Experience with large STEM models - how to build and how to handle them

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Content

1. **Cover Story** – a large STEM model for LTE networks

   1.1 Techno-economic Modelling with STEM

   1.2 Selected Model Structures and Scenarios

   1.3 Results

2. **Look behind the Scenes**

   2.1 **How to create** large STEM models

   2.2 **How to handle** large STEM models

3. **Summary & Wish List**

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A detailed STEM model for LTE networks

- Modelling effort started within the EU Celtic MEVICO project
- Starting from a simple roll-out model, it turned into an universal Germany type LTE model containing:
    - Access region dimensioning (template with up to 60 POPs)
    - ATCA based EPC modelling
    - „snap-in" bin packing for ATCA blades, shelves and racks
    - Combined CAPEX and OPEX cost & power consumption and energy dissipation figures included
    - Formula based intra-POP and inter-POP transport cost modelling
    - IXP interconnects, Caching and Operator own Services considered
    - Resource collections for telco- and non-telco specific cost tracking
    - Parameter exchange among partners using 7 Excel files
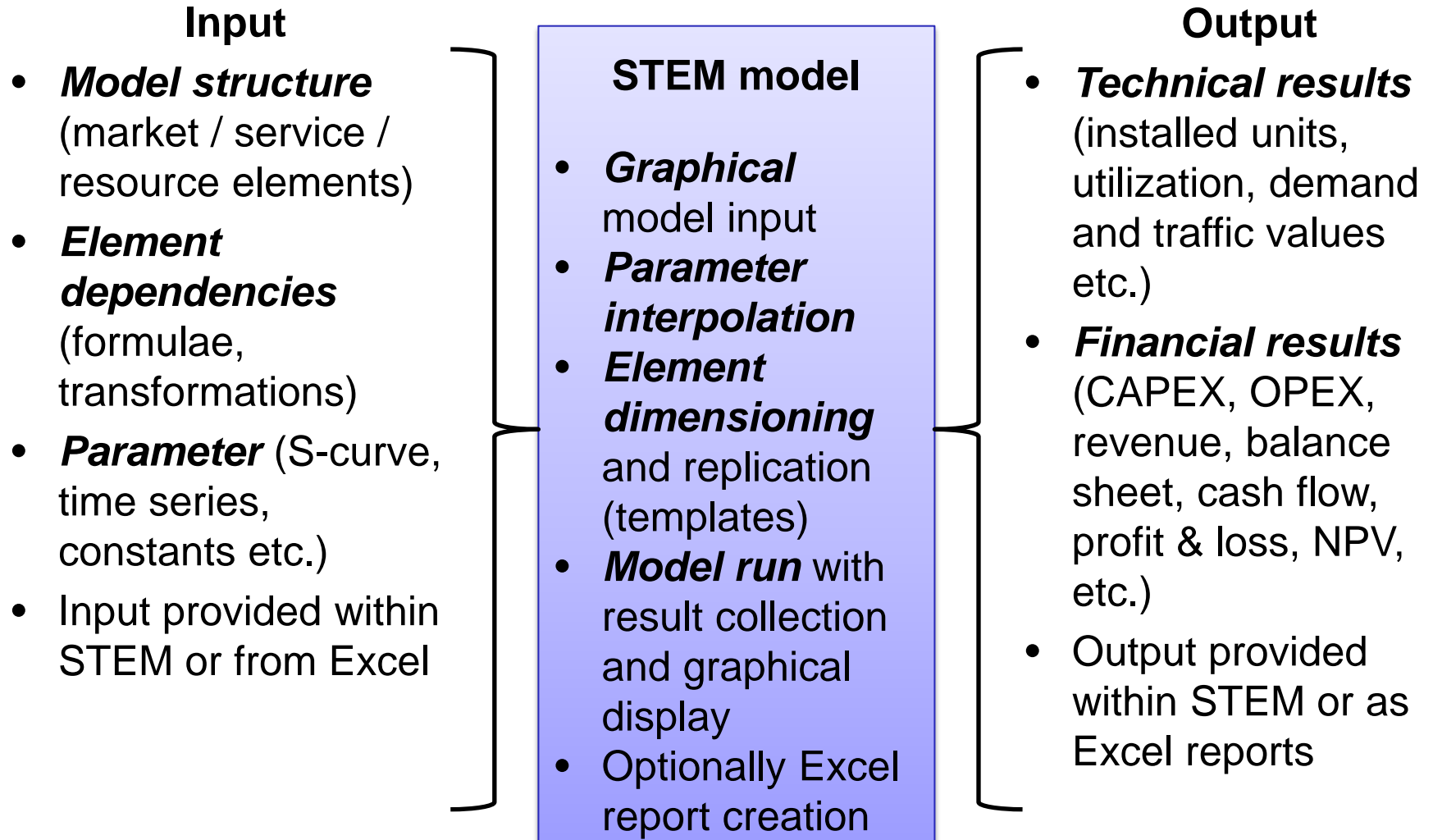- Following slides cover some details which are normally presented in public

Combined CAPEX & OPEX for Techno-economic modelling

Techno-economic modelling – What is it?

- Business case modelling taking into account the <u>technical dependencies</u> and constraints during the process of <u>cost and revenue calculations</u>

- <u>Long term business planning</u> supporting <u>strategic decisions</u> and medium term operations and management decisions

- <u>Periodic model runs</u> with adopted input for result consolidation, operations controlling and decision valuation

- <u>Sensitivity analysis</u> reveals focus areas/elements for optimization

Techno-economic modelling – What is it not?

