A review of tools, methods, and approaches for smart cities: the experience of EERA JP Smart Cities Taskforce on Simulation Platform Development

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what it is

the Simulation-Task Force ?

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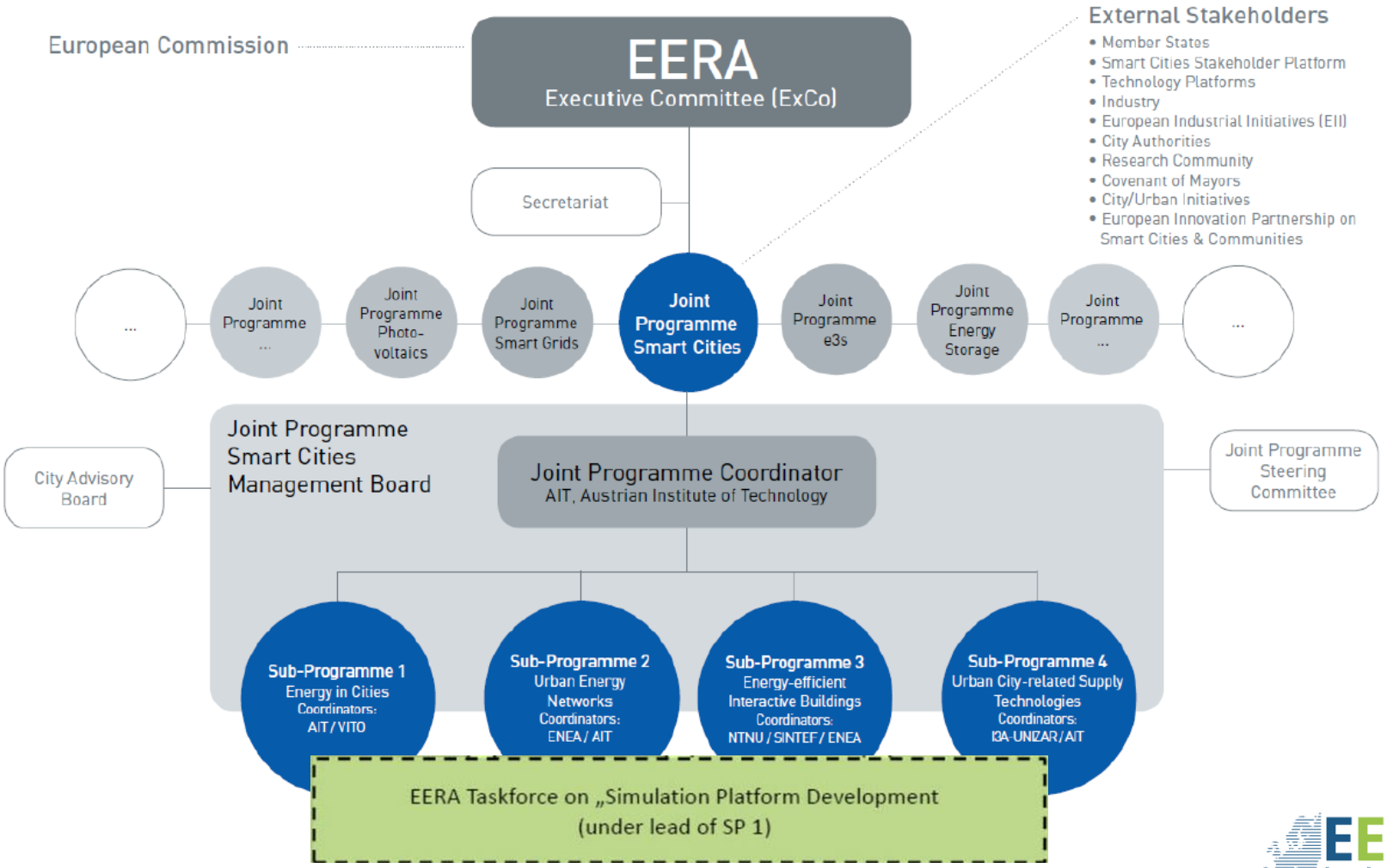
What it is the Sim-TF?

