MARS
Long distance leisure and business travel	LUNA
Market penetration electric propulsion technologies	SERAPIS
Indirect rebound effects between transport, heating & appliances	URANUS

MARS (Metropolitan Activity Relocation Simulator)

- **Start of development**: 2000
- **Topic**: Strategic land use and transport interaction modeling
- **Coverage**: different versions from local (cities) to national (Austria), first version Vienna subdivided into 23 zones
- **Background**: proSpects
- **Link**: www.ivv.tuwien.ac.at/forschung/mars-metropolitan-activity-relocation-simulator

MARS (**M**etropolitan **A**ctivity **R**elocation **S**imulator)

- Overview case studies (>25)

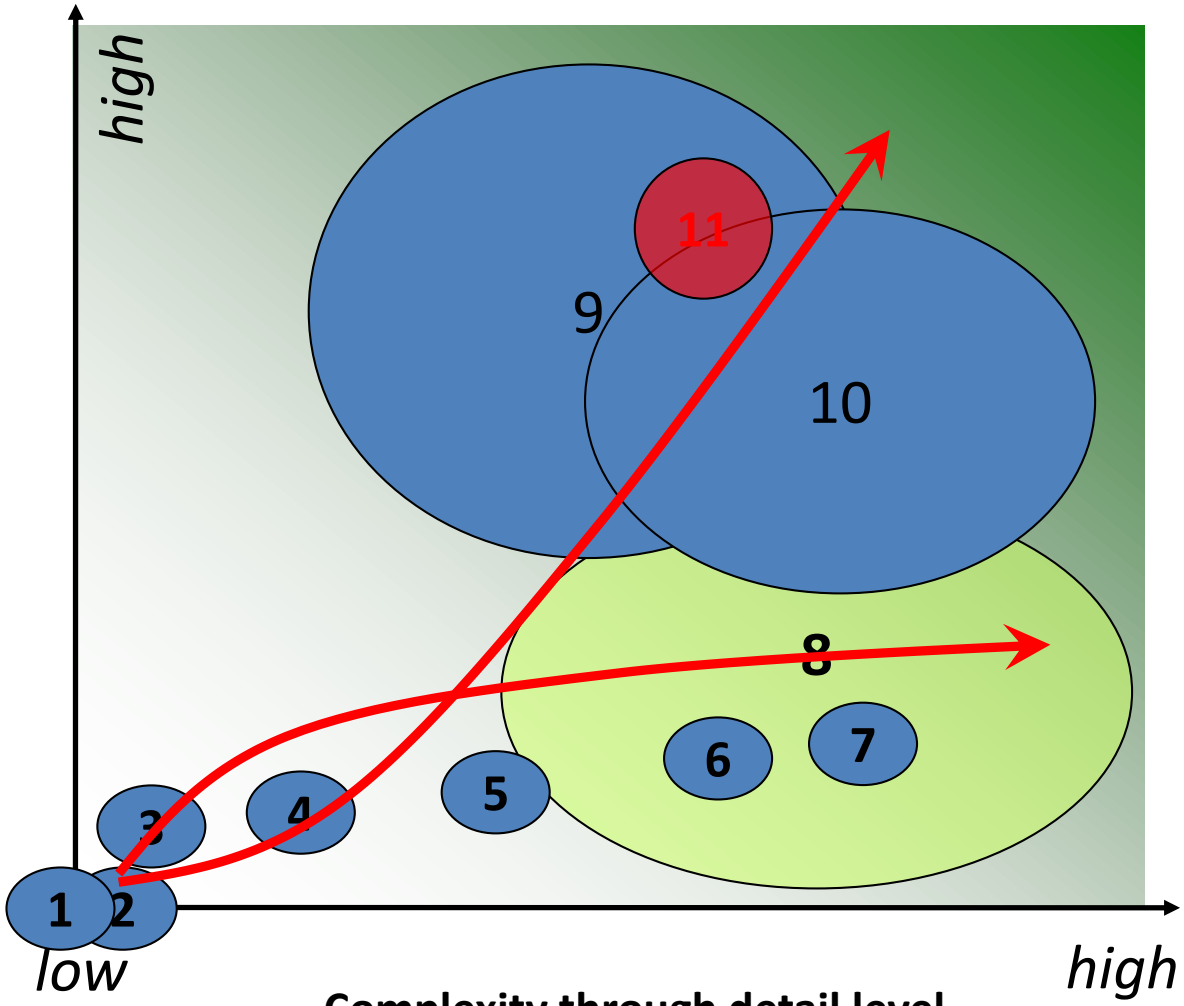
MARS Applications – case studies

Gateshead, Leeds, Edinburgh (GBR)	3
Oslo, Trondheim (NOR)	2
Helsinki (FIN),	1
Vienna, Salzburg, Eisenstadt, Carinthia, Austria (AUT)	4
Madrid (ESP),	1
Stockholm (SWE),	1
Ho Chi Minh City, Hanoi (VIN)	2
Chiang Mai (THA), Ubon Ratchantani (THA)	2
Washington DC (USA),	1
Porto Alegre (BRA),	1
Bari (ITA),	1
Mulhouse (FRA), Straßbourgh (FRA)	2
Niigata (JPN)	1

MARS (Metropolitan Activity Relocation Simulator)

- **Modes of transport**: Walking, Cycling, Motorcycle, Private car (ice & bev), Bus/coach, Railway, Informal PT (Tuk Tuk, etc.)
- **Trip purposes**: Commuting, Others
- **Main Sub-Models/Modules**:
  - a travel demand model,
  - a household location model,
  - a workplace location model model,
  - a policy definition user interface,
  - a module calculating process and evaluation indicators and
  - an dynamic GIS mapping tool for spatial temporal visualization.
- **Time horizon**: typically 30 years in steps of ¼ years

Model Classification



Complexity through systems involved
data sources
set up cost / maintenance cost / run time

Complexity through detail level
data requirements
set up cost / maintenance cost / run time

1. No model
2. Simple cost based
3. Spreadsheet model
4. Sketch planning model
5. Network assignment model without elastic assignment
6. Network assignment model with elastic assignment
7. Network assignment model in conjunction with external demand / mode-choice model
8. Four stage models
9. Land-use Transportation Interaction (LUTI) model
10. Strategic Transport/Environment Model
11. MARS