- No replacement for network planning

- Normally not inventory based

- No real-time or short term monitoring or controlling

Techno-economic Modelling with STEM

Input

- **Model structure** (market / service / resource elements)
- **Element dependencies** (formulae, transformations)
- **Parameter** (S-curve, time series, constants etc.)
- Input provided within STEM or from Excel

STEM model

- **Graphical** model input
- **Parameter interpolation**
- **Element dimensioning** and replication (templates)
- **Model run** with result collection and graphical display
- Optionally Excel report creation

Output

- **Technical results** (installed units, utilization, demand and traffic values etc.)
- **Financial results** (CAPEX, OPEX, revenue, balance sheet, cash flow, profit & loss, NPV, etc.)
- Output provided within STEM or as Excel reports

(STEM … Strategic Telecoms Evaluation Model)

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Techno-economic Modelling with STEM

Cost modelling capabilities

- Combined CAPEX + OPEX

Fixed Assets

Capital Cost	Constant { 25.000,0 }
Residual Value	Constant { 0,00 }
Maintenance Cost	Constant { 3.000,0 }
Churn Cost	Constant { 1.000,0 }
Decommissioning Cost	Constant { 0,00 }

Leased Facilities

Connection Cost	Constant { 5.000,0 }
Rental Cost	Constant { 0,00 }
Usage Cost	Constant { 0,00 }

Overheads

Operations Cost	Constant { 0,00 }

Units

Global Currency Unit	EUR
Cost Period	Year

Cost Trends

Calibration Period	Y0
Use Global Trends	Yes

Template replication

- Assign elements to template
- Define parameters for copies
- Replication during model run

Template POP area

Collections

- Group elements into collection
- Enables result tracking for the group

Coll. telco specific

Scenarios and Sensitivities

- Switch model parameters for scenarios
- Vary model parameters by e.g. ±20% for sensitivity analysis

Scenario global

Sensitivity non-telco cost
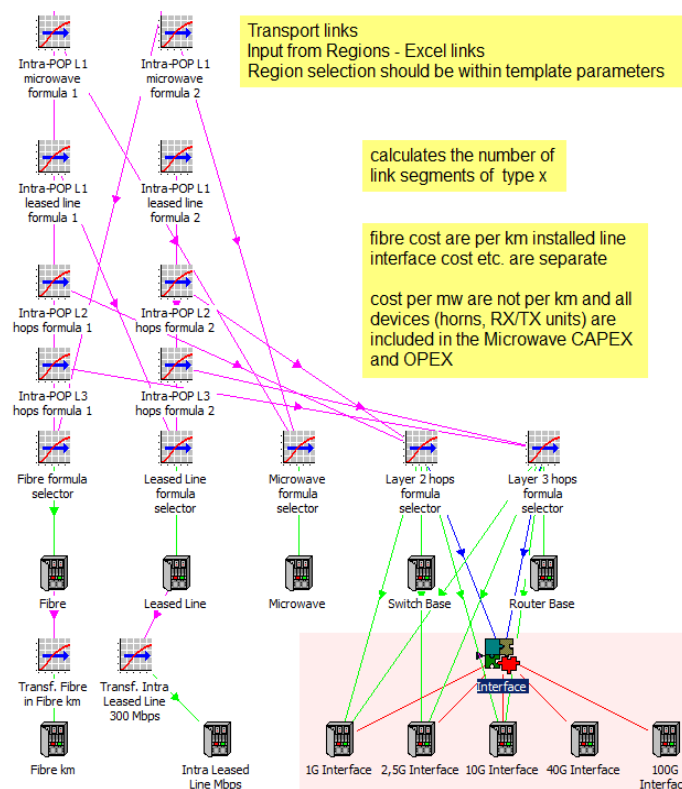
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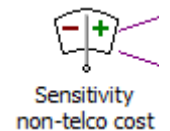
Access network dimensioning