- Taskforce on Simulation Platform Development is framed in the EERA Joint Programme (JP) on Smart Cities



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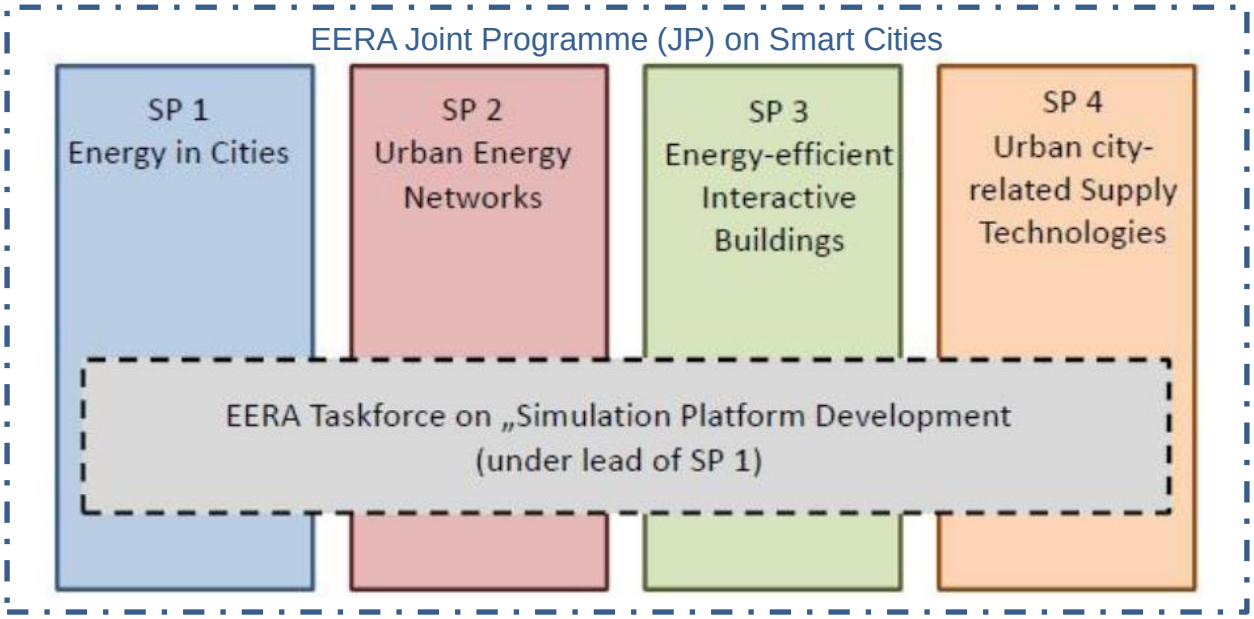

- Modeling and simulation techniques play a major role for the entire JP on Smart Cities with regards to method development;
- Within each sub-programme a broad range of tools and software packages are currently being developed and used by the participating partners for analyzing distinctive components and elements of urban energy systems and planning.

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The objectives of Sim-TF

- Evaluate the **State-of-the-art** of modelling and simulation of urban planning and energy systems and at different levels (buildings, district and city);
- Identify **gaps** and **barriers** in current modelling and simulation techniques.
- Specify **user requirements** and **functionalities** of tools useful for different urban stakeholders and decision makers involved in planning and energy projects.
- Translate these requirements into a **technical specification** for the urban energy simulation platform of the future.
  - Acquisition, sanitation and management of data will be key.
  - Different simulation approaches may be required at different levels of spatiotemporal aggregation
  - The platform should be extensible to accommodate complementary simulation capabilities in the future

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What has been addressed so far

- Introduction of already used tools within the Sim-TF members (ongoing)
- Find a way to **categorize** these different tools
- Search for **existing platform comparisons** (evaluations)
  e.g. “A review of computer tools for analyzing the integration of renewable energy into various energy systems”. (D. Connolly et al., 2010)
- Find ways to **collect** the information:
  - Advantages and disadvantages of these tools
  - For what can and should they be used
- First draft of a **questionnaire** for the SP1-SP4
  - To get what are their needs from the Sim-TF, what are the/their gaps

How

Sim-TF Survey on Modelling and Simulation in the context of Smart Cities

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Methodology - Composition of the questionnaire

- The questionnaire has the aim of mapping approaches, methods and tools (AMT) for urban planning support and energy systems simulation to develop smart cities

- It is organized in seven sections:
  - *PART A: Background and relation between science and policy decision makers*
  - *PART B: Model specific questions*
  - *PART C: Model use*
  - *PART D: Related to the link with other tools*
  - *PART E: Variables, parameter needs by the tools*
  - *PART F: Technical description*
  - *PART G: Documentation*

- The questionnaire is available on-line.