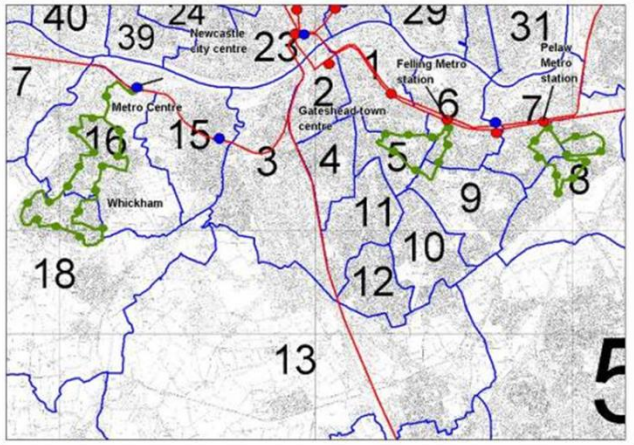
MARS (Metropolitan Activity Relocation Simulator)

- Research questions:
  - Optimisation of single instruments and policy instrument combinations (PROSPECTS, SPECTRUM, FUNDING)
  - Assessing the effects of
    - metro line extensions (PhD thesis Vieira)
    - high occupancy and bus lanes (PhD thesis Vieira)
    - scarcity of oil supply (STEPS)
    - different scenarios of automated driving (CityMobil)
    - take up of e-mobility (Emob_Wien, EIFER-Perithel)
    - land use policies (EISERN, MARS-Kärnten, EIFER-Perithel)
    - bus rapid transit and informal PT (PhD thesis Top), etc.
  - Identify strategies to reduce GHG-emissions (GHG-Transpord)
  - Estimate direct rebound-effect (URBE), etc.

MARS (Metropolitan Activity Relocation Simulator)

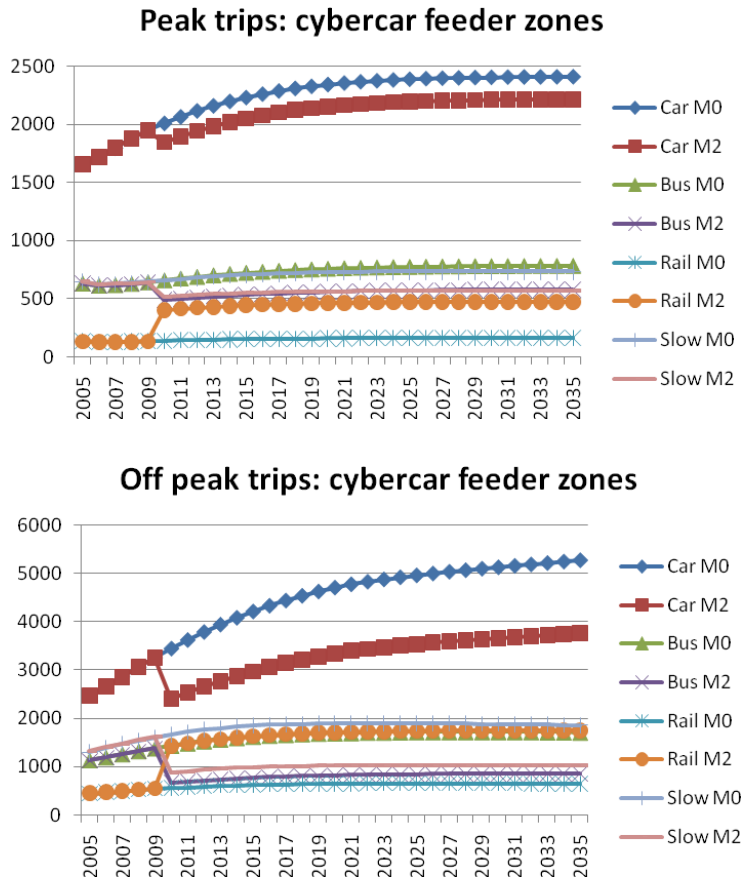
- Assessing scenarios of automated driving
  - Cycbercar PT feeder system in Gateshead Tyne and Wear
    - A system of fully automatic, clean, driverless vehicles

www.citymobil-project.eu



MARS (Metropolitan Activity Relocation Simulator)

- Assessing scenarios of automated driving
  - Cycbercar PT feeder system in Gateshead Tyne and Wear



In 2035, introduction of cybercar results in:

- Car: 8% peak decrease, 30% off peak decrease
- Bus: 36% peak decrease, 50% off peak decrease
- Rail: 193% peak increase, 170% off peak increase
- Slow: 29% peak decrease, 45% off peak decrease

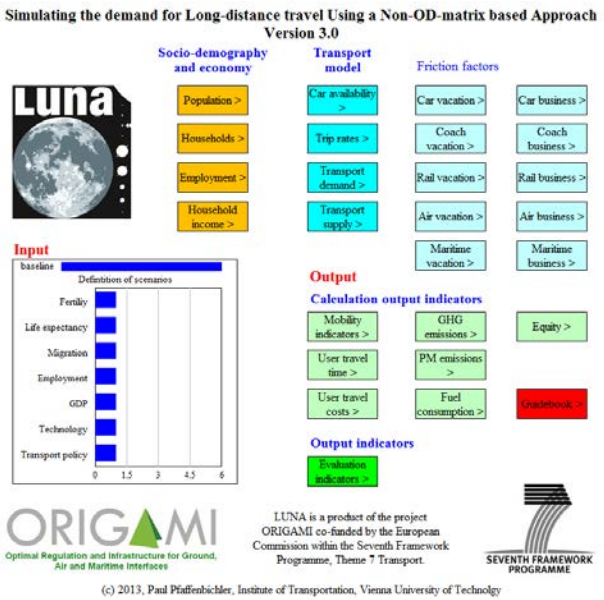
LUNA (Simulating the demand for **L**ong-distance travel **U**sing a **N**on-OD-matrix based **A**pproach)

