RESPONDER
Linking SCP and Growth Debates

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Energy-Efficient Internet Access

AUSTRIAN ENERGY AGENCY

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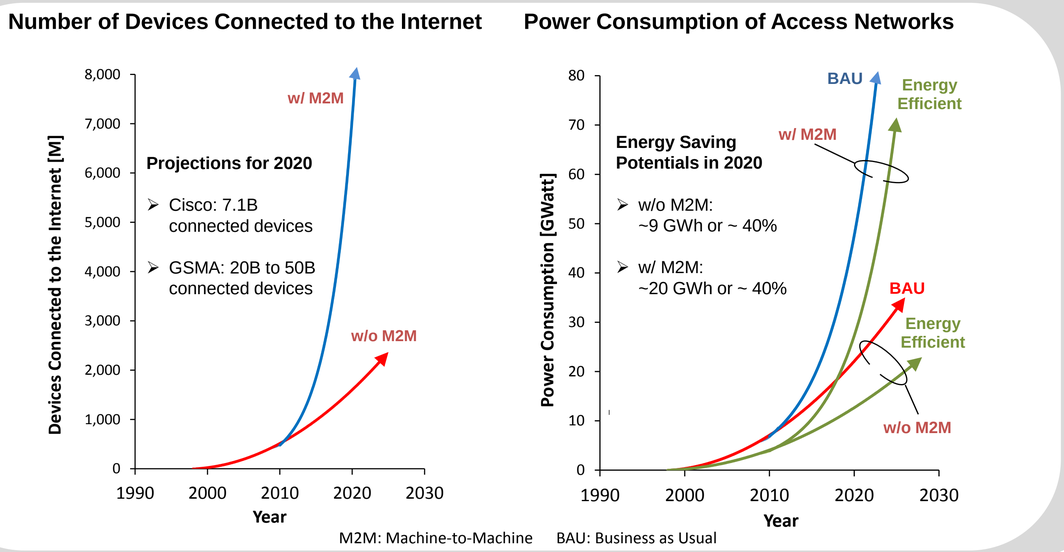
Energy Consumption in Access Networks

- Ever-increasing number of broadband subscribers
- Broad use of advanced applications increasingly drive the need for high capacity
- The most complex part of today's Internet is the access network area, which also contributes mainly to the high total energy consumption of the global network infrastructure
- To fulfill the vision of the Internet of Things, a huge number of intelligent, self-communicating devices need to be connected to the Internet
- All these trends indicate an urgent need for more efficient access networks [1, 2, 3]

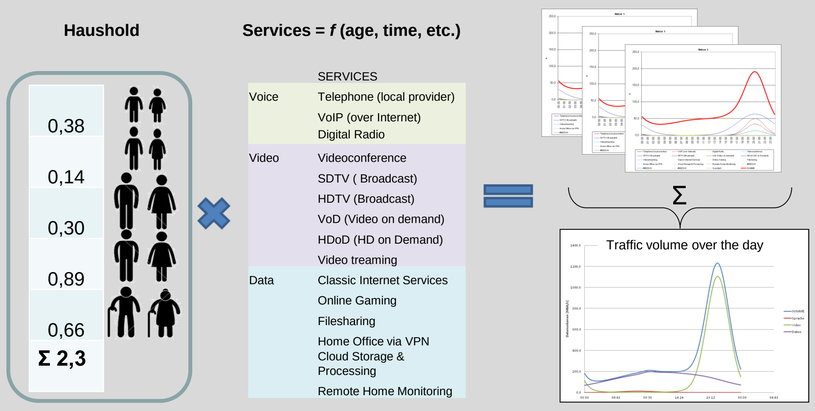


The Goal

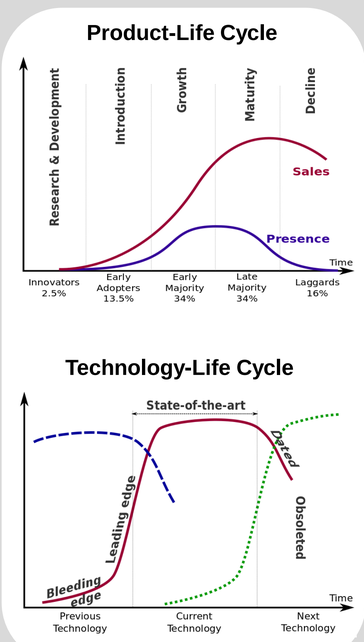
- Model and study energy efficiency of access networks and end-user devices
- Active involvement of stakeholders
- Estimate the energy efficiency of the current internet access
- Identify and assess energy saving methods and potentials
- Develop scenarios for future developments (BAU, best case, worst case, …)
- Develop recommendations for policy makers in order to support a development and a wide use of energy-efficient concepts and devices

