Network Investments

Lecture outline

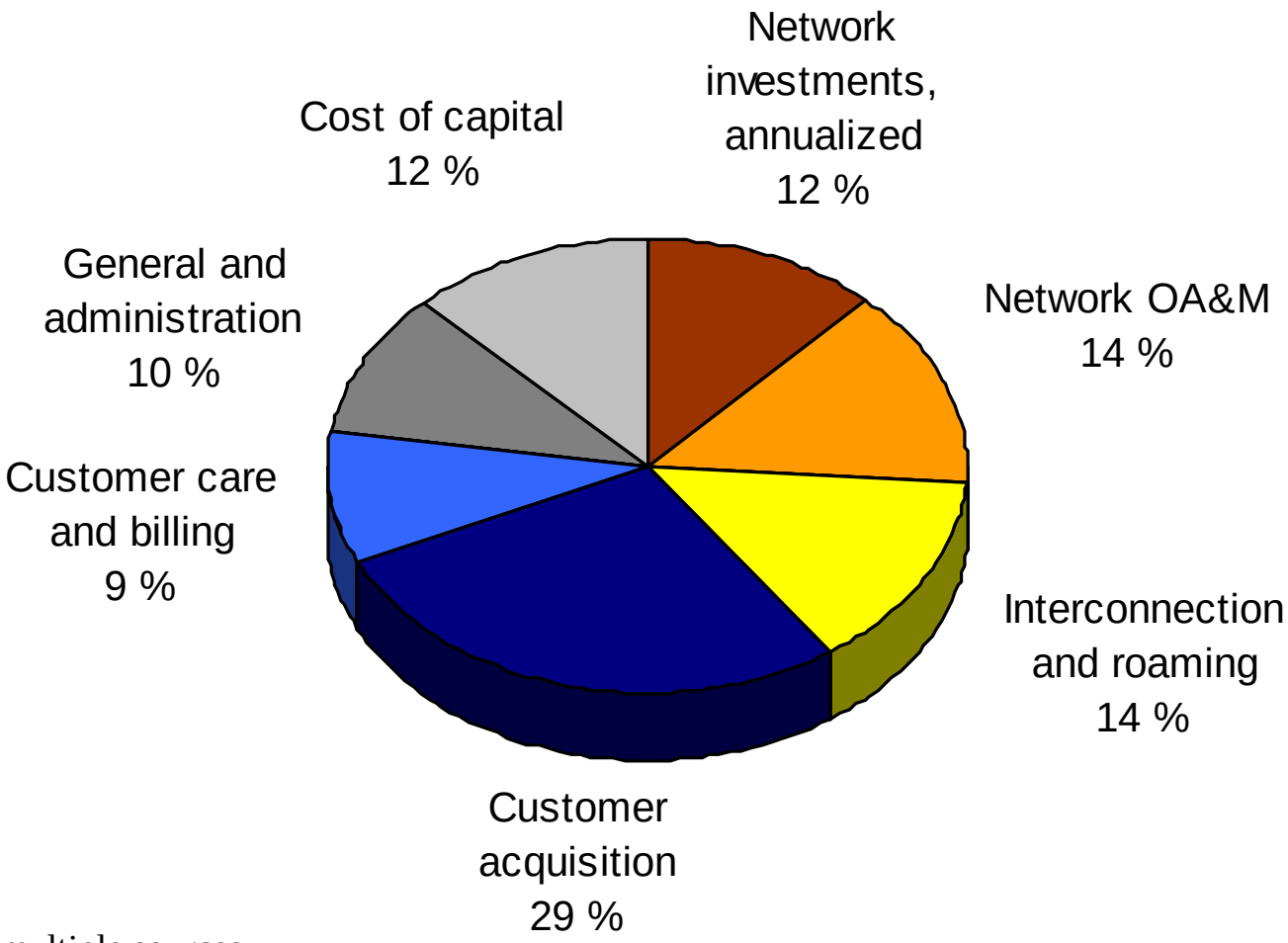
- Introduction
- Discounted Cash Flow (DCF) analysis, basics
  - NPV, IRR
- Techno-economic models and tools
  - Inputs, logic, and outputs
  - Revenue modelling
  - CAPEX modelling
  - OPEX modelling
- Example case: Fixed WiMAX

Introduction

- Extensive capital investments required in the telecommunications industry
  - Fiber / copper cables, active elements, spectrum licenses
- Expanding set of both complementary and competitive access technologies
  - ADSL, ADSL2+, VDSL, FTTH, Cable modems, WiMAX…
  - GPRS, EDGE, WCDMA, HSPA, LTE, WLAN, Mobile WiMAX, DVB-H, Flash-OFDM, …
  - ”Technology portfolio” must be optimized
- Systematic analysis required to compare investment possibilities

Introduction

Cost structure of mobile operators



Average over multiple sources

Operator investments

Big picture

- Types of large investments:
  - Material (e.g. network coverage & capacity)
  - Immaterial (e.g. brand marketing, spectrum license)
- Types of funding:
  - Risk-averse >> financial loans (e.g. banks, equipment suppliers)
  - Risk-seeking >> equity investments (e.g. governments, private equity)

Operator investments

Relative characteristics of selected examples

	Cellular licence	**Cellular coverage**	**Cellular capacity**	**New service**
Decision mode	One-step	One-step	Incremental	Optional
Investment size	High or low	High	Medium	Low
CAPEX (%)	High (& low)	High	Medium	Low
OPEX (%)	Low	High	Low	Medium
Payback time	Long	Long	Short	Short

- Services are based on other services (e.g. MMS over GPRS)
- Cross-elasticity of services >> high common costs >> calculation problems

Discounted Cash Flow analysis

Basic concepts

- A method to value a project, taking into account the the time value of money
- Future cash flows are estimated and discounted with a proper discount rate to give them a present value
- Cash flow (CF): Amount of cash flowing to/from a company / project during a time period
- Discount rate (r): Reflects the opportunity cost of capital
- Discounted cash flow (DCF): Value of a cash flow adjusted for the time value of money
- Net present value (NPV): Sum of all DCFs during a study period
- Internal rate of return (IRR): Discount rate that gives a NPV of zero

$$DCF_t = \frac{CF_t}{(1+r)^t}$$

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}$$

DCF analysis

A simple example

- Consider a project yielding the following cash flows:

Year	0	1	2	3	4
+ Revenue	0	5	6	7	8
- OPEX	0	-2	-2	-2	-2
- CAPEX	-12	0	0	0	0
= Cash flow	-12	3	4	5	6
Cumulative cash flow	-12	-9	-5	0	6

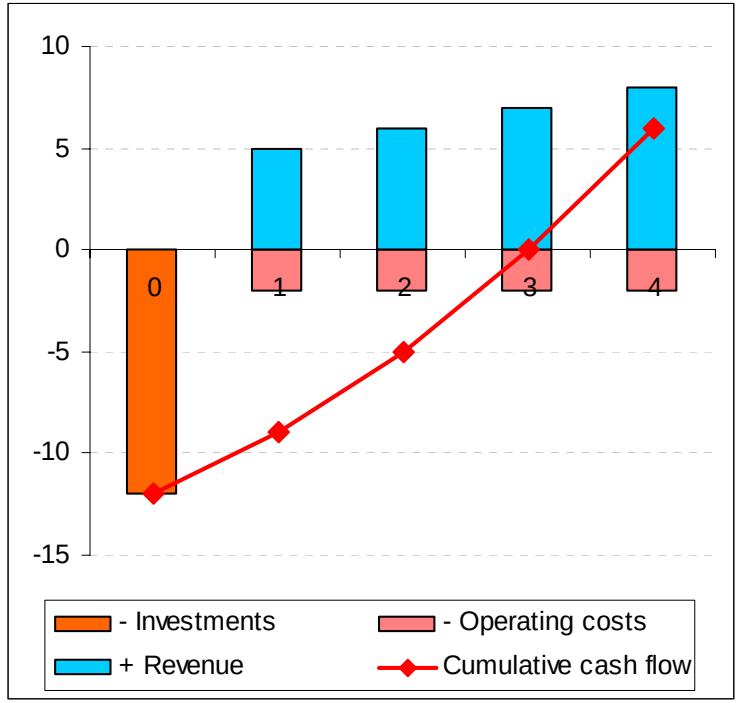
- As seen, the payback period is 3 years
- With different discount rates, we get the following DCFs and NPVs:

Discount rate	15 %				
Discounted cash flow	-12,00	2,61	3,02	3,29	3,43
Net present value	0,351				

Discount rate	20 %				
Discounted cash flow	-12,00	2,50	2,78	2,89	2,89
Net present value	-0,935				

- Iteration gives us the IRR:

Discount rate = IRR	16,3 %				
Discounted cash flow	-12,00	2,58	2,96	3,18	3,28
Net present value	0,000				



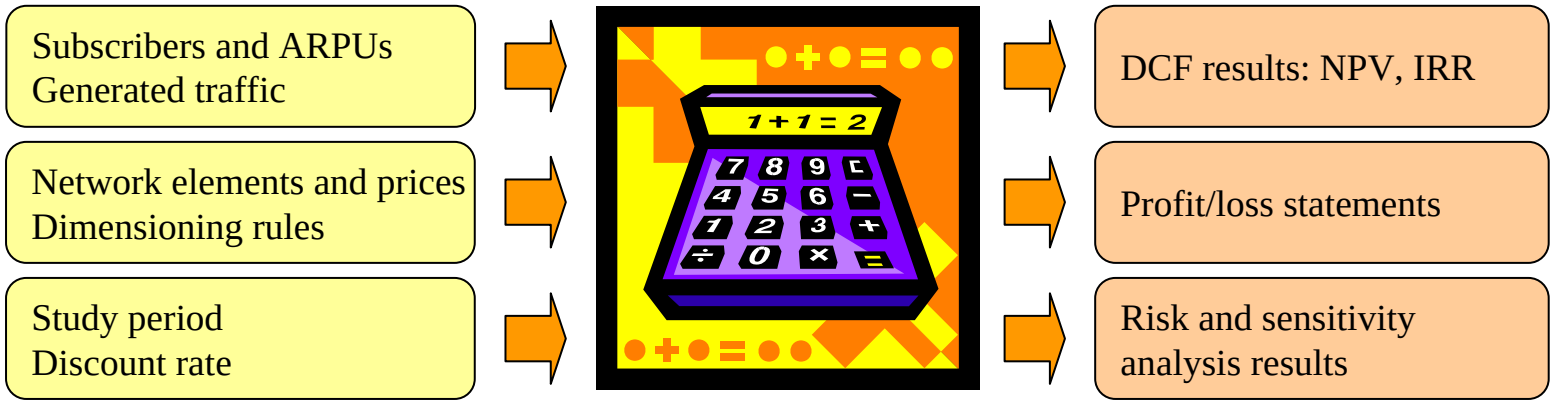
Techno-economic models and tools

Logic and inputs

- Profit = Revenue – Cost
  = (Subscribers * ARPU) – (CAPEX + OPEX)
- Revenue side modelling:
  - Service penetration
  - Market share evolution
  - ARPU evolution
  - Revenue sharing models
- Cost side modelling:
  - CAPEX
    - Network dimensioning, cost evolution
  - OPEX
    - OAM costs: fixed, per service, per subscriber

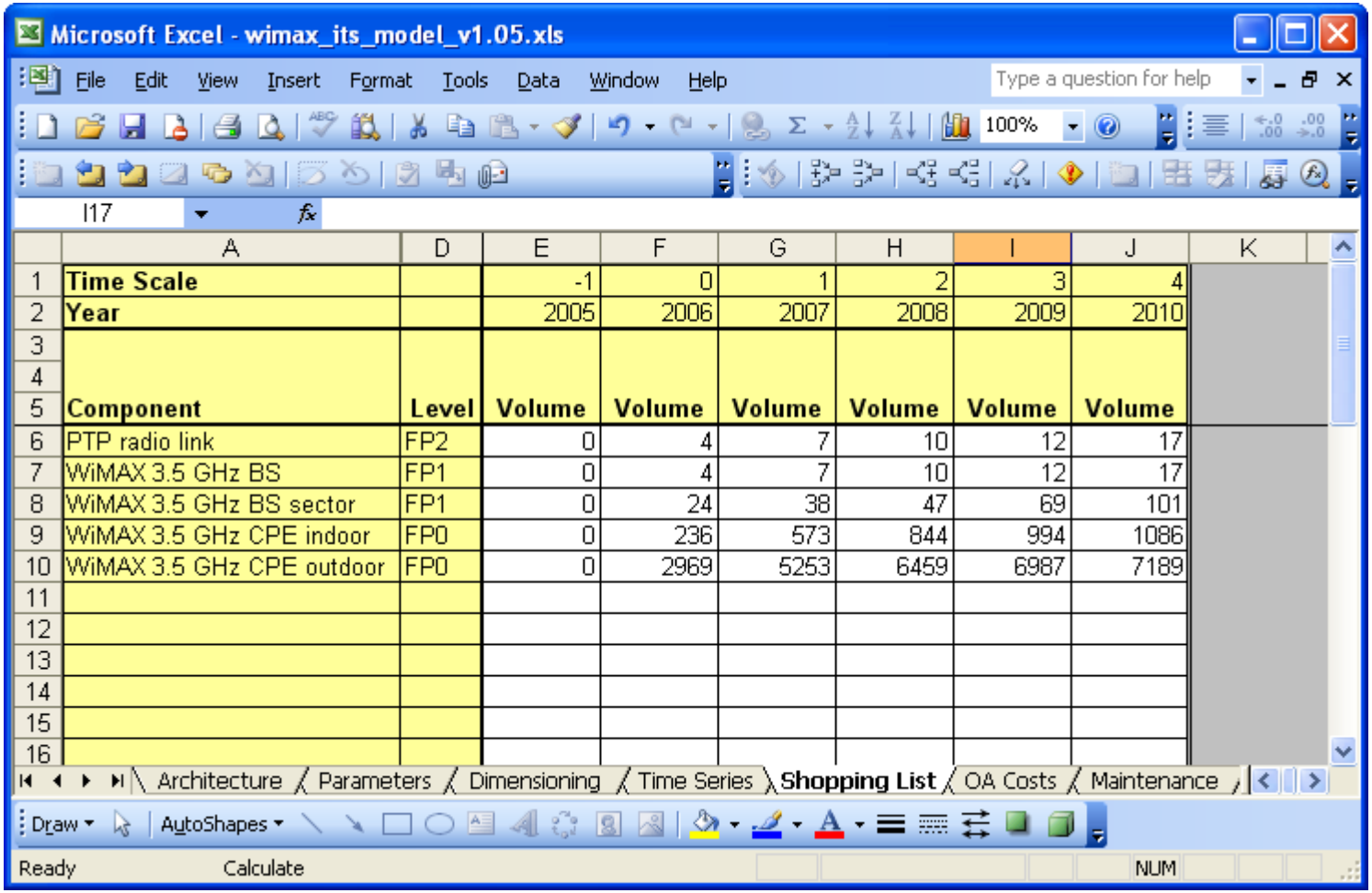
TONIC/ECOSYS tool

Example of a techno-economic tool



- Excel-based spreadsheet application
- Integrates basic DCF methods and analysis logic to an user-friendly tool
- Automates many straight-forward calculations
  - Time savings, less errors, repeatibility
- Considerable aid in sensitivity and risk analyses
- Majority of the work still has to be done outside the tool