- Market segment
- Service penetration and tariff
- eNodeB demand by:
  - Coverage, Throughput and
  - Signalling
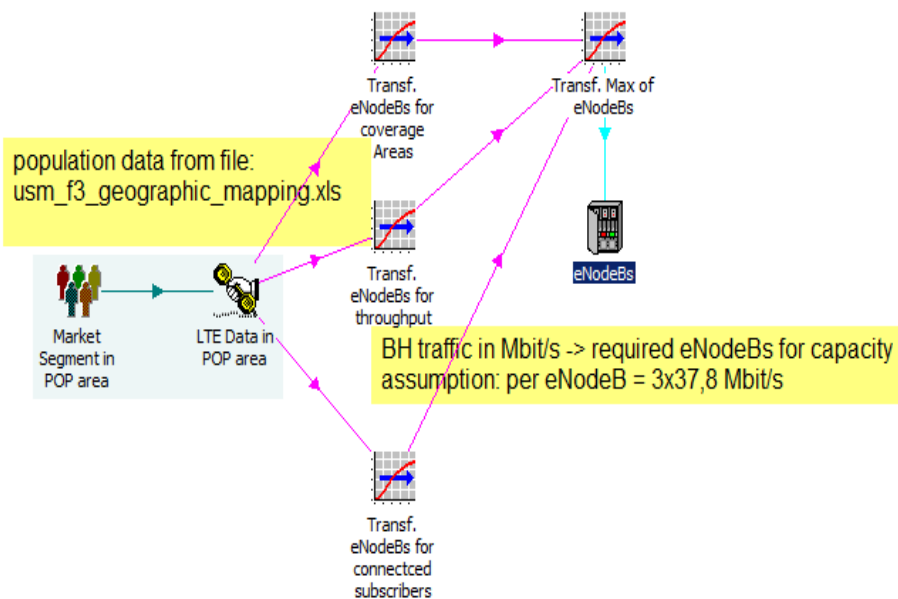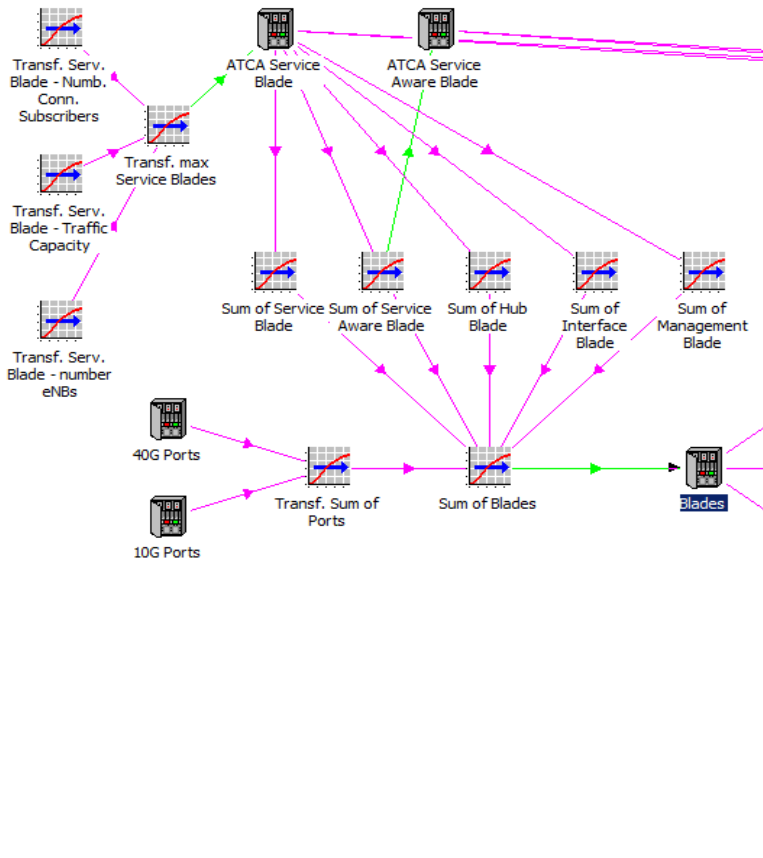
Aggregation network dimensioning

- Intra-POP transport
- Inter-POP transport
- Formula based technology mix

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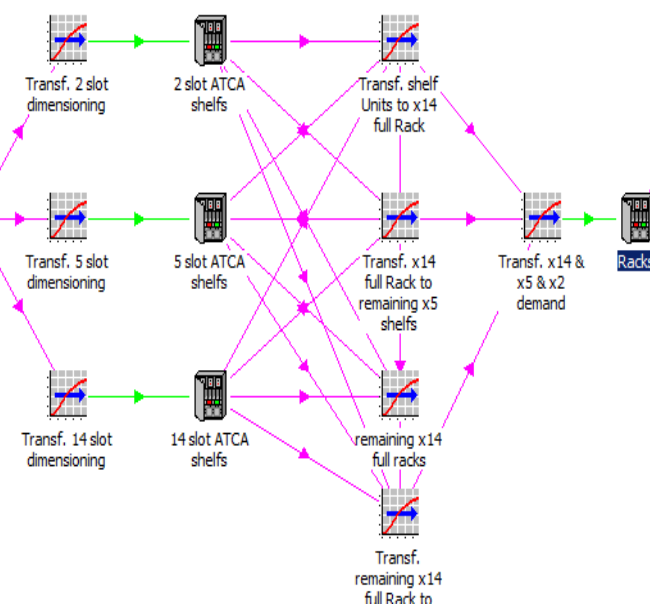
Core network dimensioning

- POP specific EPC modelling

- ATCA based technology
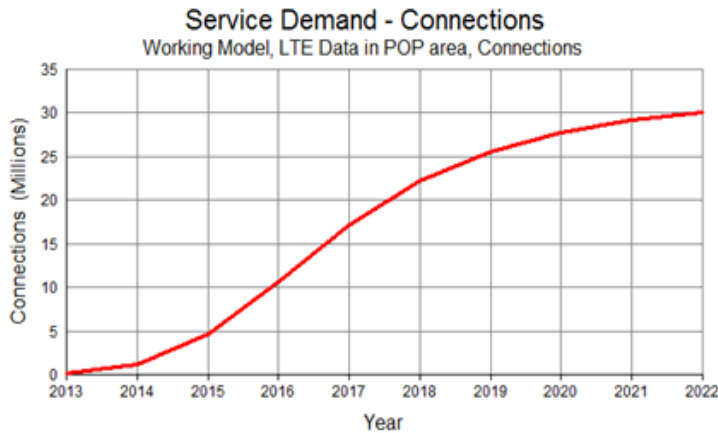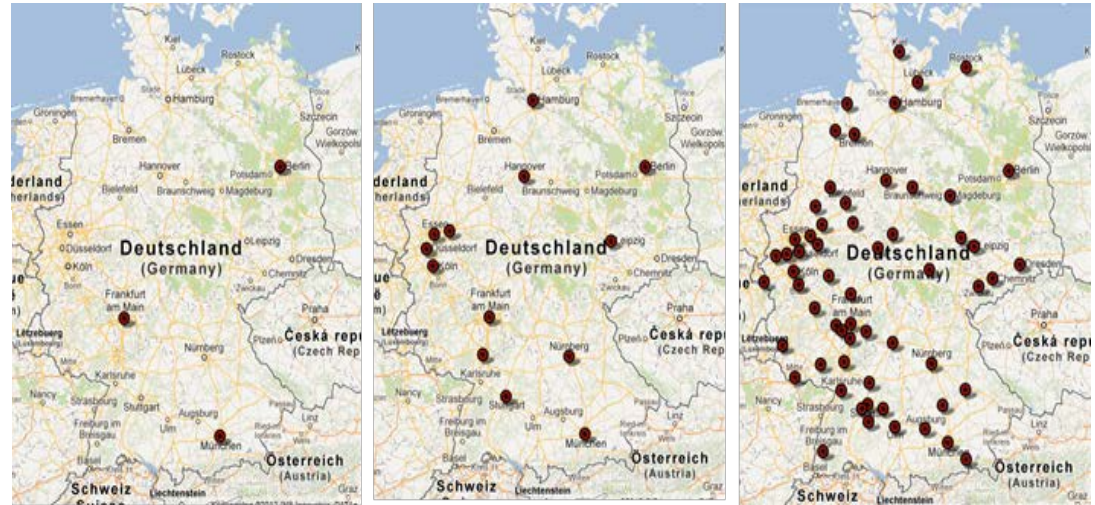
ATCA "snap in" dimensioning