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which outcomes

We had from the test of the questionnaire internally in the Sim-TF

Responding Institutions

- The quuestionnaire has been tested internally among the partners in the Sim-TF. 13 questionnaire have been filled in so far from 9 Institutions in the Sim-TF.

  - *Norhumbria University – Newcastle upon Tyne*
  - *Sir Joseph SWN Centre for Energy Research*
  - *KTH – Energy Department, Heat and Power division*
  - *University of Strathclyde, Glasgow*
  - *Energy System Catapult*
  - *AIT - Austrian Institute od Technology*
  - *NTNU - Norwegian University of Science and Technology*
  - *Loughborough University*
  - *DTU - Technical University of Denmark*

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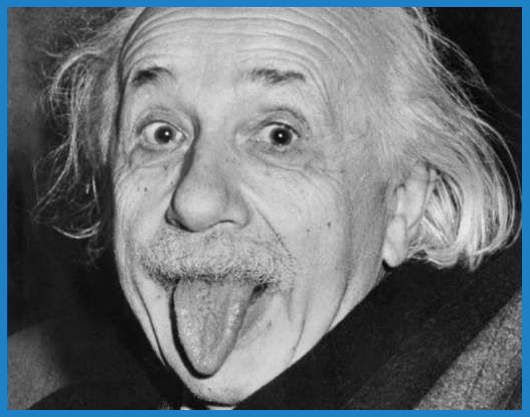
Part A

Background and relation between science and policy decision makers

Challenge

Policy makers

How they can speak and work together?



Researchers

Tools investigated

- MATLAB,
- Dynamic Energy System Optimizer,
- ESP-r
- Urban Development and Infrastructor Cost Simulator
- DIVA for Rhino
- ENVI-met
- Community Domestic Energy Model
- Energy+
- TRANSFORM Decision Support Environment

Used simulation methods

- System Dynamics,
- Stochastic methods,
- DES and ODE
- Multi-Method simulation

Outcomes:

Mainly Energy Systems models (50%)

Financed by funded research projects

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Can the tools be used without assistance?

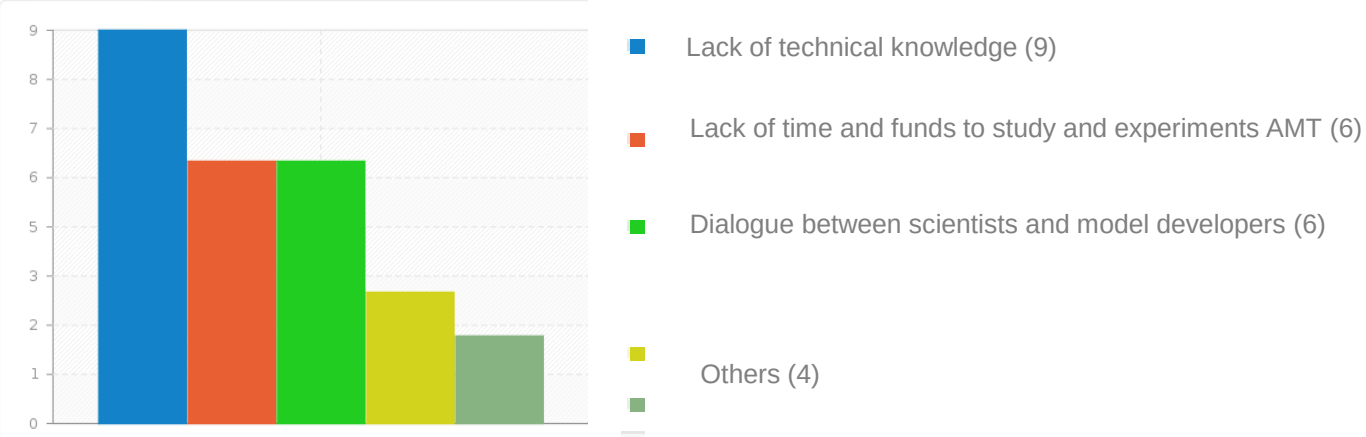
- Tools need assistance
  - Yes (2)
  - No (11)

Reason:
model complexity and level of development.
Wide ranging software and analysis skills are required.

What are the main challenges and barriers to use tools?