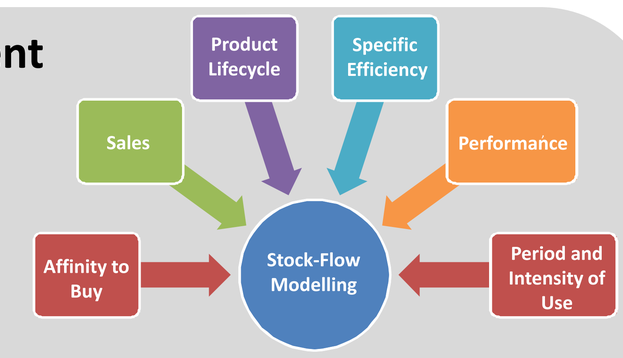
Users, Applications, Traffic

- Socio-demographic parameters
- Application usage patterns
- Traffic volume over the day



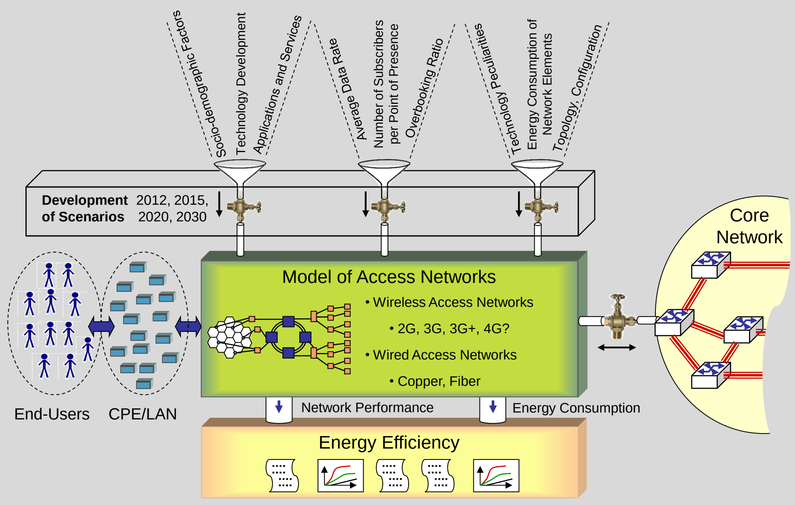
End-User Equipment





- Estimation of the number of units in use
- Variety of input parameters influence the sales flow over the next years
- Product lifetime and replacement probability determine how long equipment remains in use
- End of a technology lifecycle triggers a coming changeover to new technology
- Affinity to buy, assessed product value, presence of products for sale, etc. change over time

Model of Access Networks



- Urban, suburban and rural areas
- Wireless (GSM/GPRS/EDGE, UMTS/HSPA, LTE) and wired access technologies (xDSL, HFC, Optical)
- Multiple network providers
- Traffic models, trends
- Technology and socio-demographic peculiarities
- Configuration , topology, limitations
- Energy Efficiency (e.g. bit/Joule)

Technology Matrix (suitability of end-user equipment and network technologies to support different applications)