- Shelf upgrade by utilization

60%	1,2		3			8,4		
# of slots	# of shelf			# of shelf			# of shelf		
		used slots	usage %		used slots	usage %		used slots	usage %
	2 slot			5 slot			14 slot		
"step-up" threshold	2			3			8		
1	1	1	50%						
2	1	2	100%						
3				1	3	60%			
4				1	4	80%			
5				1	5	100%			
6	1	1	50%	1	5	100%			
7	1	2	100%	1	5	100%			
8							1	8	57%
							1	9	64%
							1	10	71%
							1	11	79%
							1	12	86%

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POP location scenarios

3 POP, 13 POP and 60 POP

Service Demand - Connections
Working Model, LTE Data in POP area, Connections

Service Demand - Busy-Hour Traffic
Scenario 60 POPs, Busy Hour Traffic

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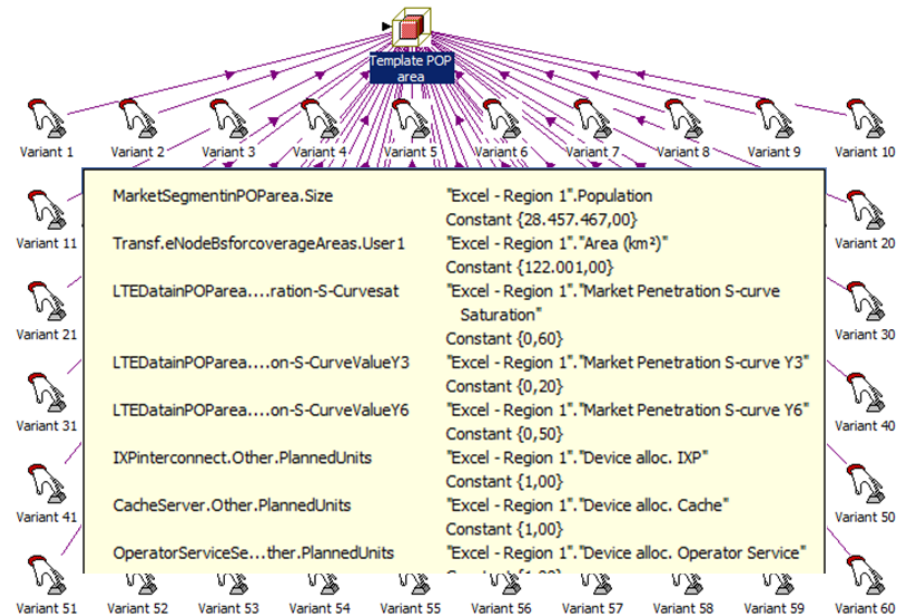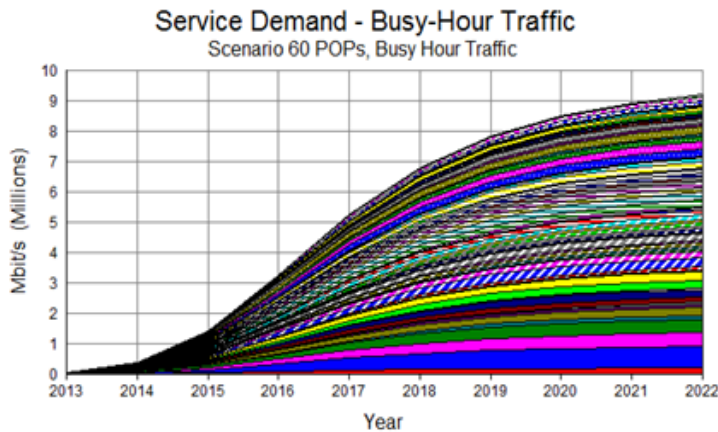
Results
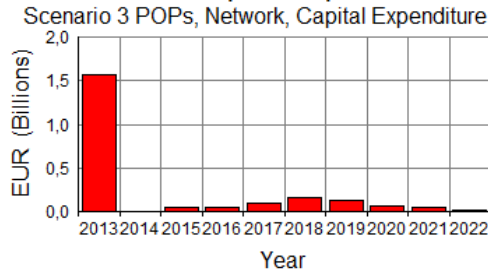
Dimensioning and CAPEX & OPEX results