- Lack of technical knowledge
- Lack of funds and time to experiment
- Missing dialogue with the scientists and model builders and policy makers

Reason:
Lack of adequate preparation on specific topics, lack of informative and educational workshops and seminars



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Possible solutions to overcome the barriers

- Workshops and training courses
- Improve the interaction with researchers during the model development
- Only once mentioned to build tools that are easy to use

Suggestions:

With intense communication we can use the tools for stakeholders and help them to understand the outputs / strengths and limitations. The challenge is if stakeholders wish to use tools themselves. In these cases complexity and state of development make this impractical. Stakeholders often do not have the skills and resources required.

Suggestions:

Organize seminars and training sessions

Deep learning; skills, knowledge and practical experience

Purpose for the modelling tools

- Scientific publication and research (85%)
- To study and create new policy scenarios and new urban intervention in cities
- To study and predict climate risks' scenarios
- To provide data to urban planners/municipalities

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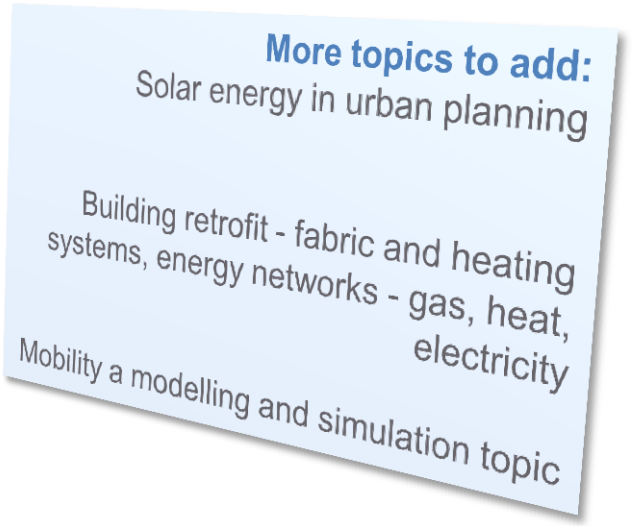
Energy related goals topics in the work with municipalities

1. Energy demand, Energy production
2. Climate mitigation and adaptation
3. Smart grid
4. Climate adaptation
5. Climate mitigation
6. ICT Technology
7. Water management
8. Green/Blue/Soft infrastructures
9. Air quality and pollution
10. Mobility and transportation



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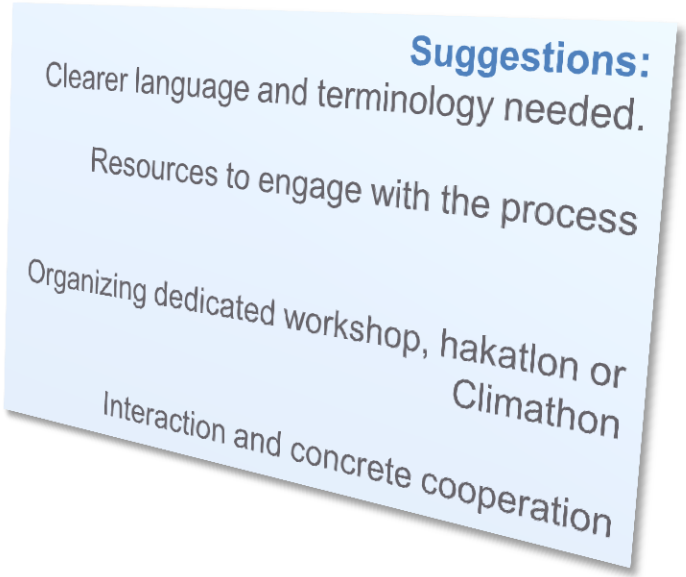
How is the experience in using models in the work with municipalities?

- Most often seen as difficult and complex but positive
- More often the researchers:
  1. Develop measures
  2. Provide data
  3. Generating options and supporting data to allow informed local decision makings
  4. Develop urban planning instruments
  5. To explore the climate challenges, issues and potentialities of the city
  6. Research collaboration; advice
- Communication:
  1. Graphs and diagrams
  2. Reports
  3. Visualization (images, videos, 3D graphics etc.)
  4. Presentations

How to improve the dialogue with the stakeholders?