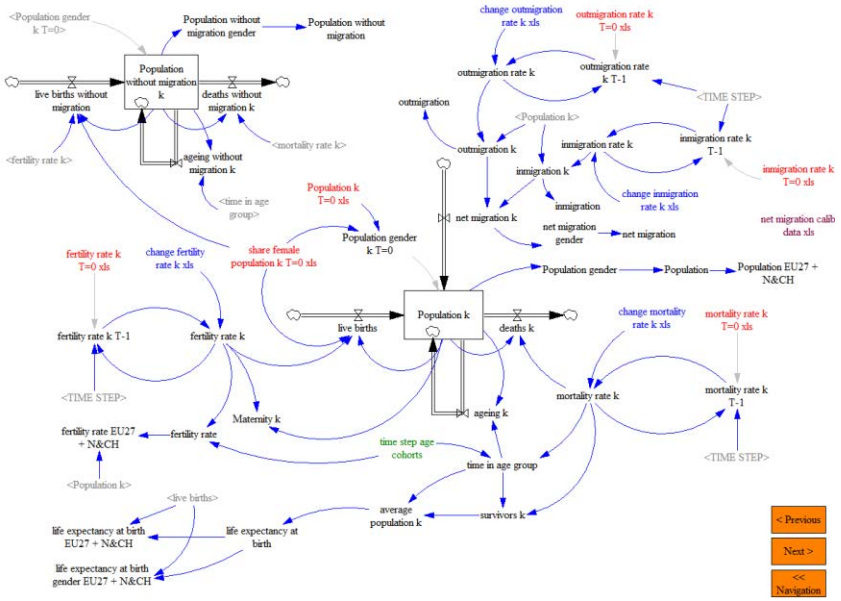
- **Start of development**: 2011
- **Topic**: Multimodal estimation of long distance travel demand (leisure and business trips)
- **Coverage**: EU27 plus Norway and Switzerland on a national level
- **Background**: ORIGAMI SEVENTH FRAMEWORK PROGRAMME
- **Link**: www.ivv.tuwien.ac.at/forschung/projekte/international-projects/origami-luna/ & www.transport-research.info/project/optimal-regulation-and-infrastructure-ground-air-and-maritime-interfaces

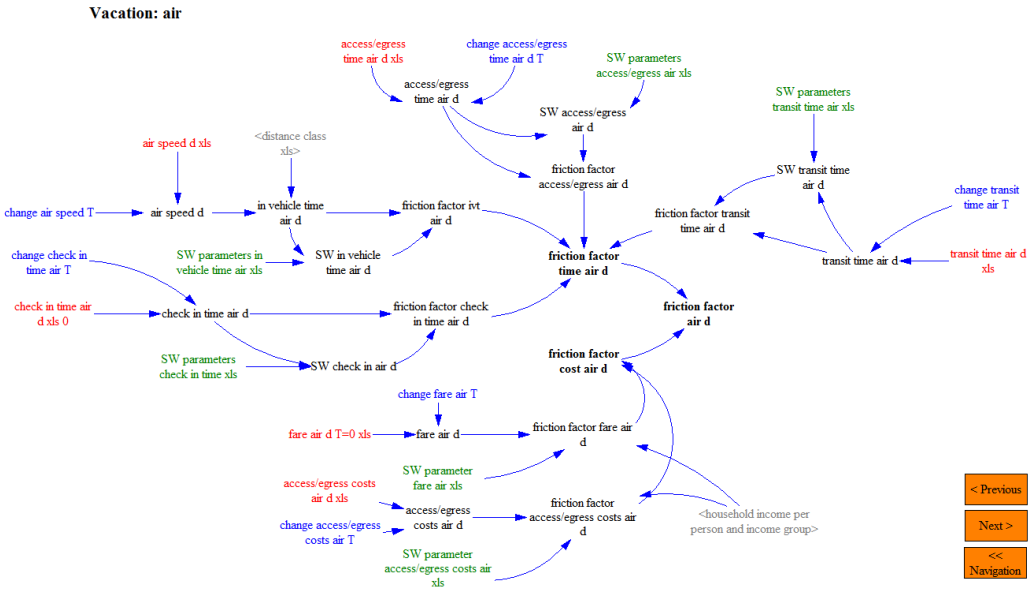
LUNA (Simulating the demand for **L**ong-distance travel **U**sing a **N**on-OD-matrix based **A**pproach)

- **Modes of transport**: Private car, Bus/coach, Railway, Air and Maritime
- **Trip purposes**: Vacation, Business
- **Sub-Models/Modules**:
  - a population cohort model,
  - a household formation model,
  - a car ownership model,
  - a non-OD-matrix based transport demand model,
  - an aggregate transport supply model and
  - a module calculating evaluation indicators.
- **Time horizon**: 2010 to 2050 in time steps of one year

LUNA (Simulating the demand for **L**ong-distance travel **U**sing a **N**on-OD-matrix based **A**pproach)



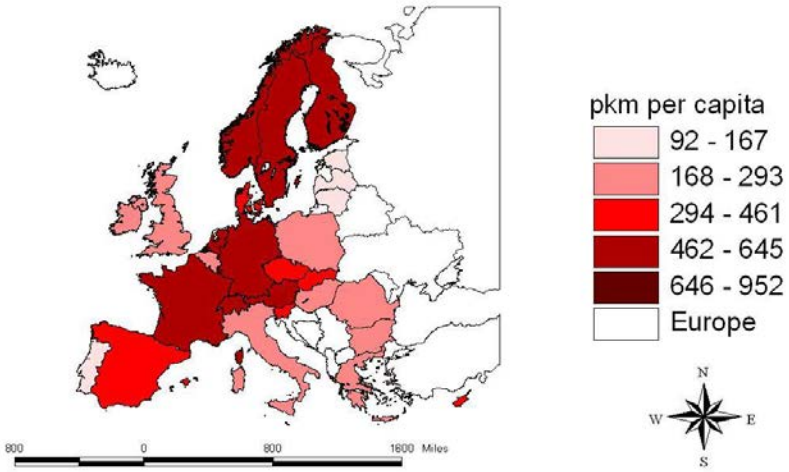




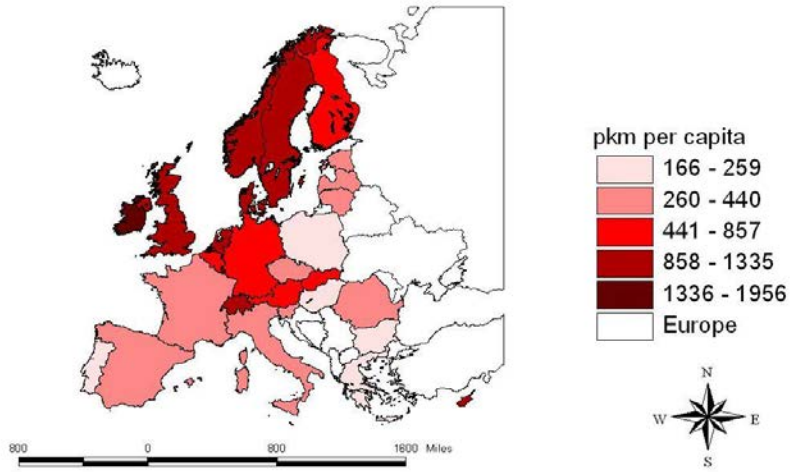
LUNA (Simulating the demand for **L**ong-distance travel **U**sing a **N**on-OD-matrix based **A**pproach)