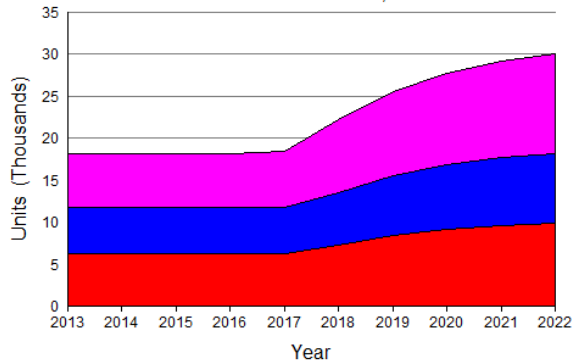**Transformation Instantaneous Output**
Scenario 3 POPs, Instantaneous Output

General eNodeB dimensioning

Resource Installed Units
Scenario 3 POPs, Installed Units

Installed eNodeBs for 3 POP scenario

Network Capital Expenditure
Scenario 3 POPs, Network, Capital Expenditure

Network Operating Costs
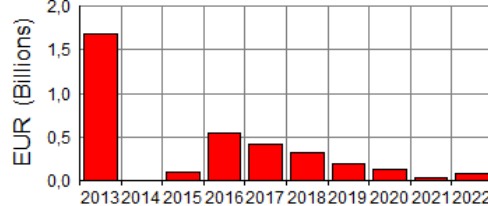Scenario 3 POPs, Network, Operating Costs

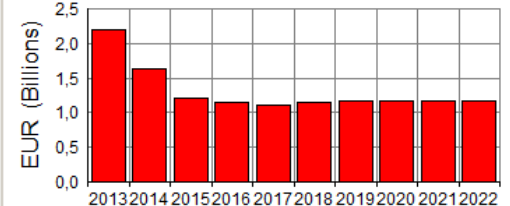Scenario 13 POPs, Network, Capital Expenditure
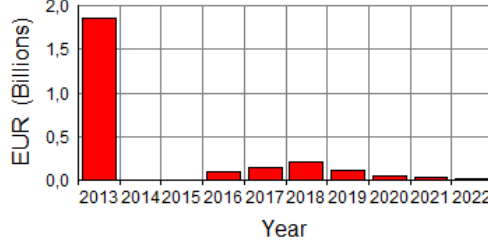
Scenario 13 POPs, Network, Operating Costs
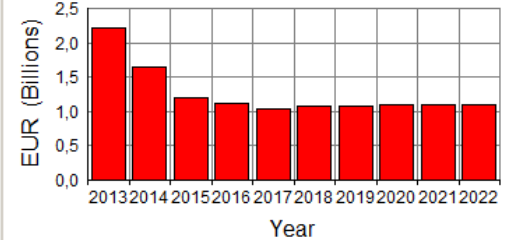
Scenario 60 POPs, Network, Capital Expenditure

Scenario 60 POPs, Network, Operating Costs

Combined overall CAPEX and OPEX report
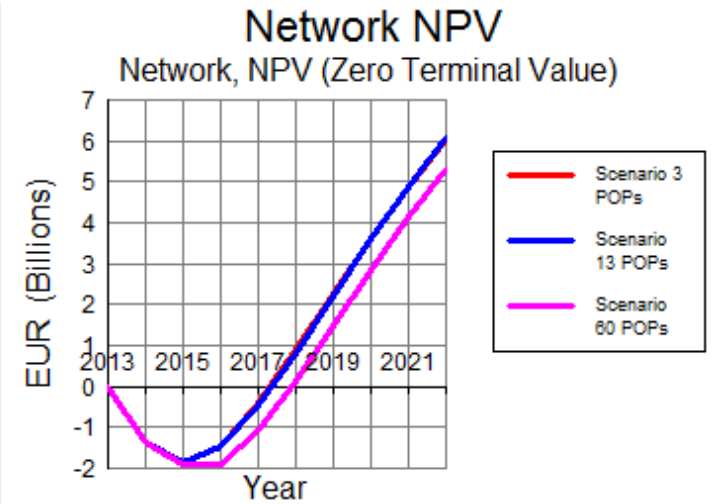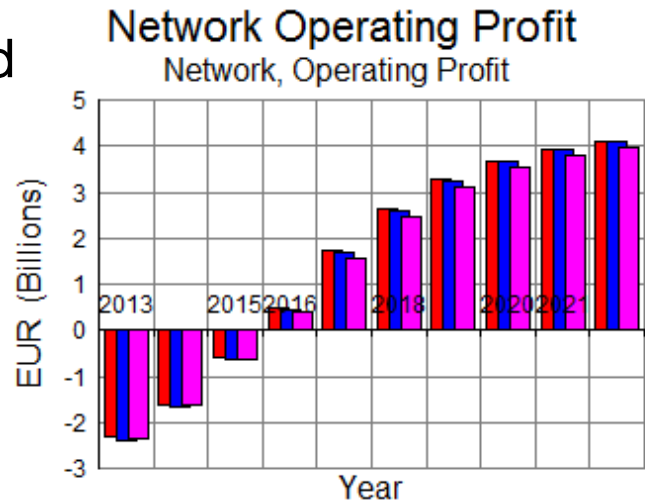
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Results

Network Profit and
NPV results

- POP specific

- Sensitivity ±20%
  service penetration

Network Operating Profit — Network, Operating Profit

Network NPV — Network, NPV (Zero Terminal Value)