- Competence and technical background (*for the stakeholder*)
- New instruments, tools and communication skills (*for the model builder*)



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Part B

Model specific questions

General modelling purpose

1. Strategic planning
2. Validation and verification (before, during the after the process)
3. Not often forecasting and control

Model development status and financing

- Mostly released or prototypes available
- Most often financed by funded research projects or the institute

Tool availability

- All are some how available (open source…), some have different versions open source and commercial versions
- Sometimes only within research projects available

Tool adoptability

- Tools can use external data to be parameterized by the user, but source code can often not be changed

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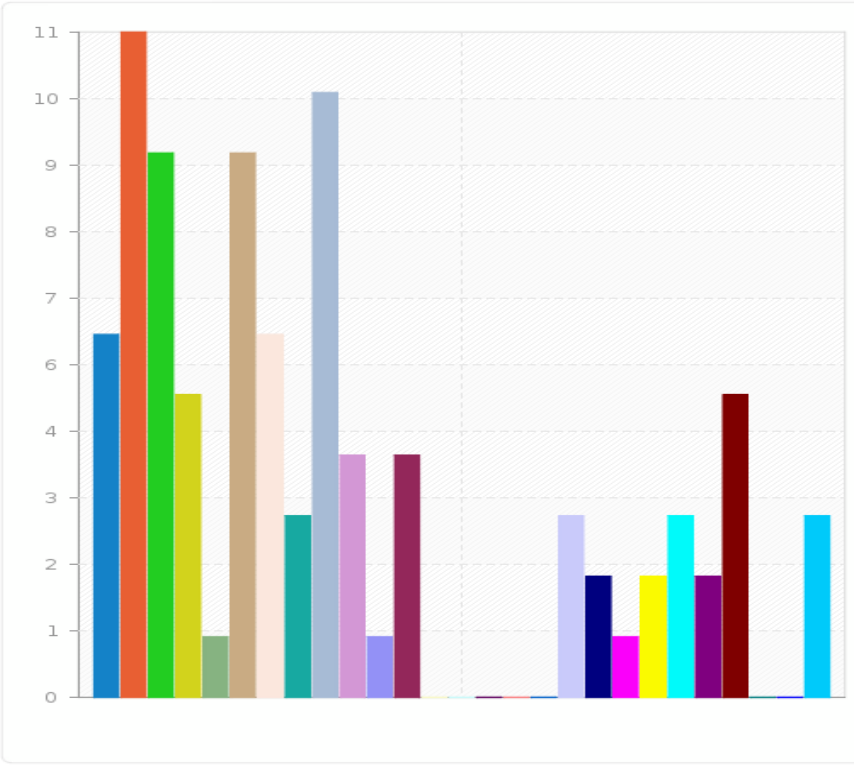
Part C

Model use

List of themes covered by the models

Outcomes:

Mainly Energy Systems models related to buildings and CO_2 emissions and also Economic and investement



- Urban Planning
- Energy demand
- Energy production
- Energy distribution
- Mobility
- Building refurbishment
- New Building refurbishment
- Smart grid
- Emission CO_2
- Climate adaptation
- Land Use
- Air quality
- Urban climate (Large scale)
- Microclimate (small scale)
- Physical activity
- Population
- Workplaces
- Economic performance
- Investment cost
- Other

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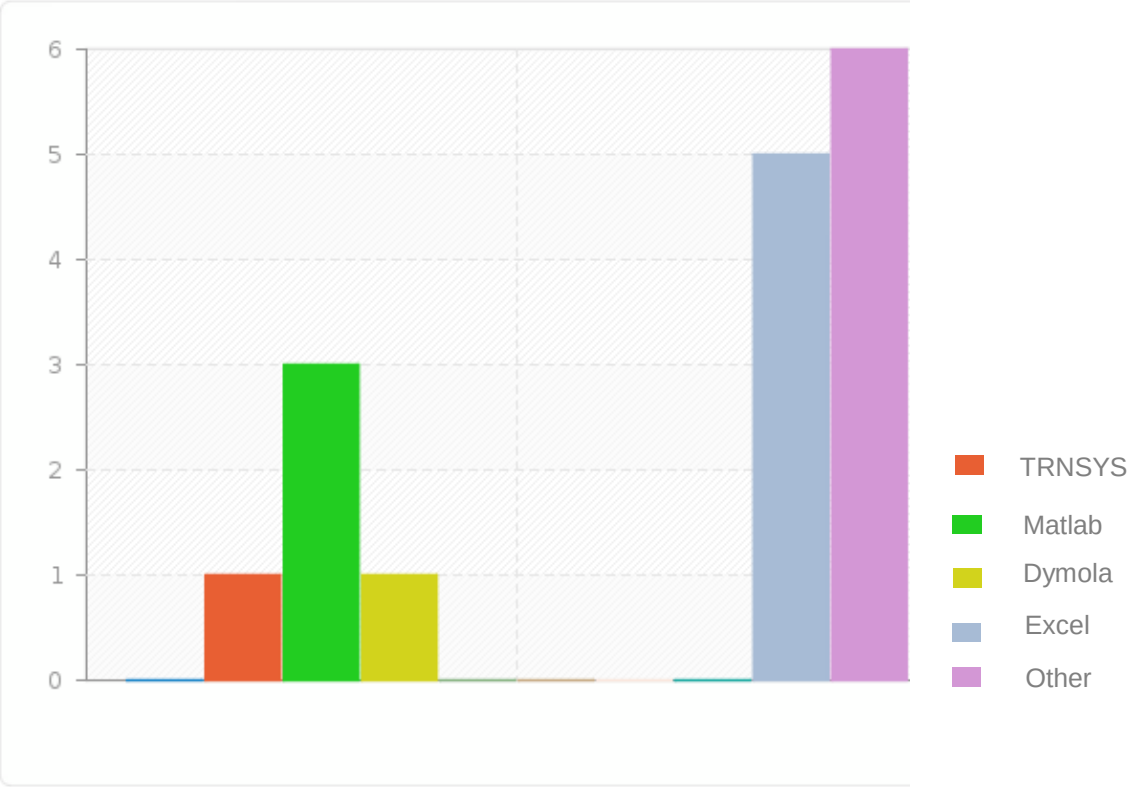
Part D