- Results

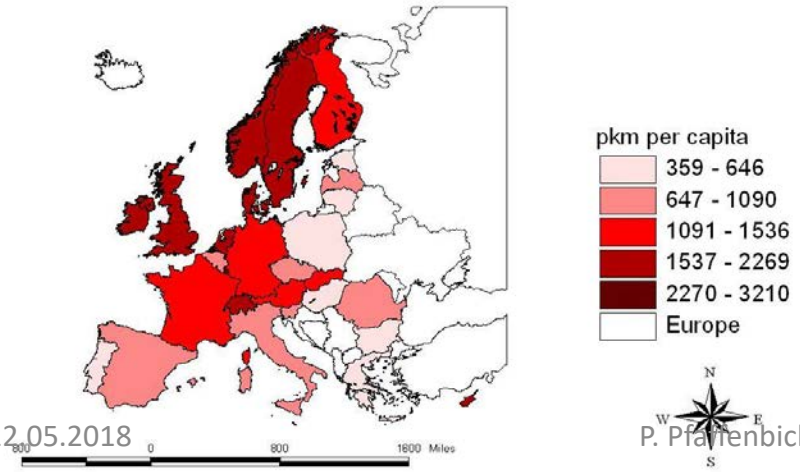
Car 2010



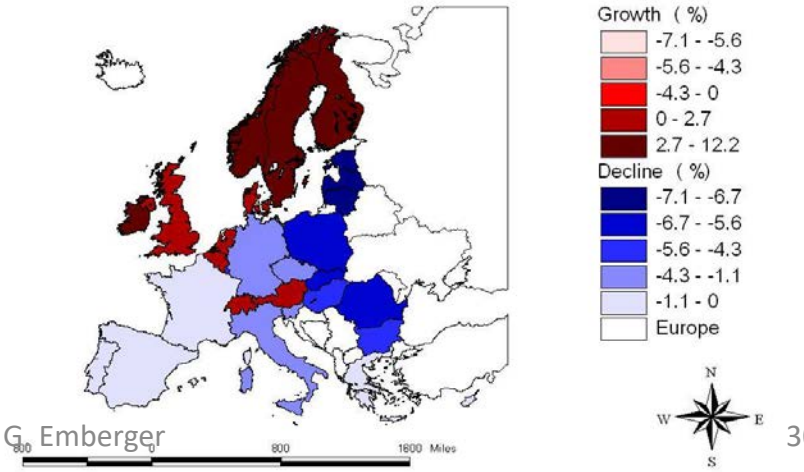
Air 2010



Total 2010



Difference Normative - Baseline 2050

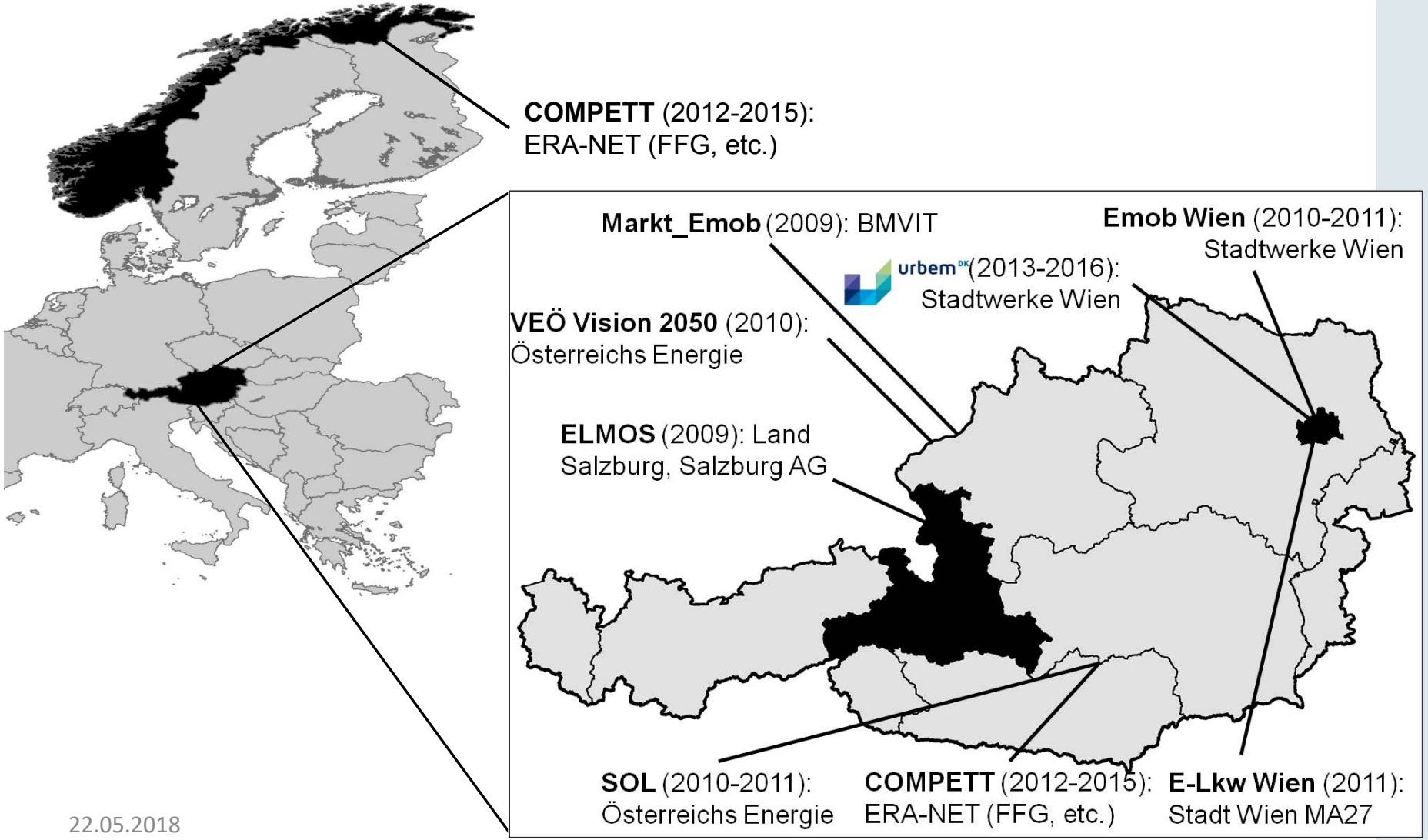


SERAPIS (Simulating the Emergence of Relevant Alternative Propulsion technologies in the car and motorcycle fleet Including energy Supply)

