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Optimizing a public 3G/LTE wireless network and associated services for minimum energy consumption or emissions

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Issues

- 1. Characterize the energy consumption and emissions *jointly* of public wireless network *infrastructure* and of the actual services derived *traffic*
- 2. Characterize wireless infrastructure *technology* and *standards* migration effects (e.g. 3G,HSPDA, LTE
- 3. Offer a tool to industry allowing to *design basic and value-added service tariffs* in view of eventual investments in reneweable energy production, and of the introduction of « *green » telecommunications tariffs*

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Modelling approach

- Build from an industry tool a quasi-real *network infrastructure and traffic model*, with energy footprints for all main subsystems (radio, transmission , cooling) and traffic dependent energy consumption (circuit switched and IP); there is provisioning of a set of services to a subscriber base
- Structure the *economic sub-model* of CAPEX, OPEX, Billing, CRM, Network management,Content acquisition and net energy costs, as a model of the *marginal flows* linked to one additional user, on top of an existing subscriber base;use of estimated Cobb Douglas functions
- Include a *reverse auction bidding process*, whereby the incremental user states the service duration, his basic bundle price offer, and his value-added bundle offer for the service duration; operator then must select and configure network ressources accordingly allowing *fine-tuning of tariffs and incentives with profitability and emissions contraints*

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Infrastructure

- UTRAN (Radio): RBS* etc.. for:GSM/GPRS, EDGE/HSPDA , LTE (100 Mb)
- Transmission: line cards*, Microwave links*, ATM over IP*, WDM , SONET
- Backbone: MGW*, edge routers*, core routers*, AAA, signalling
- Storage : CDR , billing / CRM data , on-demand media, regulated security records
- Power: electrical grid power, local wind power, local sun power , backup local power
- Cooling: (*)
- Network capacity adapted to meet QoS thresholds given subscriber bids (incl, service mix); excess capacity not used by generic services may be used by value-added services ; if it is insufficient, extra capacity provisioned by SLA at higher rates

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Services

- Basic: Network management , billing / CRM
- Generic services: voice, SMS/MMS and metered IP traffic
- Value-added service : for illustration: M-Singing where a user download songs, and has interactive comments by a paid employee to improve his performance; extensively researched in terms of personalized tariffs
- Other value-added services studied : Mobile video, technical wireless field support , public ticketing

Incremental user bids e.g: 6 months, 60 Euros for generic services, and eventually 150 Euros for value-added service

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Energy

- Parametric proportion of distributed nodes (RBS, TRX , links) with renewable energy sources
- Provision of a minimum electrical grid / backup supply proportion of all distributed nodes in relation to infrastructure nodes' and local traffic power consumption (incl. cooling)
- All core infrastructure, real-time storage and backup transmission links on in-sourced electrical grid power
- Parametric mix wind/ solar with full imputation of CAPEX power source infrastructure costs to operator
- Excess reneweable power supply from the wireless network sold at eventually subsidized rates, reducing total OPEX

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Subsystem data

- Real technical data (power, volume, voltage, frequency, performance) used in most cases from 8 different worlwide suppliers, for different technologies / generations
- Real cost, power usage and investment data cross-validated between three public international operators
- When relevant statistical regression estimated or usage of different research groups approximation formula from physical measurements
- Available but no yet incorporated: building premises and eventual separate data center models; buildings model available from our COST804 partner Cenergia A/S

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Base case

- 10 Million subs
- Teledensity 576 users/ cell
- Typical average power consumption / user /month 18 kWh
- Parametric share of RBS with reneweable sources, typically 15 %

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Infrastructure emissions vs. Service based

CASE 1:

Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

Mostly EDGE

CO2 emissions driven by capacity in kg/user/contract: 20,02
CO2 emissions driven by capacity and generic services in kg/ user/ contract :21,05
CO2 emissions driven by value-added service in kg/ user/ contract:0,45
Reneweable energy resold: 403 581 Euros

CASE 2:

Contract duration in month(s)	1
User proposed Msinging service bundle price (euro)	50
User basic bundle (euro)	260

Mostly LTE

CO2 emissions driven by capacity in kg/user/contract: 6,57
CO2 emissions driven by capacity and generic services in kg/ user/ contract :7,09
CO2 emissions driven by value-added service in kg/ user/ contract:0,00
Reneweable energy resold: 194 071 Euros