Related to the link with other tools

Tools used to build the model

Outcomes:
Many different tools are used as well as MS Excel (spreadsheet tools) and MATLAB



Outcomes:
The outputs of most of the tools (70%) could be used as input in other tools

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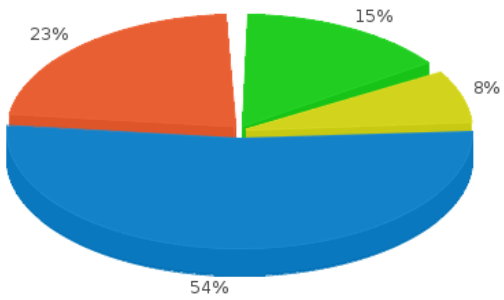
Part E

Variables and parameters needs for the model

How many parameters are used and effort for parameterization

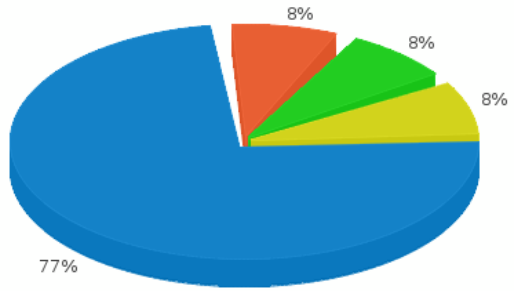
Number of Variables



- Low number of variables (<100)
- Medium number of variables (100-500)
- High number of variables (>500)
- Other

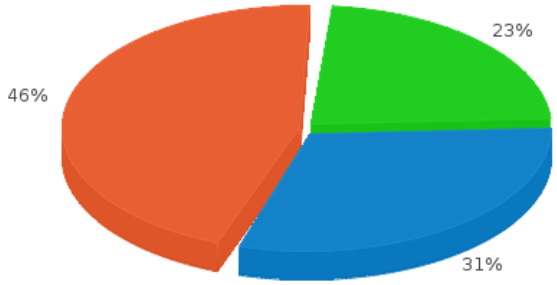
Outcomes:
Most of the tools have low number of variables

Number of Parameters



- Low number of parameters (<100)
- Medium number of parameters (100-500)
- High number of parameters (>500)
- Other

Effort of parameterisation



- Low
- Medium
- High

Outcomes:
Most of the tools have low number of parameters and effort to parameterize