- **Start of development**: 2009
- **Topic**: Modelling consumer choice of propulsion technology (ICE, PHEV, BEV)
- **Coverage**: Austria (9 counties), Norway (428 districts)
- **Background**: Pre-feasibility study e-mobility on behalf of the Austrian Ministry for Transport, Innovation and Technology
- **Link**:
  e.g. http://compett.org

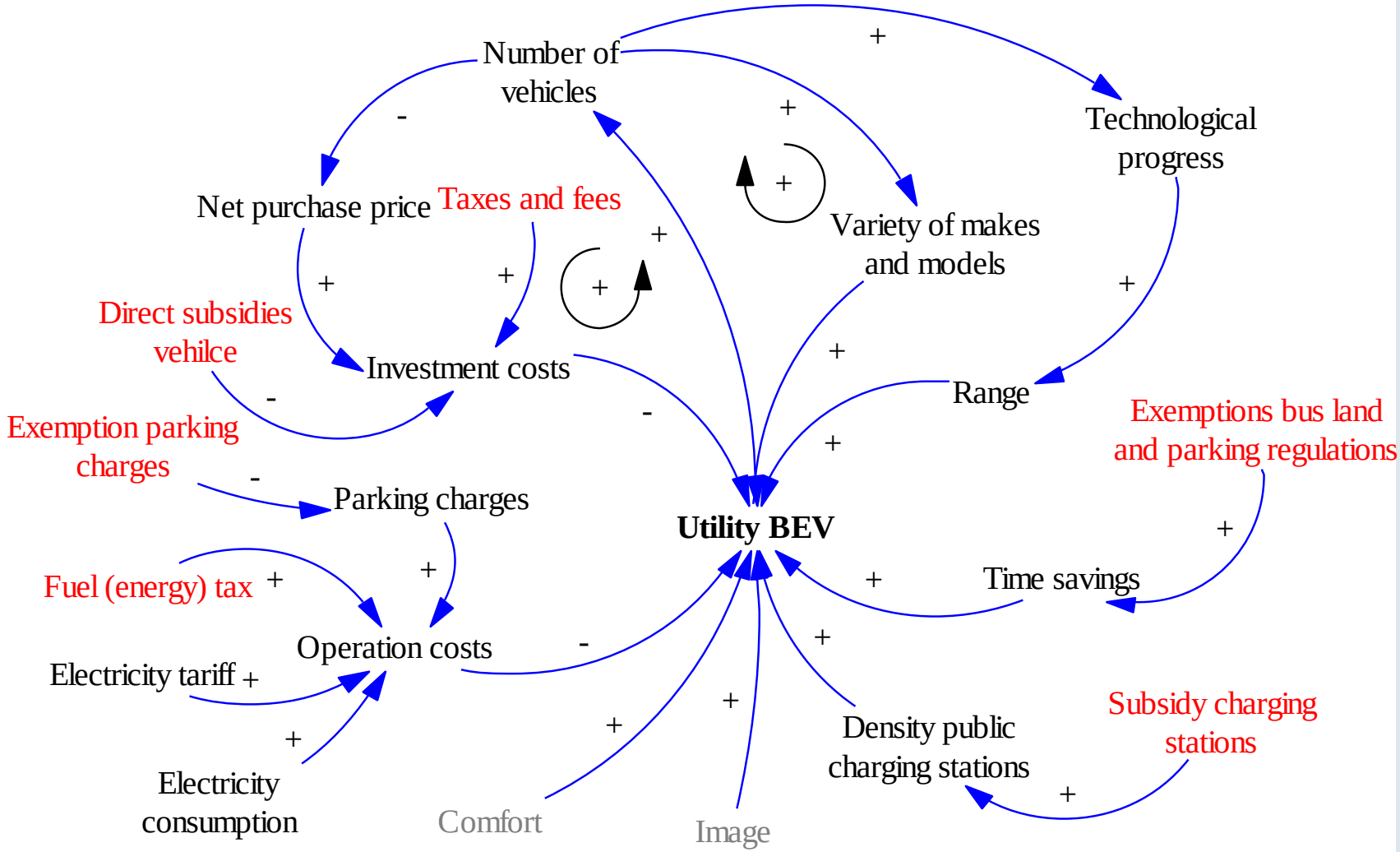
SERAPIS (**S**imulating the **E**mergence of **R**elevant **A**lternative **P**ropulsion technologies in the car and motorcycle fleet **I**ncluding energy **S**upply)