Look behind the Scenes
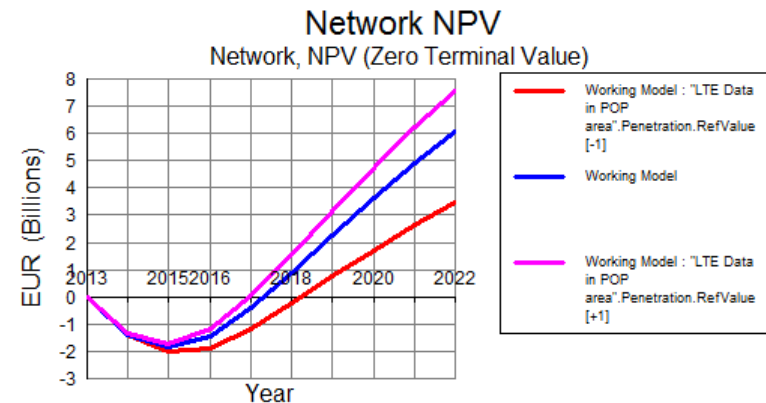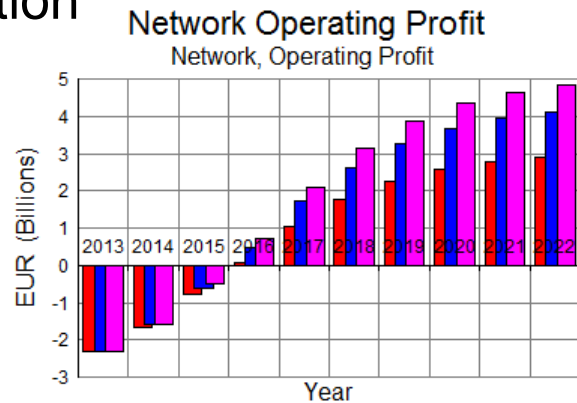
How to create large STEM models

- Graphical input

- Text based input

- Script programming

How to handle large STEM models

- Powerful machines and Patience

- Excel to control model runs

- Dodgy TU Chemnitz method

- Memory issues

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Look behind the Scenes – How to Create

How to create large STEM models

- Graphical input
  - Native input method
  - Left / right mouse click customs….
  - Optimized over the years
    - Element placement,
    - Element selection,
    - Grouped parameter input,
    - Intelligent element linking etc.

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How to create large STEM models

- Text based input
  - „*.dtl" ASCII file structure easily guessed
  - Close the STEM editor
  - Backup the „original" „*.dtl" file
  - Open „*.dtl" in text editor (recommend using Notepad++)
  - Do the manual editing
  - Beware not to destroy its structure
    → destroys the file when opened up
    → therefore the backup
  - Use the edited „*.dtl" file as usual

```
CostIndex "Excel - Device alloc. S-GW" = {
        next = "Excel - Device alloc. P-GW",
User1 = {
                Constant = $3!"Allocation (EPC technology)"]$E$8,
                },
User2 = {
                Constant = $3!"Allocation (EPC technology)"]$E$9,
                },
User3 = {
                Constant = $3!"Allocation (EPC technology)"]$E$10,
                },
User4 = {
                Constant = $3!"Allocation (EPC technology)"]$E$11,
                },
User5 = {
                Constant = $3!"Allocation (EPC technology)"]$E$12,
                },
…
```

Look behind the Scenes – How to Create

How to create large STEM models

- Script programming
  - **Python or Pearl scripts** to **generate the „*.dtl" file**
  - Tedious index and cell counts cry for generation by programmed loops
  - Generate the entire file or
  - Selectively replace placeholders within a given dtl skeleton file
    → simple string replacement {TAGS} with loop generated text lines
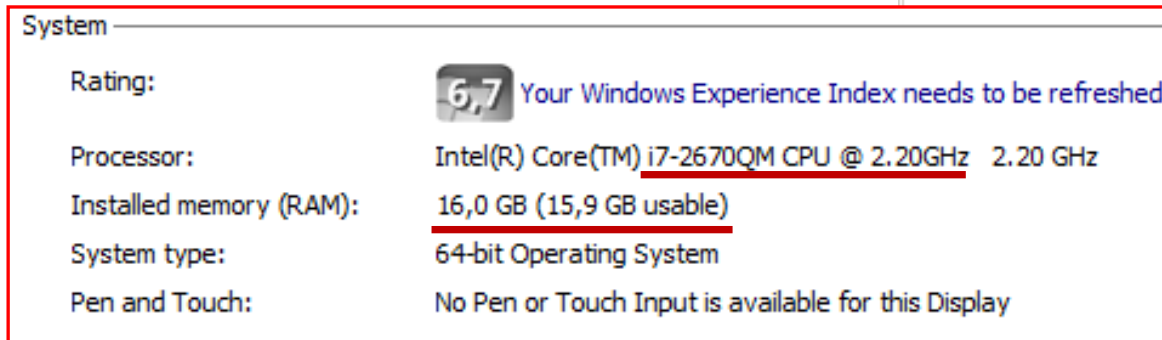
```
CostIndex "Excel - Device alloc. S-GW" = {
          next = "Excel - Device alloc. P-GW",
          {USER_DATA_S-GW}
          …
```

```
CostIndex "Excel - Device alloc. S-GW" = {
          next = "Excel - Device alloc. P-GW",
User1 = {
                    Constant = $3!"Allocation (EPC technology)"]$E$8,
          },
User2 = {
                    Constant = $3!"Allocation (EPC technology)"]$E$9,
          },
User3 = {
                    Constant = $3!"Allocation (EPC technology)"]$E$10,
          },
User4 = {
                    Constant = $3!"Allocation (EPC technology)"]$E$11,
          },
User5 = {
                    Constant = $3!"Allocation (EPC technology)"]$E$12,
          },
…
```

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Look behind the Scenes – How to Handle

How to handle large STEM models

- **Powerful machines and Patience**

STEM Results | Implied Logic

File *.dtm not found.

It is essential to re-run the model now in order to view the results.