TONIC screenshot: Shopping List



Microsoft Excel - wimax_its_model_v1.05.xls

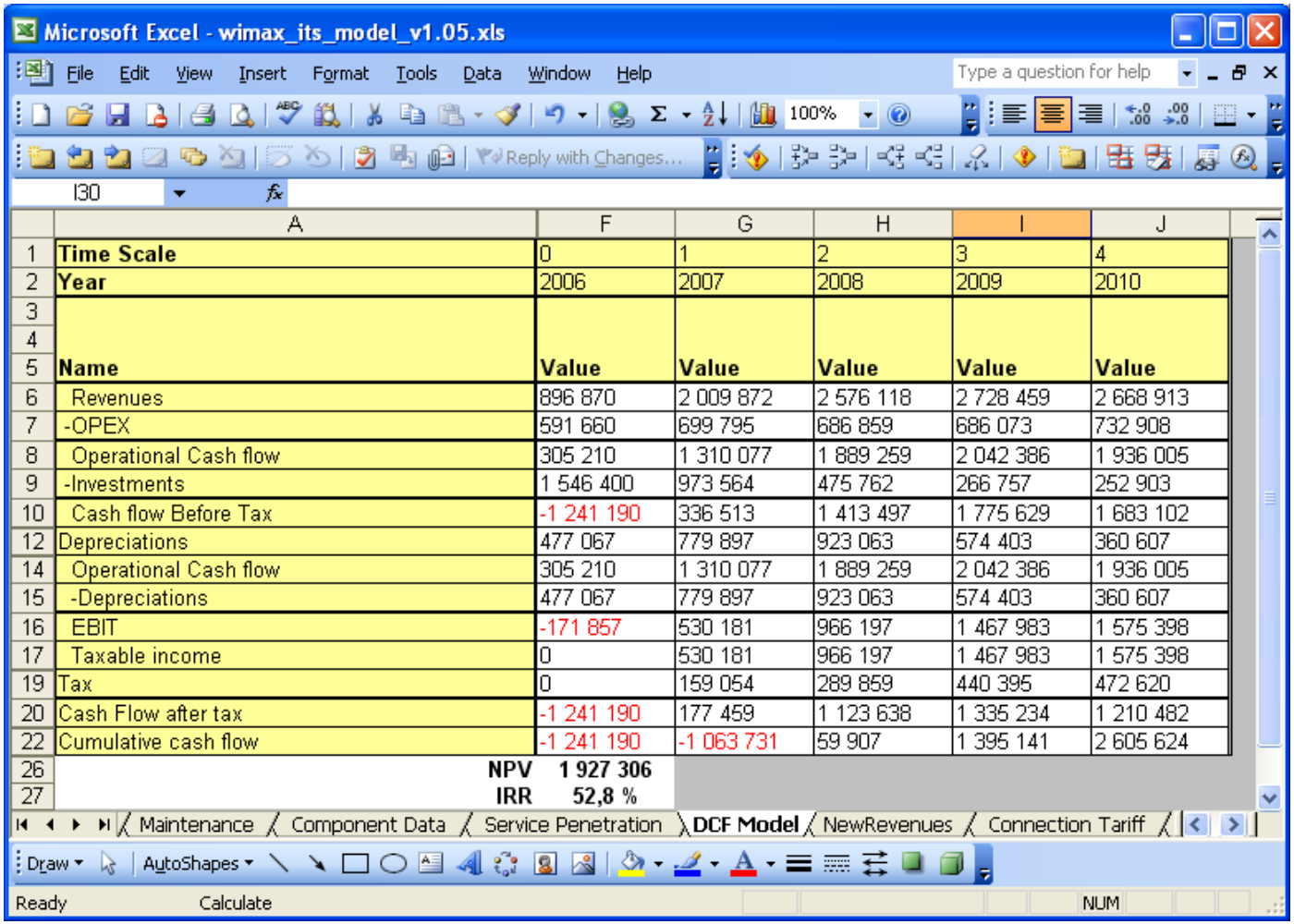
	A	D	E	F	G	H	I	J	K
1	**Time Scale**		-1	0	1	2	3	4	
2	**Year**		2005	2006	2007	2008	2009	2010	
3									
4									
5	**Component**	**Level**	**Volume**	**Volume**	**Volume**	**Volume**	**Volume**	**Volume**	
6	PTP radio link	FP2	0	4	7	10	12	17	
7	WiMAX 3.5 GHz BS	FP1	0	4	7	10	12	17	
8	WiMAX 3.5 GHz BS sector	FP1	0	24	38	47	69	101	
9	WiMAX 3.5 GHz CPE indoor	FP0	0	236	573	844	994	1086	
10	WiMAX 3.5 GHz CPE outdoor	FP0	0	2969	5253	6459	6987	7189	
11									
12									
13									
14									
15									
16									

Architecture | Parameters | Dimensioning | Time Series | **Shopping List** | OA Costs | Maintenance

Ready Calculate NUM

TONIC screenshot: Results

Mixed DCF analysis and Profit/Loss statement



Microsoft Excel - wimax_its_model_v1.05.xls

	A	F	G	H	I	J
1	**Time Scale**	0	1	2	3	4
2	**Year**	2006	2007	2008	2009	2010
3						
4						
5	**Name**	**Value**	**Value**	**Value**	**Value**	**Value**
6	Revenues	896 870	2 009 872	2 576 118	2 728 459	2 668 913
7	-OPEX	591 660	699 795	686 859	686 073	732 908
8	Operational Cash flow	305 210	1 310 077	1 889 259	2 042 386	1 936 005
9	-Investments	1 546 400	973 564	475 762	266 757	252 903
10	Cash flow Before Tax	-1 241 190	336 513	1 413 497	1 775 629	1 683 102
12	Depreciations	477 067	779 897	923 063	574 403	360 607
14	Operational Cash flow	305 210	1 310 077	1 889 259	2 042 386	1 936 005
15	-Depreciations	477 067	779 897	923 063	574 403	360 607
16	EBIT	-171 857	530 181	966 197	1 467 983	1 575 398
17	Taxable income	0	530 181	966 197	1 467 983	1 575 398
19	Tax	0	159 054	289 859	440 395	472 620
20	Cash Flow after tax	-1 241 190	177 459	1 123 638	1 335 234	1 210 482
22	Cumulative cash flow	-1 241 190	-1 063 731	59 907	1 395 141	2 605 624
26		**NPV**	**1 927 306**			
27		**IRR**	**52,8 %**			

Maintenance | Component Data | Service Penetration | DCF Model | NewRevenues | Connection Tariff

Ready Calculate NUM

Revenue modelling

- Revenue = Penetration * Market share * ARPU
  - Service penetration forecasts
    - E.g. trend extrapolation, analogies
  - Achievable market shares
    - Number/size of competitors, regulation, strategy (mass/niche)
  - Tariff/ARPU evolution
    - Difficult to forecast, linked to e.g. competition, regulation, targeted market segment
    - >> Use of alternative tariff scenarios and sensitivity analyses
- Different revenue types: e.g. retail service revenues, interconnection, roaming

CAPEX and OPEX

- Two different views/uses:
- In accounting
  - CAPEX is *capitalized*, i.e. added to an asset account and depreciated over many years
  - OPEX is *expensed*, having an effect on the current year only
- In cash flow analysis
  - All costs are attached to the actual time period during which they occur, no depreciations
  - >> CAPEX and OPEX are treated in the same way

Profit/loss statement:

Year	**0**	**1**	**2**	**3**	**4**
+ Revenue	0	5	6	7	8
- OPEX	0	-2	-2	-2	-2
= EBITDA	0	3	4	5	6
- Depreciation	0	-3	-3	-3	-3
= EBIT	0	0	1	2	3
- Interests and taxes	0	0	-0,3	-0,6	-0,9
= Profit / loss	0	0	0,7	1,4	2,1