- Overview case studies



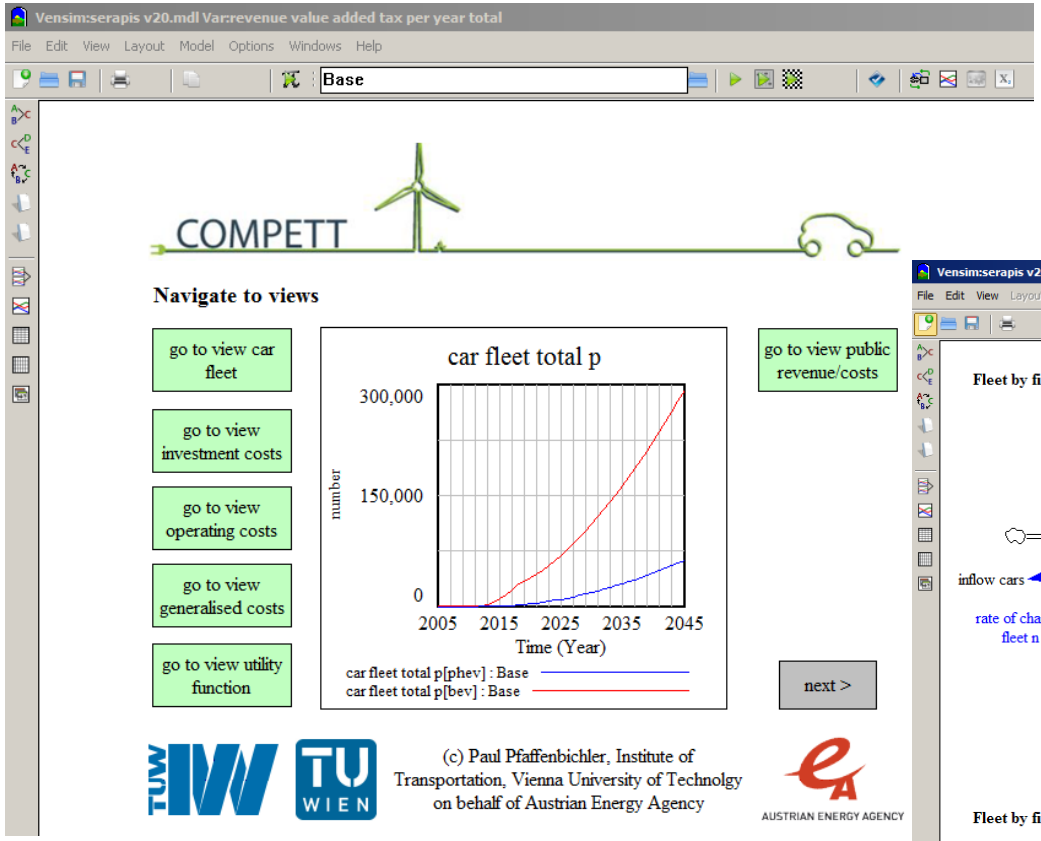
- **Vehicle characteristics**:
  - Propulsion technology:
    - ICE: internal combustion engine incl. non-plug in hybrids (e.g. Prius)
    - PHEV: plug in hybrid & range extender veh. (e.g. Prius Plug In, Volt)
    - BEV: battery electric vehicles
  - Utilisation:
    - 1st (or only) car
    - 2nd+ car
  - Size:
    - Compact (from micro-cars up to cars like Renault Clio, Volkswagen Polo etc.)
    - Family (from Volkswagen Golf, Ford Focus, etc. up to BMW 3, Mercedes C, etc.)
    - Luxury (BMW 5 and 7, Audi A6, A7 and A8, Mercedes E and S, Ferrari, Lamborghini, BMW X series, Jeep Wrangler, etc.)

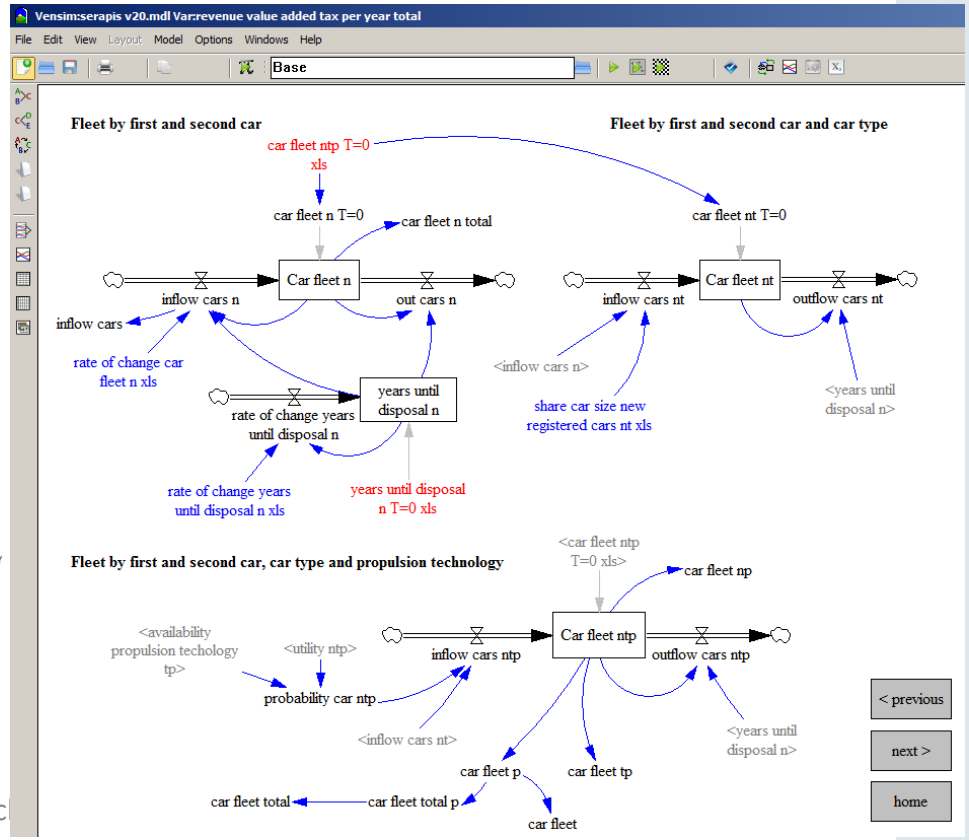
- Causal loop diagram utility BEV



SERAPIS (Simulating the Emergence of Relevant Alternative Propulsion technologies in the car and motorcycle fleet Including energy Supply)