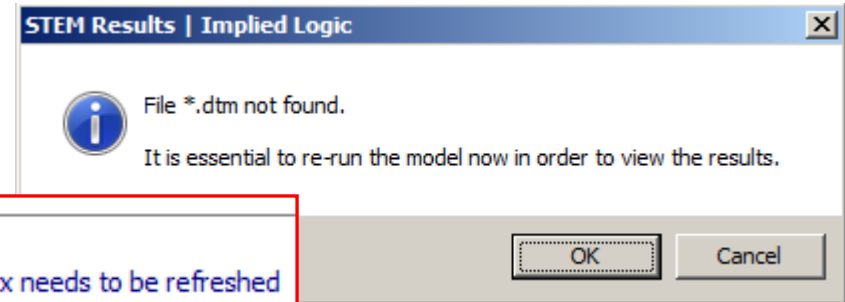[OK]   [Cancel]

System

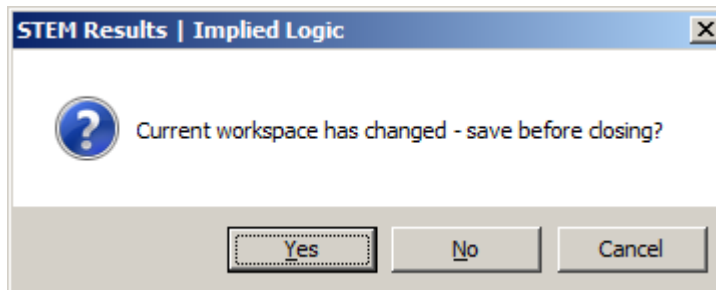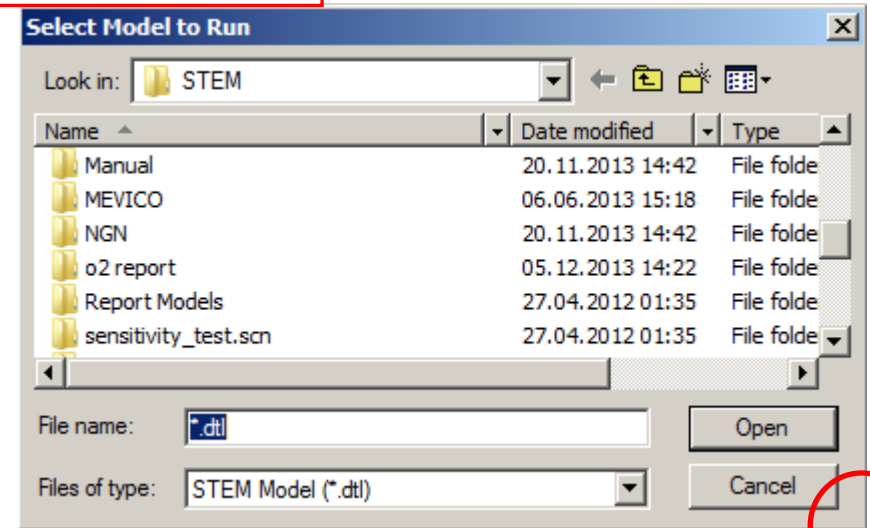|	
Rating:	6,7 Your Windows Experience Index needs to be refreshed
Processor:	Intel(R) Core(TM) i7-2670QM CPU @ 2.20GHz 2.20 GHz
Installed memory (RAM):	16,0 GB (15,9 GB usable)
System type:	64-bit Operating System
Pen and Touch:	No Pen or Touch Input is available for this Display

- Keep watching for **intermitted error dialogues….**
- Would be nice to automate the answers

STEM Results | Implied Logic

Current workspace has changed - save before closing?

[Yes]   [No]   [Cancel]

Select Model to Run

Look in: STEM

| Name ▲	Date modified	Type
Manual	20.11.2013 14:42	File folde
MEVICO	06.06.2013 15:18	File folde
NGN	20.11.2013 14:42	File folde
o2 report	05.12.2013 14:22	File folde
Report Models	27.04.2012 01:35	File folde
sensitivity_test.scn	27.04.2012 01:35	File folde

File name: *.dtl   [Open]

Files of type: STEM Model (*.dtl)   [Cancel]

Look behind the Scenes – How to Handle

How to handle large STEM models

- Excel to control model runs
    - Click the STEM Add-In bar within Excel to run STEM models in the background
    - Use Visual Basic programs to trigger the same model runs now by program control and coordinate input feeding and result collection in those VBA macros