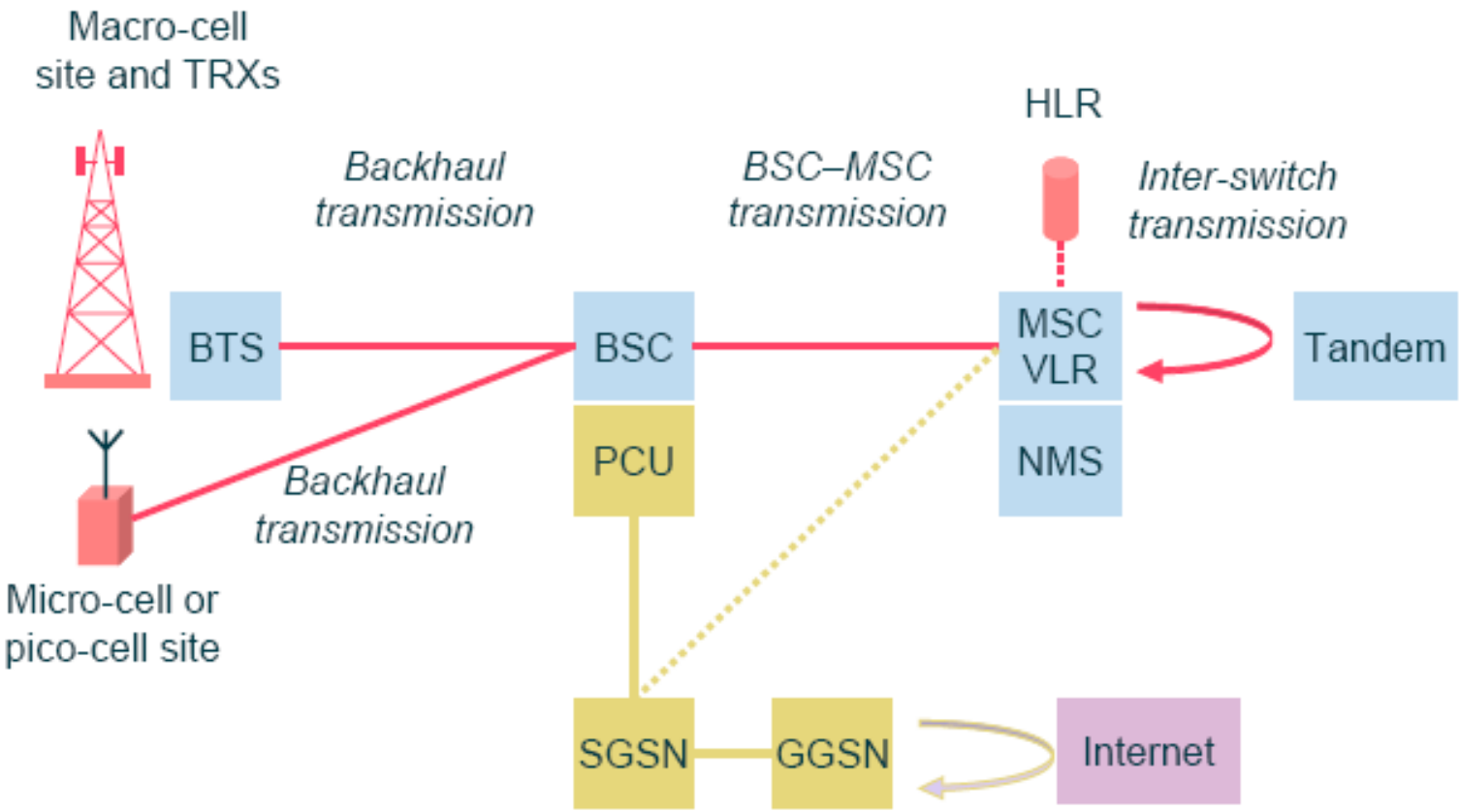
Cash flow analysis:

Year	**0**	**1**	**2**	**3**	**4**
+ Revenue	0	5	6	7	8
- Operating costs	0	-2	-2	-2	-2
- Investments	-12	0	0	0	0
= Cash flow	-12	3	4	5	6
Cumulative cash flow	-12	-9	-5	0	6

Modelling of network investments (CAPEX)

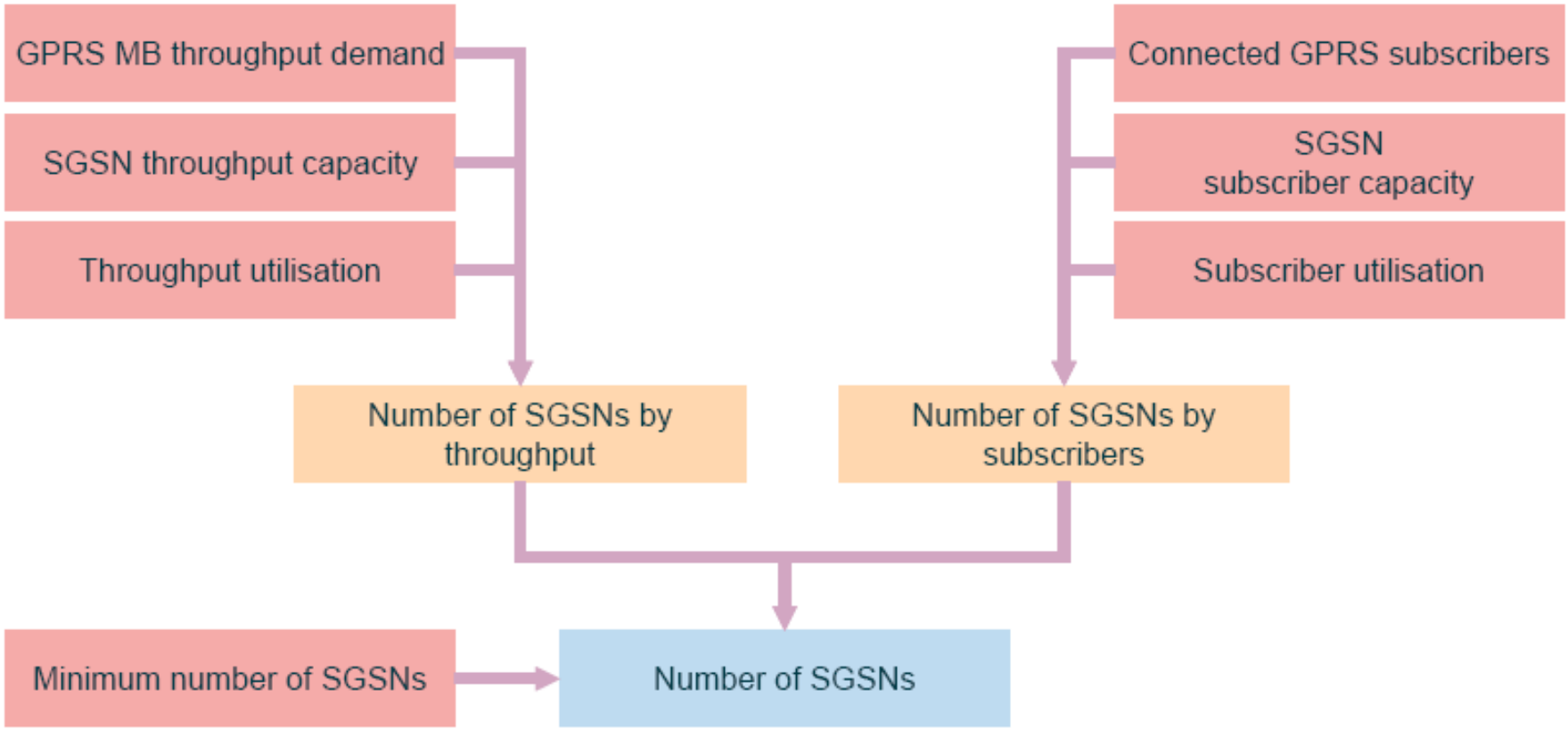
- Network engineering and dimensioning skills required!
- Network architecture
  - Hierarchy of nodes and links
- Network element characteristics
  - Capacity / coverage
  - Price evolution
- Traffic demands
  - Busy hour traffic demand
- >> Required investments per year