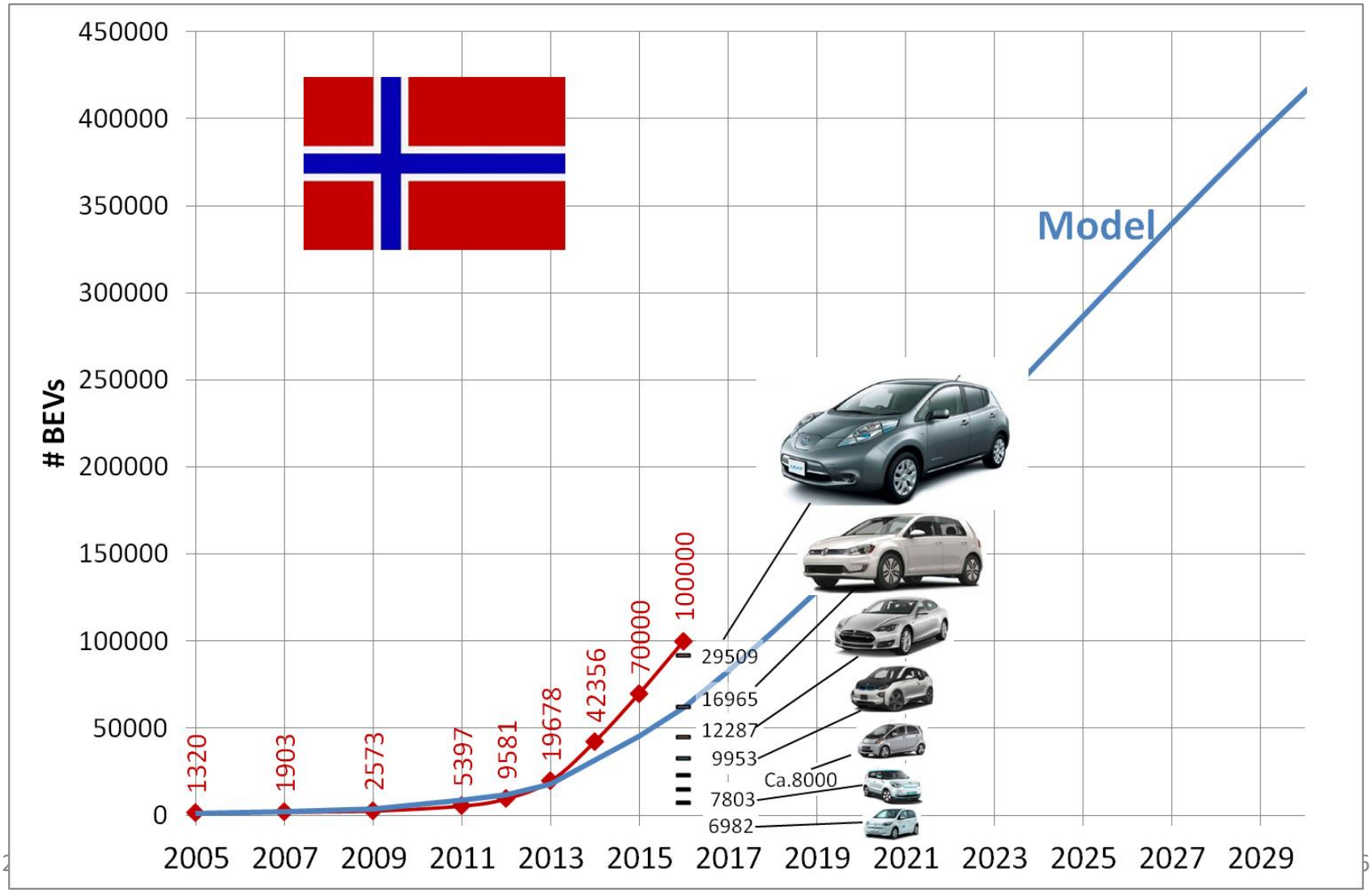
- Quantitative stock flow modelling





SERAPIS (Simulating the Emergence of Relevant Alternative Propulsion technologies in the car and motorcycle fleet Including energy Supply)

- Comparison Modelling Results - Statistics



URANUS (Causes of indirect rebound-effects between mobility, appliances and heating[1])

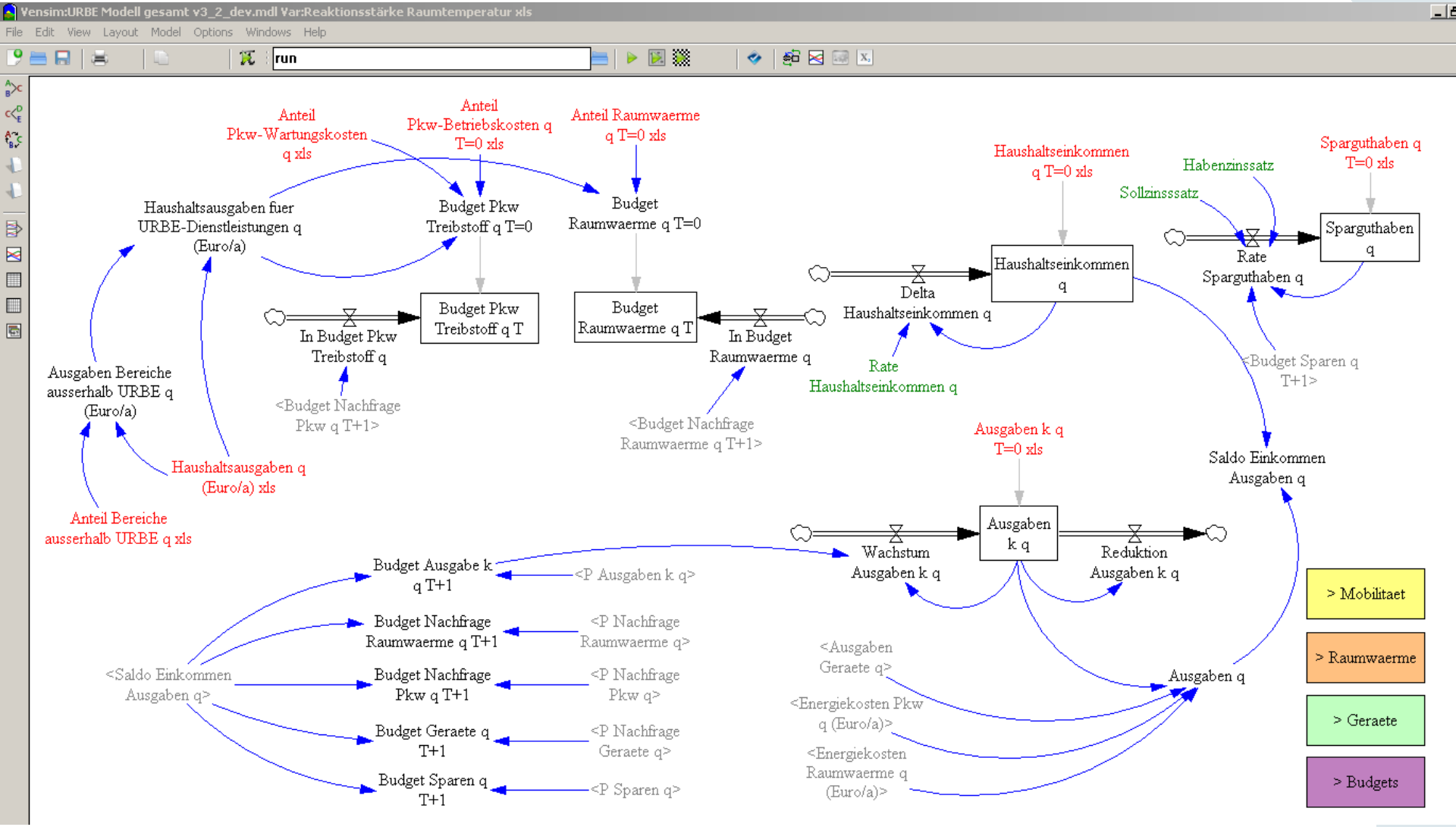
- **Start of development**: 2009
- **Topic**: Modelling the indirect rebound-effect of efficiency gains in the sectors personal mobility, appliances and heating
- **Coverage**: Austria
- **Background**: project URBE (Urban Rebound-Effects[2])
- **Link**: www.ivv.tuwien.ac.at/forschung/projekte/nationale-projekte/urbe/