Costs of data needs are low

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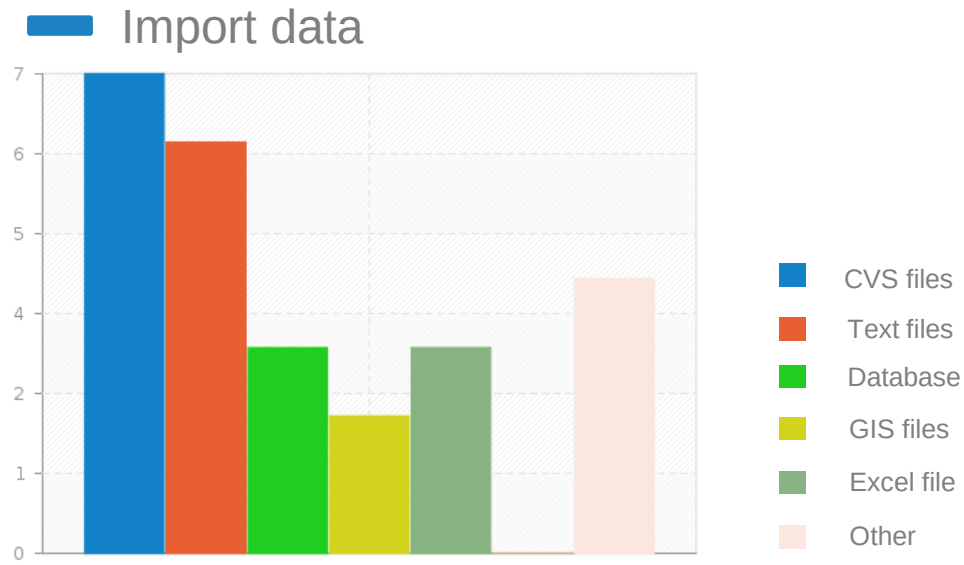
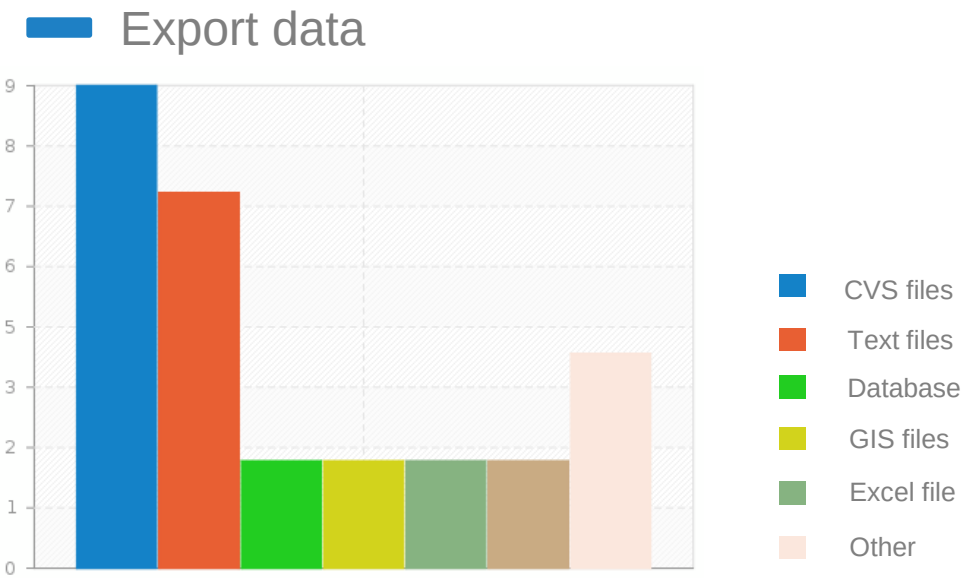
Part F

Technical description

Import/Export data format



Outcomes:
Often standard format as csv, txt, less often GIS files or databases



Outcomes:
Most often only standard export formats as: csv, txt files

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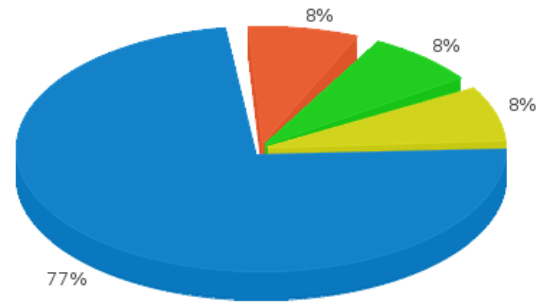
Model runtime

Average calculation time for a modelrun

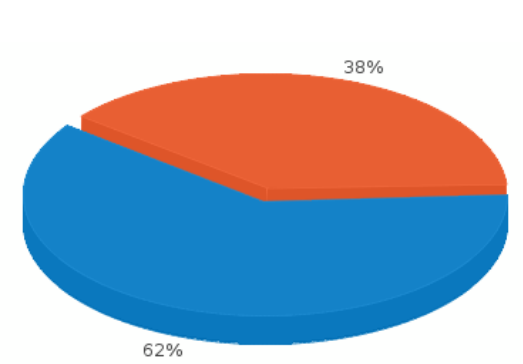


Outcomes:

Most often it is only a matter of minutes to run a simulation

For stakeholder it is often important to have a high performance (interactive tool)

Graphical user interface



Outcomes:

Most often the tools have and UI

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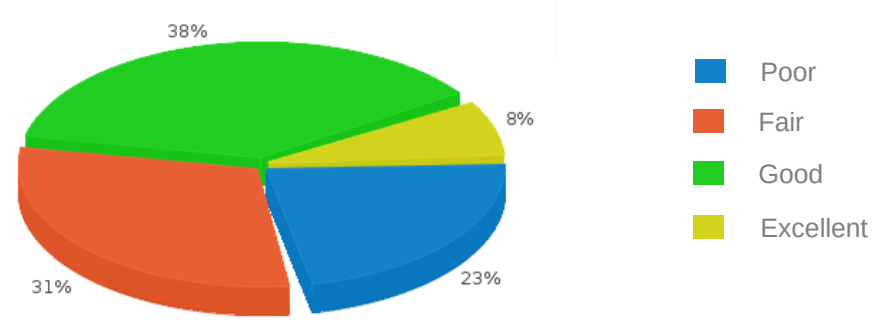
Part G

Documentation

Documentation and technical support

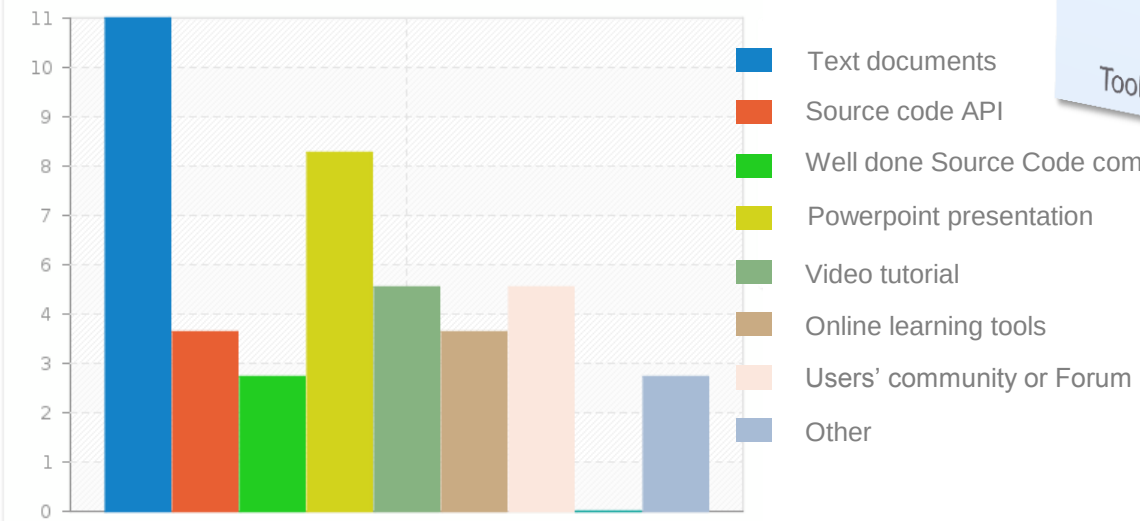
Documentation available for tools



Outcomes:

Most of the tools has good documentation available

Type of documentation



Outcomes:

The type of documentation is often rather simple and not very well elaborated

Tools most often lack in professional support

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Conclusion and next steps

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Conclusions

- All reported tools are referred as tools which need assistance to use
- Main barriers:
  - Lack of technical knowledge, funds and time.
  - Wide range of theories and methods.
  - Missing or weak dialogue between the scientists, model builders and urban stakeholders
- Main topics tackled, availability and use:
  - Energy demand,
  - Energy production,
  - Climate mitigation and adaptation
  - Smart Grids
  - The most tools are open source or can be accessed as part of a research collaboration.
  - Simple data import and export formats
  - only few data with low effort (cost and time) regarding their parametrization.
- Main needs:
  - Develop new instruments, communication skills to improve the dialogue with the stakeholders.
  - Improve simulation tools regarding waste

Next steps

- Adapt the questionnaire according to the first round of answers
  - Include some options to answer and make some questions better understandable or obvious
- Make a version which is similar but for the Cities (e.g. City advisory board of EERA)
- Increase the audience to the questionnaire to other EERA JPs
- The result can be an input for the Cost Action we want to apply

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Thanks

for your Attention!

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