Example: Network architecture and cost elements



Source: Swedish National Post and Telecom Agency, 2003

Example: GPRS SGSN calculation



Source: Swedish National Post and Telecom Agency, 2003

OPEX modelling

One possible classification

- Network-related OPEX
  - Operations, administration, maintenance & provisioning (OAM&P)
  - Driven by number of network elements
- Sales & marketing
  - Depends on chosen strategy and market conditions
  - Affected by e.g. churn, handset subsidies, advertising campaigns
- Billing and customer care
  - Drivers: Number of subscribers, quality of customer care
- Interconnection and roaming
  - Paid to other operators
  - Drivers: Minutes of use
- General & Administration
  - As a percentage of e.g. revenues

OPEX modelling - example

1 Network related elements	Example formula
Network operations and administration	x% of cumulative investments
Network maintenance	x% of cumulative investments
Equipment installations	x% of equipment cost
Site rentals	x € per m2 x € per network element
2 Sales and marketing related elements	
Sales and marketing	x € per new customer
Handset subsidies	x € per new customer
3 Customer service related elements	
Customer care	x € per customer per year
Charging and billing	x € per customer per year
4 Interconnection and roaming	
Interconnection	x € per outgoing minute
Roaming	x € per minute
5 Other	
General & Administration	x% of revenues

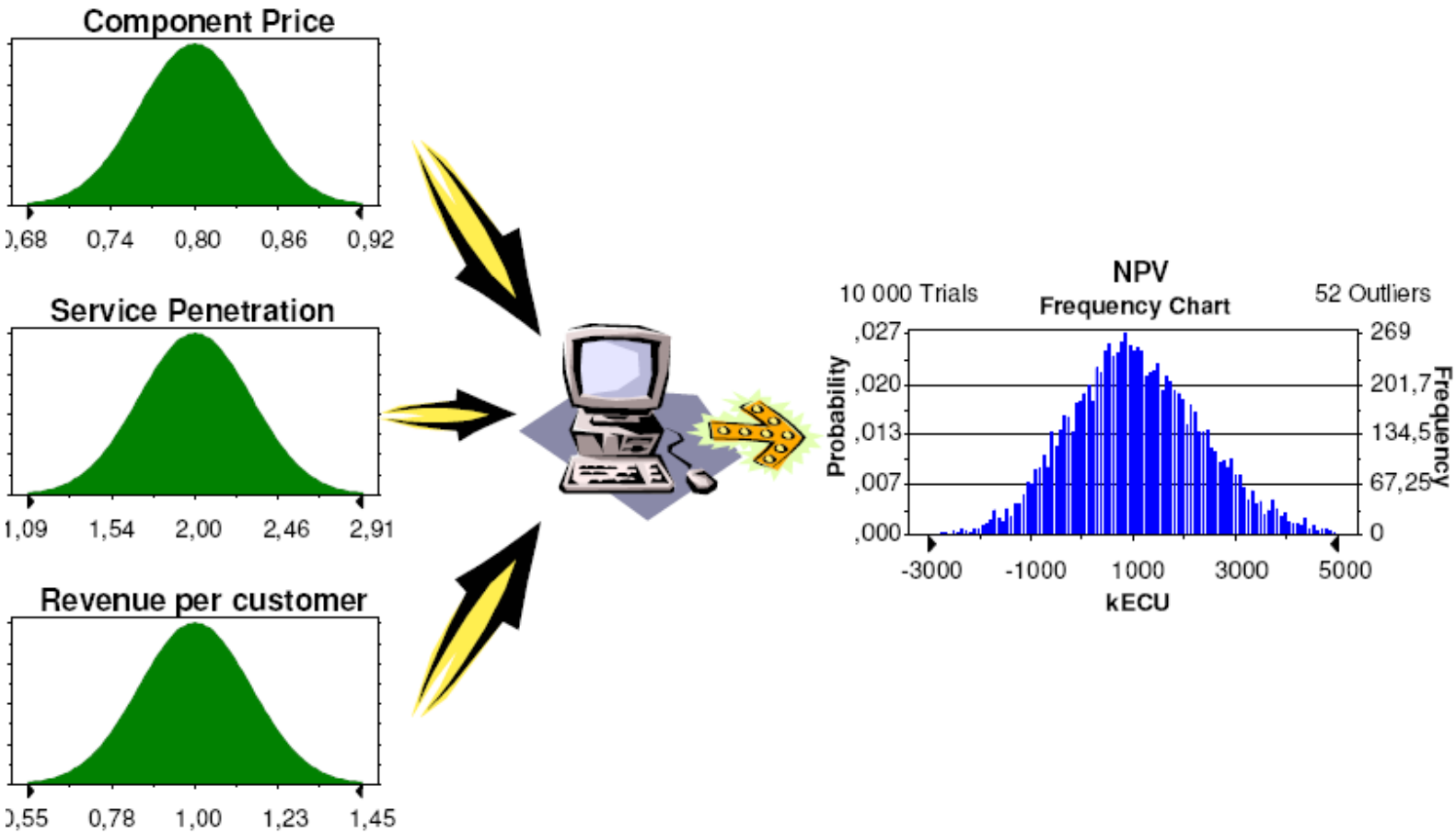
Risk and sensitivity analyses

Tackling uncertainty

- Most of the inputs to the models are uncertain
  - Service tariffs >> Competition, regulation
  - Service penetration and usage>> Alternatives, fashion
  - Element prices >> Mass market adoption
- Uncertainty can be coped with different means
  - Sensitivity analysis:
    - considers the effects of changes in key assumptions only one at a time
  - Scenario analysis:
    - many or all of the variables are changed simultaneously, enabling different what-if and worst/best case scenarios to be analyzed
  - Simulation analysis:
    - probability distributions specified for the variables, Monte Carlo simulation used to generate thousands of different scenarios

Risk and sensitivity analyses

Example



Techno-economic case studies

- Technology-oriented
  - WLAN / WiMAX
    - Feasibility as substitute and/or complement to 3G
    - Fixed (vs. ADSL), Mobile (vs. GSM/3G)
  - Broadband / Fiber-to-the-x scenarios
  - Cost of IP Multimedia Subsystem deployment
- Service / Business model -oriented
  - Feasibility of Mobile TV business models
    - Mobile operator vs. Broadcaster point-of-view
  - Feasibility of MVNOs
    - MVNO strategies and evolution paths: SP > ... > Full MVNO
    - Differentiation vs. cost leader strategies