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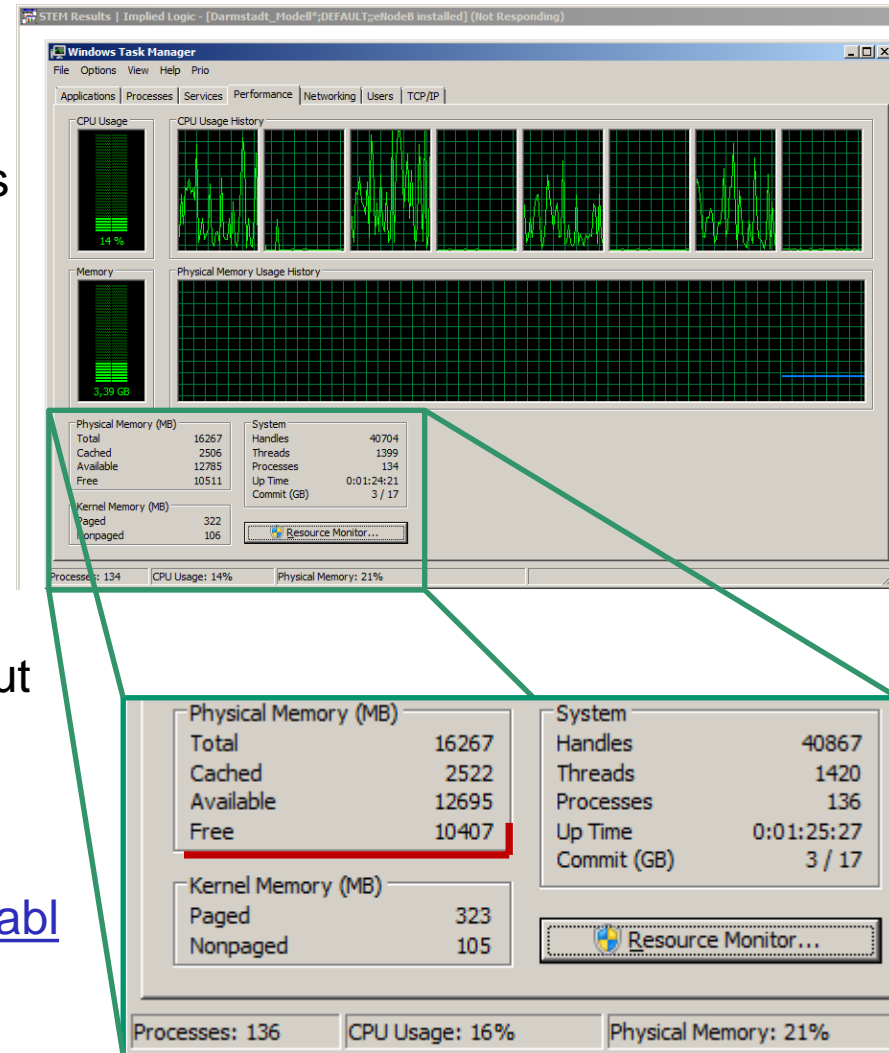CHEMNITZ

Look behind the Scenes – How to Handle
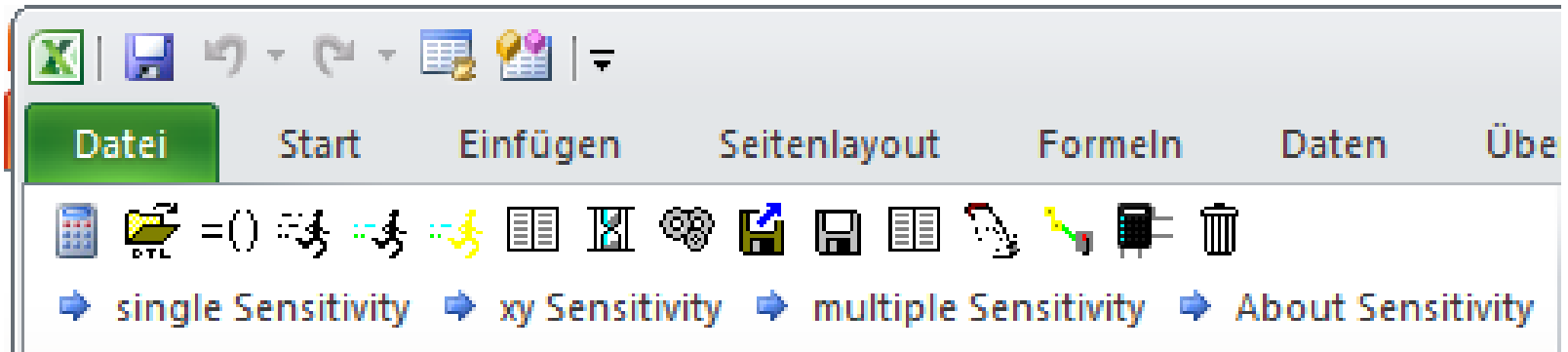
How to handle large STEM models

- Dodgy TU Chemnitz method
  - Windows processes keystrokes and mouse events in event queues
  - **Simulate keystrokes and mouse clicks using Python scripts**
  - **Before and after model runs, copy files** by Python to change input settings, run different models, collect the produced output for later result analysis, etc.
  - Advise Python to **take screenshots before and after each event** to document smooth runs or any error windows popping up
  - If you know which **intermitted dialogues** pop up and how to answer them, you can now put Python into action to **emulate the interaction** …

Look behind the Scenes – How to Handle

How to handle large STEM models

- Memory issues
  - 16 GB RAM is plenty for model runs
  - Still error about insufficient heap space
    despite „Available " physical memory
  - Reason: **Windows Super/Prefetch** consumes GBs of RAM for caching
  - **Not required with SSDs**
    should automatically be disabled, but often is not
  - **Disable** using the registry keys
    see the link below for details:
    http://www.thewindowsclub.com/disable-superfetch-prefetch-ssd

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Summary & Wish List

- Complex ventures require techno-economic modelling, which often results in large STEM models

- STEM nicely covers CAPEX, OPEX, Financial Statements and Sensitivity analysis at once → keep up this level of detail

- Configurable and generic LTE network model for equipment, transport and energy cost tracking as well a revenue, profit and NPV calculations

- Excel and scripting languages help to prevent tedious input and model run procedures

- Simple knowledge about Windows memory handling and deactivation of useless services speed up model runs

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Summary & Wish List

- „**% vs. %**" - result reports for sensitivities → suggested last year
- Option for automatic **removal of absolute path references** → exists?
- Automatic **handling** options **for intermitted dialogue questions**
- Enlarge tiny file selection dialogue

- Biggest show stopper for large models
  - **60 User Data field limitation**
  - **60 Template Variant limitation**

I keep saying: Please, please do something about it!

e.g. double it to 120

Reason: some operators have more than 70 POPs …

Thank you for your attention.

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