1) Akronym in German: **U**rsachen indirekter **R**ebound-Effekte – **A**nalyse effizienzbedingter **N**achfrageänderungen in den Bereichen Mobilität, **U**nterhaltungselektronik und thermische **S**anierung
2) Original in German: Urbane Rebound-Effekte

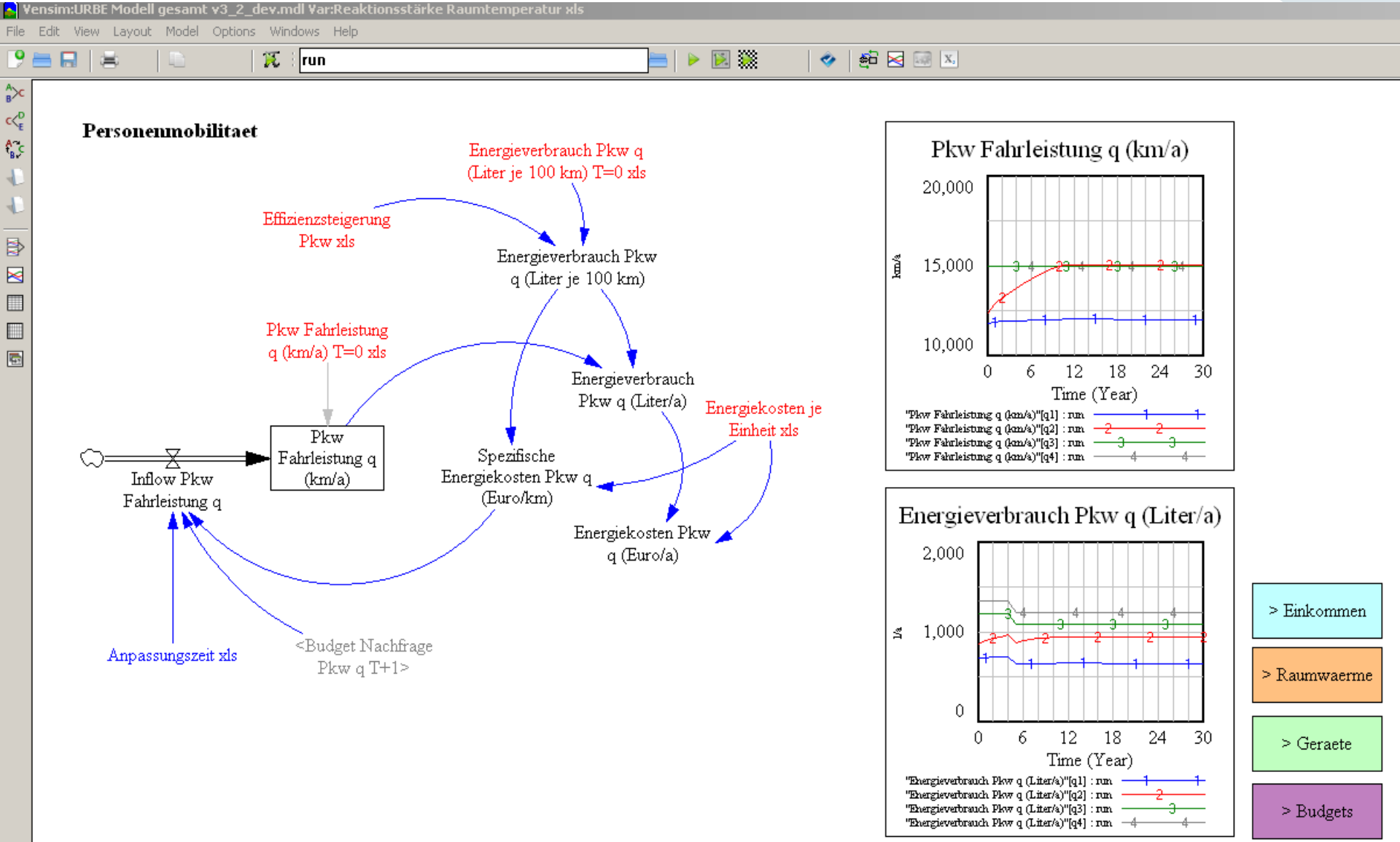
URANUS (Causes of indirect rebound-effects between mobility, appliances and heating)

- **Sectors**: personal mobility (private car), appliances, heating
- **Sub-Models/Modules**:
  - module balance income - spending - saving,
  - demand model personal mobility (private car),
  - demand model appliances,
  - demand model heating and
  - model of allocation of monetary resources.
- **Time horizon**: 30 years

URANUS (Causes of indirect rebound-effects between mobility, appliances and heating)



URANUS (Causes of indirect rebound-effects between mobility, appliances and heating)



URANUS (Causes of indirect rebound-effects between mobility, appliances and heating)

- The rebound effects are higher than estimated in the literature
- The technical improvements are compensated by the rebound effects
- People spent the saved money to buy more things/activities which consume more energy as in the status quo
- Only through implementation of policy packages also in other sectors can minimize the occurrence of rebound effects

Summary

- long experience at TU Vienna – FVV
- very difficult to teach system thinking in tradional structured curricula of civil engineering
- 1 single lecture is not enough to spread the knowledge to students
- System thinking and SD modelling is maybe to complex for master theses (had only one in my whole career – I was not satisfied with outcome)
- at present – most of PhD theses are applications and not developments of new SD models (again very hard for students)
- need for an international network using SD as methodology in transport planning/civil engineering

Outlook

Extending our knowledge through further

1. **Research activities** (application/development of SD concept on further research questions
2. **Teaching and education** programs for students national and if possible also international
3. **Publications**

SD is be a very important tool to gain more insight into complex, dynamic, non-linear systems with feedbacks

Would like to hear your opinion how we should proceed?

Cooperation & Competence

Further information http://www.ivv.tuwien.ac.at/

Contact

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Paul.Pfaffenbichler@tuwien.ac.at

Thank you very much for your attention and good cooperation in the future!