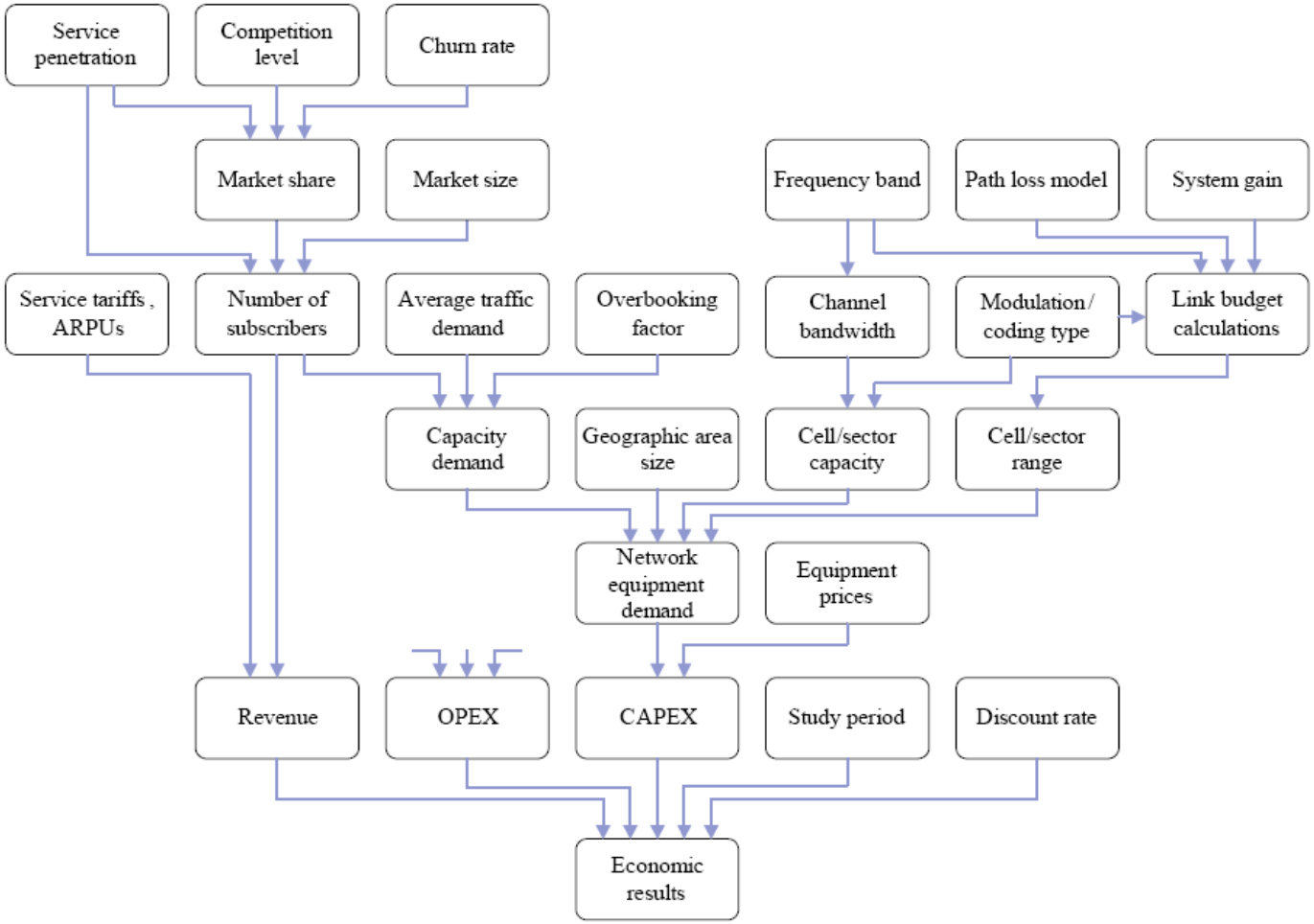
Example case study

WiMAX for fixed broadband access

Case introduction

- Motivation
  - WiMAX a potential challenger for both fixed and mobile broadband technologies
  - Techno-economic performance uncertain
- Fixed WiMAX considered as a substitute to DSL
  - Assumed to offer same user experience as DSL
  - ARPUs and bit rates as in DSL offerings
- Scenario parameters for modeling:
  - Spectrum band: 3.5 GHz, 2.5 GHz
  - Area characteristics: Urban, Suburban, Rural
    - DSL and cable not always available in sparsely populated areas >> Higher WiMAX market share
- Network operator point-of-view
  - No service operator –related OPEX, such as marketing, billing, customer care
- Study period of 5 years: 2006-2010

Techno-economic model

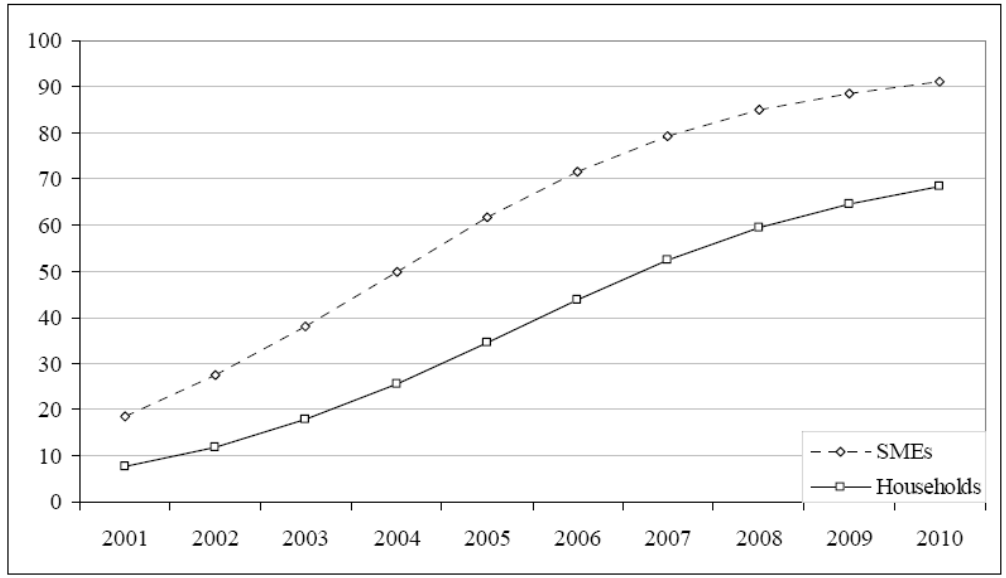


Revenue modelling

Market / service assumptions

- Average service data rates:
  - HH: 1Mbps, +20%/year
  - SME: 2Mbps, +20%/year
  - Overbooking factors 20 and 4
- DSL-like ARPUs assumed:
  - 30 Eur (HH), 200 Eur (SME)
  - -15% per year
- Wholesale (bitstream) tariffs:
  - 80% of retail ARPU
- Three area types
  - Urban, Suburban, Rural

Penetration forecasts for country groups:



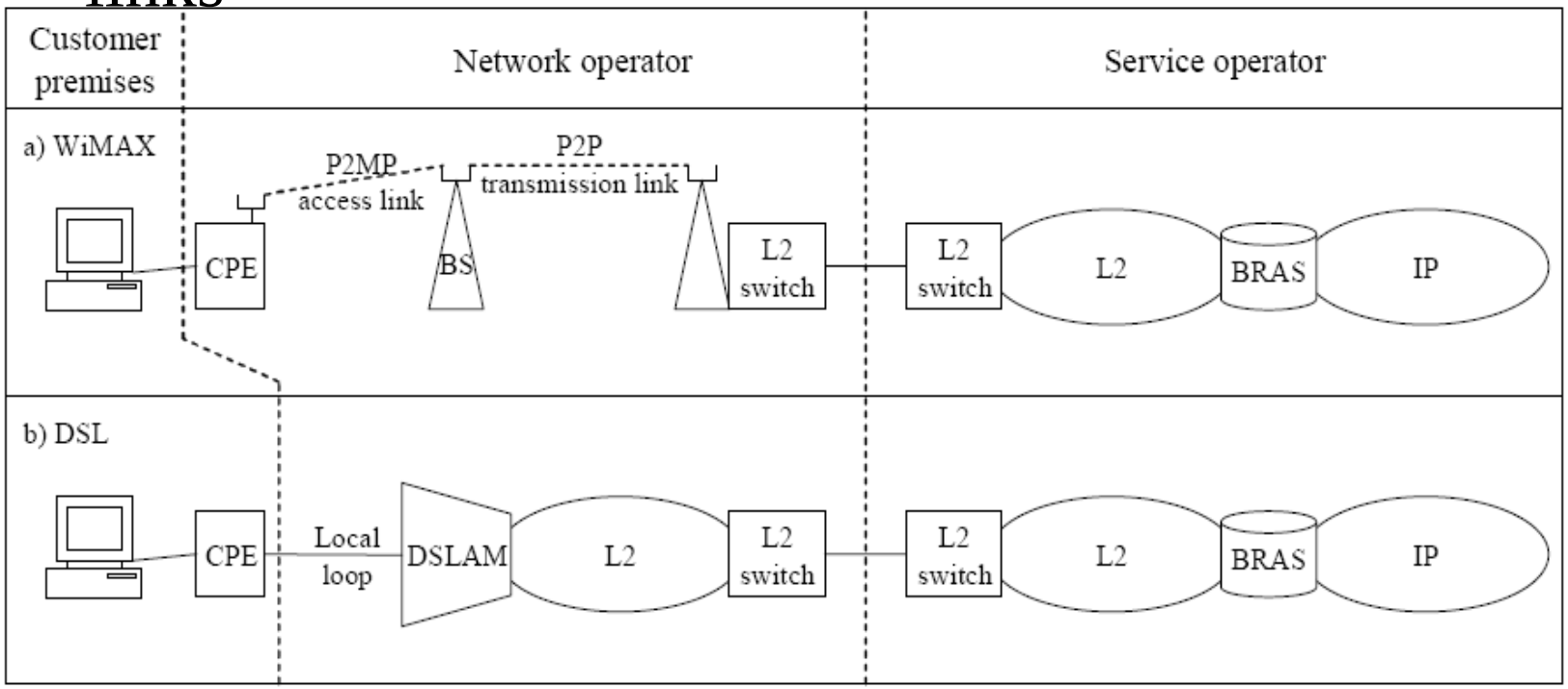
Area type characteristics:

Area type	Urban	Suburban	Rural
Area size (km2)	10 … 50	100 … 500	2500 … 10000
Household density (1/km2)	5000 … 1000	500 … 100	20 … 5
Business density (1/km2)	500 … 100	100 … 20	2 … 0.5
Competitors	2	1.5 *	1 *
DSL availability	100%	95%	75%

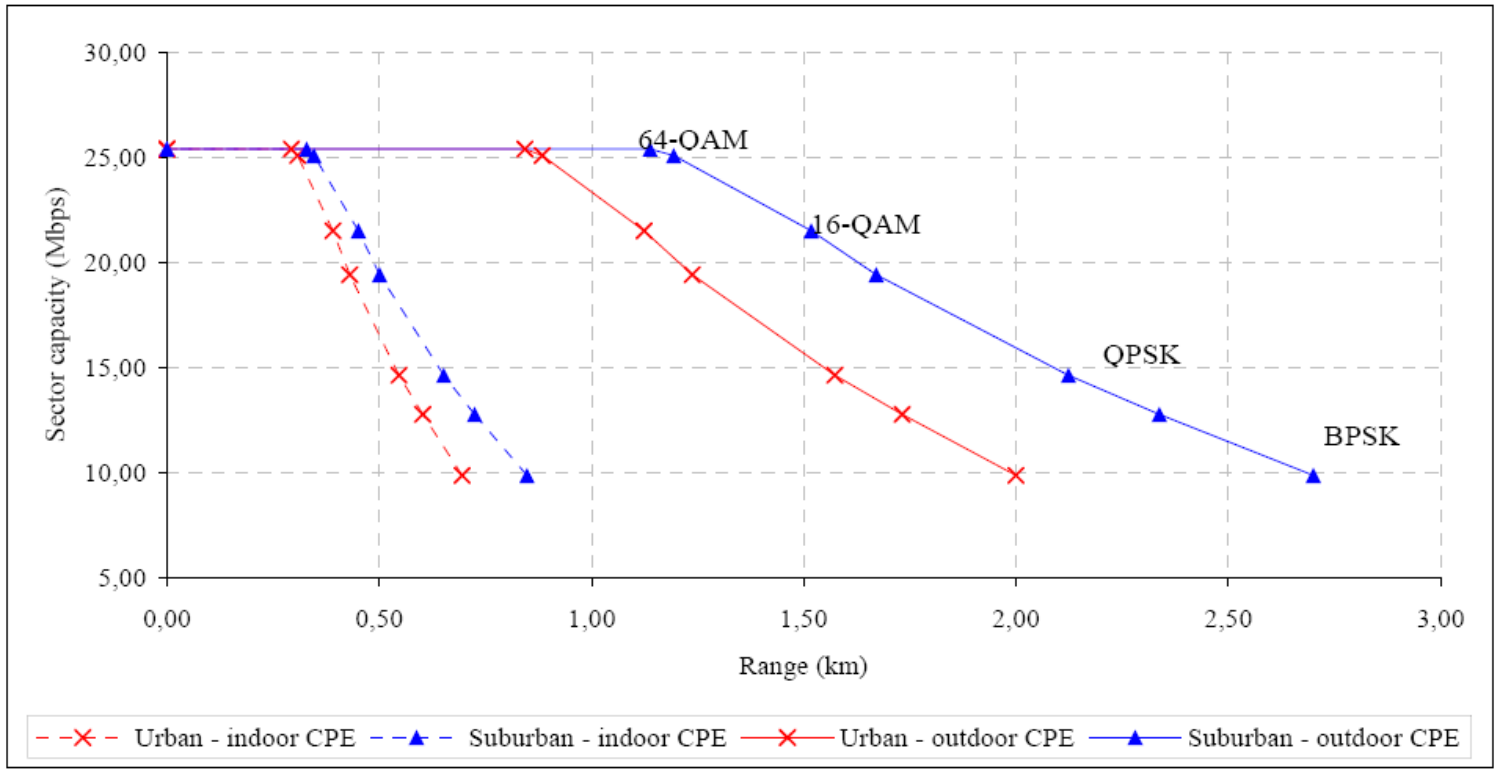
* only in areas with DSL coverage, no competition in residual markets

CAPEX modelling (1):
WiMAX network architecture

- CPEs, base stations + sectors, and transmission links



CAPEX modelling (2):
WiMAX capacity and coverage



Urban area predictions based on SUI Category A path loss model
Suburban area predictions based on SUI Category B path loss model

3.5 GHz band, 7 MHz bandwidth

CAPEX / OPEX modelling

Cost assumptions

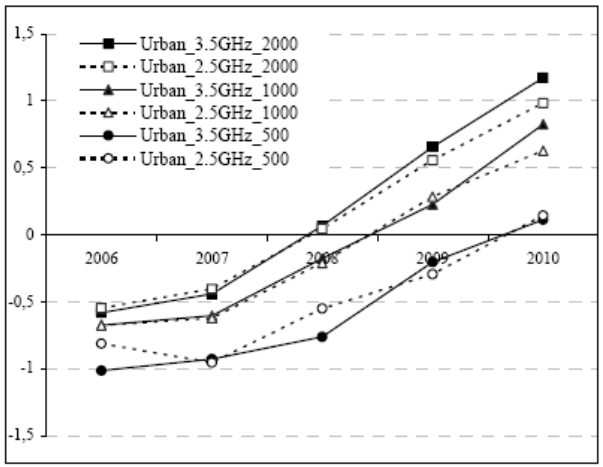
Cost component	Price in 2006	Price evolution
Spectrum license fee (e.g. 8 x 7 MHz)	0 €	-
WiMAX 3.5 GHz BS	10.000 €	-15% per year
WiMAX 3.5 GHz BS sector	7.000 €	-15% per year
BS installation cost	5.000 € per BS + $500 per sector	-
BS site rental	1.800 € per BS per year + 1.200 € per sector per year	-
Transmission link equipment (P2P radio link + port in core switch)	20.000 € per BS	-10% per year
P2P radio link site rental	2.400 € per BS per year	-
WiMAX 3.5 GHz indoor CPE	250 €	-20% per year
WiMAX 3.5 GHz outdoor CPE	350 €	-20% per year
Outdoor CPE installation cost	100 € per installation	-
Network equipment administration and maintenance costs	15% of cumulative investments	-

Economic results

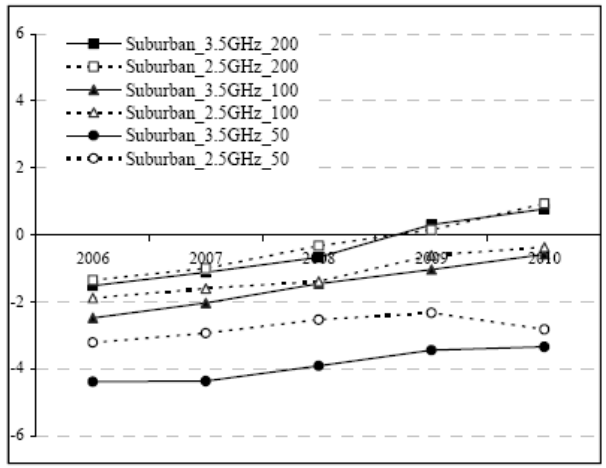
- Densest areas show profitable results
- All-indoor deployments have poor profitability