Game Console	Internet Radio	TV-Set-top-box ex. Modem	TV with DVB Receiver	Smartphone	Cell Phone	Telephone	PDA	Netbook / Tablet PC	Notebook	PC	End-User Equipment / Access Networks	ADSL	ADSL2+	VDSL	VDSL2	HFC	EPON	GPON	DVB-Sx	DVB-Cx	DVB-Tx	Public WLAN	UMTS	LTE	WiMAX	
												Wired Technologies							TV Distribution			Wireless Technologies				
2	3	x	x	3	x	x	x	3	3	2	WiFi	3	3	3	3	3	3	3	x	x	x	x	1	2	2	
3	3	x	x	x	x	x	x	3	3	3	POF	2	3	2	3	2	3	3	x	x	x	x	1	2	2	
3	3	x	x	x	x	x	x	3	3	3	PLC	2	3	2	3	2	3	3	x	x	x	x	1	2	2	
3	3	x	x	x	x	x	x	3	3	3	CAT-X	2	3	2	3	2	3	3	x	x	x	x	1	2	2	
											Ethernet LAN															
											Services															
0%	0%	0%	0%	30%	30%	35%	1%	0%	2%	2%	Telephone (local provider)	3	3	3	3	3	x	x	x	x	x	x	3	3	x	Voice
0%	0%	0%	0%	20%	0%	0%	5%	15%	30%	30%	VoIP (over Internet)	3	3	3	3	3	3	3	x	x	x	2	2	3	3	Voice
0%	5%	15%	15%	15%	0%	0%	0%	10%	20%	20%	Digital Radio	2	3	3	3	3	3	3	3	3	3	2	2	3	3	Voice
0%	0%	0%	0%	10%	0%	0%	0%	15%	35%	40%	Videoconference	2	3	2	3	2	3	3	x	x	x	1	2	3	3	Video
0%	0%	40%	35%	0%	0%	0%	0%	5%	10%	10%	SD-TV (Broadcast)	x	x	x	x	3	x	x	3	3	3	x	x	x	x	Video
0%	0%	35%	40%	0%	0%	0%	0%	5%	10%	10%	HD-TV (Broadcast)	x	x	x	x	3	x	x	3	3	3	x	x	x	x	Video
0%	0%	30%	0%	10%	0%	0%	0%	15%	20%	25%	Video on Demand	1	3	2	3	3	3	3	x	x	x	1	2	3	3	Video
0%	0%	0%	0%	15%	0%	0%	0%	20%	30%	35%	Videostreaming	2	3	2	3	2	3	3	x	x	x	1	2	3	3	Video
2%	0%	0%	0%	20%	3%	0%	5%	15%	30%	25%	Classic Internet Services	3	3	3	3	3	3	3	x	x	x	3	3	3	3	Data
40%	0%	0%	0%	5%	0%	0%	0%	5%	20%	30%	Online Gaming	2	3	2	3	2	3	3	x	x	x	1	2	3	3	Data
0%	0%	0%	0%	10%	0%	0%	0%	15%	35%	40%	Filesharing	2	3	2	3	2	3	3	x	x	x	0	2	3	3	Data
0%	0%	0%	0%	10%	0%	0%	0%	20%	35%	35%	Home office via VPN	3	3	3	3	3	3	3	x	x	x	-	2	3	3	Data
0%	0%	0%	0%	15%	0%	0%	0%	25%	30%	30%	Cloud Storage & Processing	2	3	2	3	2	3	3	x	x	x	2	3	3	3	Data
0%	0%	0%	0%	20%	10%	0%	0%	20%	25%	25%	Remote Home Monitoring	3	3	3	3	3	3	3	x	x	x	1	3	3	3	Data

Abbreviations:

M2M: Machine-to-Machine
POF: Polymer Optical Fiber
VPN: Virtual Private Network
BAU: Business as Usual
HFC: Hybrid Fiber Coax
LTE: Long Term Evolution
CPE: Customer Permisses Equipment
PLC: Powerline Communication
HVAC: Heating, Ventilation and Air Conditioning

Legend:
3 excellent (there are no limitations in use and quality)
2 → good (most users are satisfied)
1 → acceptable (could be better, but)
0 → poor but still possible to use
- → it could be theoretically used, but very poor quality
x → currently not usable (no interface,…)

Recommendations for Improving Energy Efficiency

- Passive and active site and network sharing by several network operators
- Promoting deployment of energy-efficient optical technologies
- Dynamic network operation and energy management
- Standardization of efficient low-power and standby modes for network equipment
- Deployment of energy-efficient HVAC and free cooling systems
- Utilizing alternative energy sources (solar, wind, …)
- Regulative support for optimal network planning and deployment

References

[1] S. Aleksic, M. Deruyck, W. Vereecken, W. Joseph, M. Pickavet, L. Martens, "Energy Efficiency of Femtocell Deployment in Combined Wireless/Optical Access Networks", Elsevier Computer Networks, pp. 1-18, 2012, doi: 10.1016/j.comnet.2012.12.013.
[2] S. Aleksic, "Energy-Efficient Communication Networks for Improved Global Energy Productivity", (invited), Springer Telecommunication Systems, ISSN: 1018-4864 ,pp. 1 - 18, 2012.
[3] S. Aleksic, A. Lovric, "Energy Consumption and Environmental Implications of Wired Access Networks", American Journal of Engineering and Applied Sciences, 4(4) , pp. 531 - 539, 2012, doi: 10.3844/ajeassp.2011.531.539.

This work was supported by the project HOME-ICT, which is funded by the Austrian Fund for Climate and Energy and accomplished within the framework of the program "NEUE ENERGIEN".

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