- Suburban areas show low profitability
- Profitability limited by sector range, rather than capacity

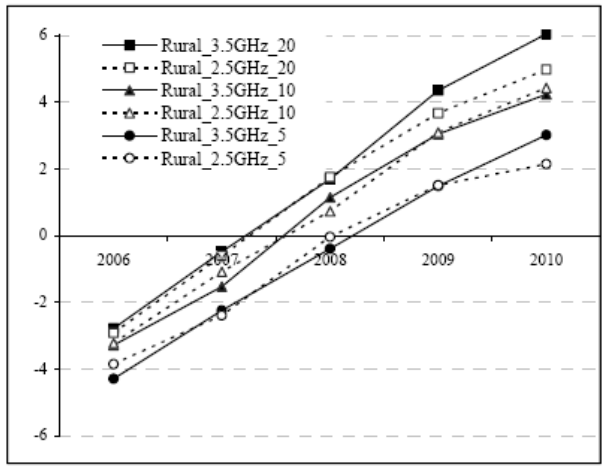
- Rural areas show good results on HH densities above 10/km2
- Large market share outweighs the initial investments



Case	NPV	IRR
Urban_3.5GHz_2000	1,017	56,4 %
Urban_2.5GHz_2000	0,956	55,3 %
Urban_3.5GHz_1000	0,695	37,7 %
Urban_2.5GHz_1000	0,634	35,5 %
Urban_3.5GHz_500	0,111	13,4 %
Urban_2.5GHz_500	0,174	15,8 %



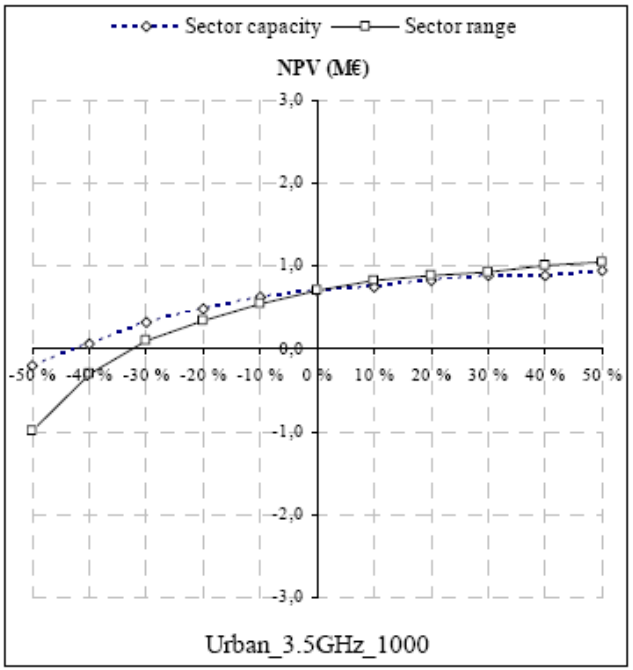
Case	NPV	IRR
Suburban_3.5GHz_200	0,664	24,6 %
Suburban_2.5GHz_200	0,808	29,2 %
Suburban_3.5GHz_100	-0,588	0,5 %
Suburban_2.5GHz_100	-0,236	5,6 %
Suburban_3.5GHz_50	-3,298	-26,2 %
Suburban_2.5GHz_50	-2,186	-19,8 %

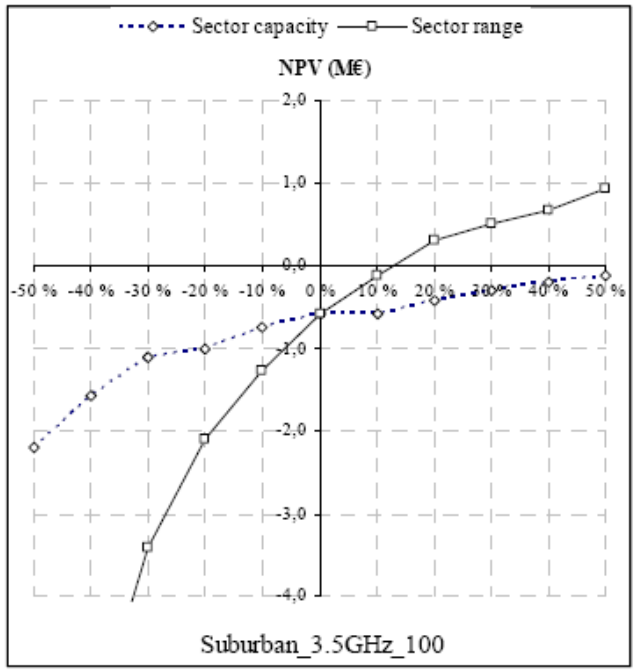


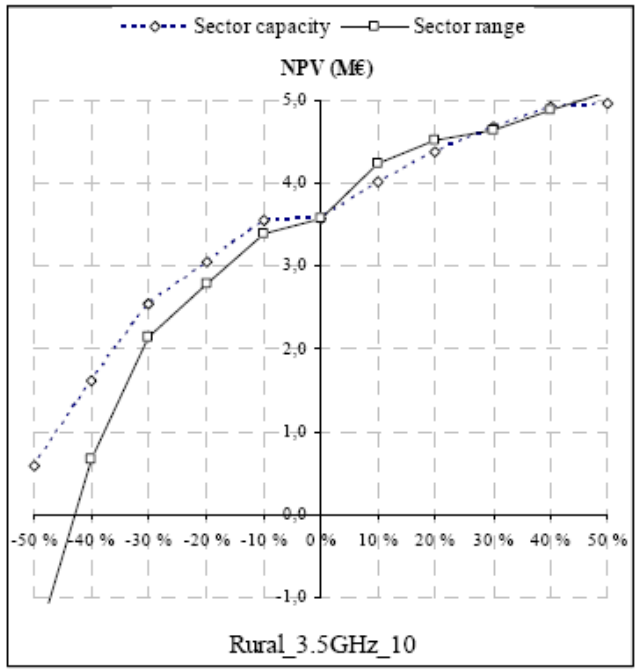
Case	NPV	IRR
Rural_3.5GHz_20	4,887	74,3 %
Rural_2.5GHz_20	4,307	66,9 %
Rural_3.5GHz_10	3,565	50,9 %
Rural_2.5GHz_10	3,658	52,9 %
Rural_3.5GHz_5	2,213	30,7 %
Rural_2.5GHz_5	1,988	30,2 %

Sensitivity analysis

Example: Sector capacity and range







Role of WiMAX in Finland?

	Fixed broadband	Mobile broadband
Urban	xDSL / Cable in dominating positions Regulator pushing service competition WiMAX cannot compete against 10-20 Mbps per user alternatives	WiMAX and 3G offer similar performance 3G / HSPA in strong positions • Industry support, time-to-market Regulator in an important role • Spectrum policy, open access Demand for bandwidth growing, opportunity?
Rural	Techno-economic performance often better than competitors' Latent demand in underserved areas Suits basic needs, but how about high throughput services? (IPTV, P2P, VoD)	Currently available spectrum not sufficient Competing solutions on good positions Flash-OFDM, CDMA @ 450 MHz UMTS/HSPA @ 900 MHz? Vs. WiMAX @ 3500 MHz

Lecture summary

- Techno-economic modeling is useful in analyzing emerging technologies
  - Feasibility studies, opportunity/threat analyses
  - Combined use of e.g. trend analysis, quantitative modeling, scenarios, and basic capital budgeting methods
- The models cannot predict the future
  - Analysis of alternative future scenarios still possible
  - Sensitivity analyses give insight to the dynamics of the models and reveal critical success factors