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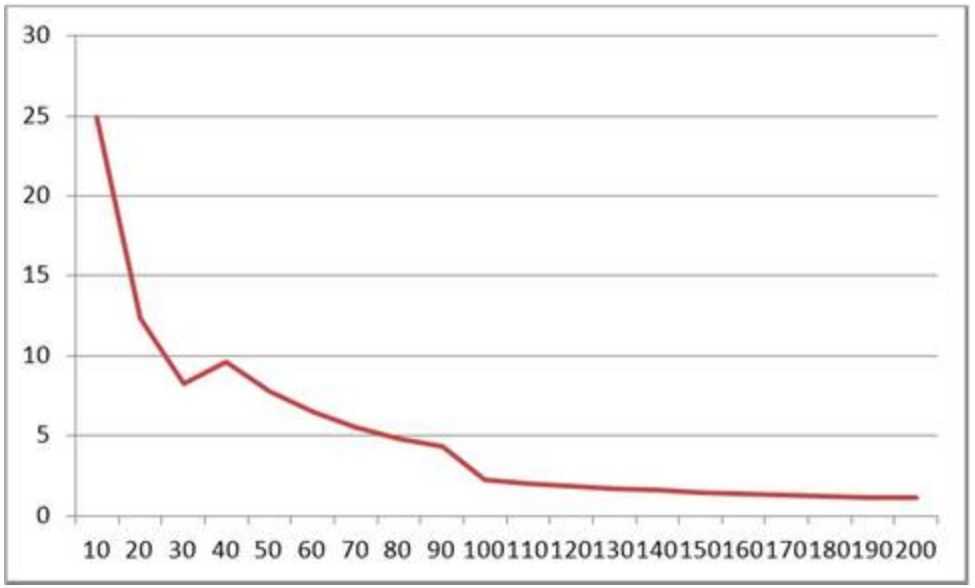
Net Energy costs per user in % of total OPEX vs Basic Bundle (Euros)



Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

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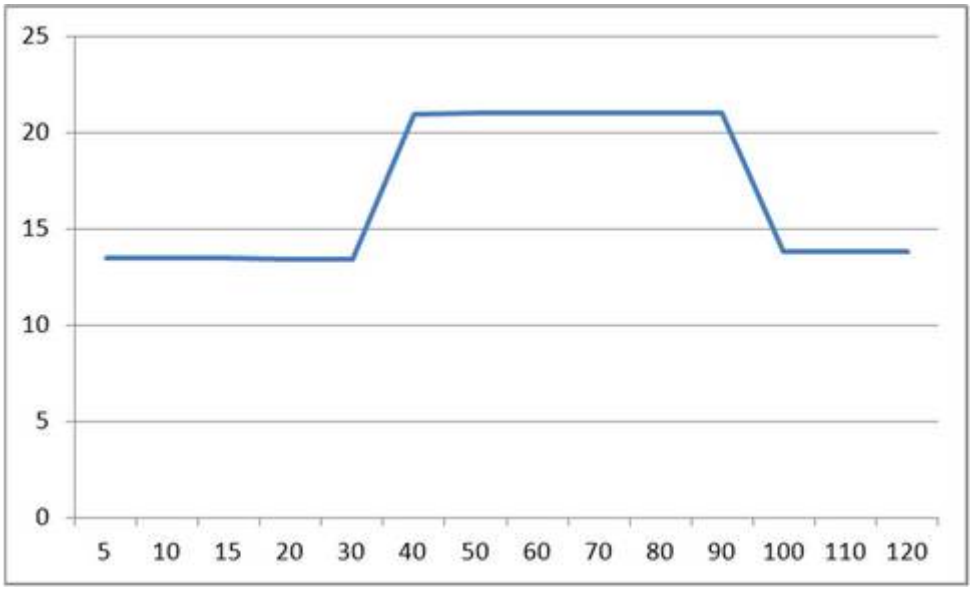
CO2 emissions per user in kg CO2 vs. Basic bundle offer (Euros) (access terminals excluded)



Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

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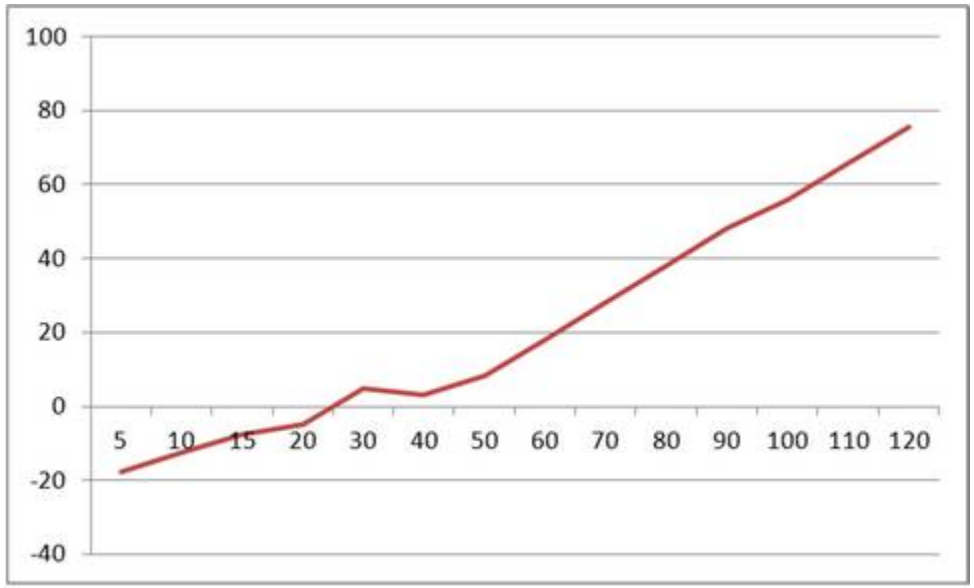
Net profit per incremental user from contract vs basic bundle offer (Euros)



Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

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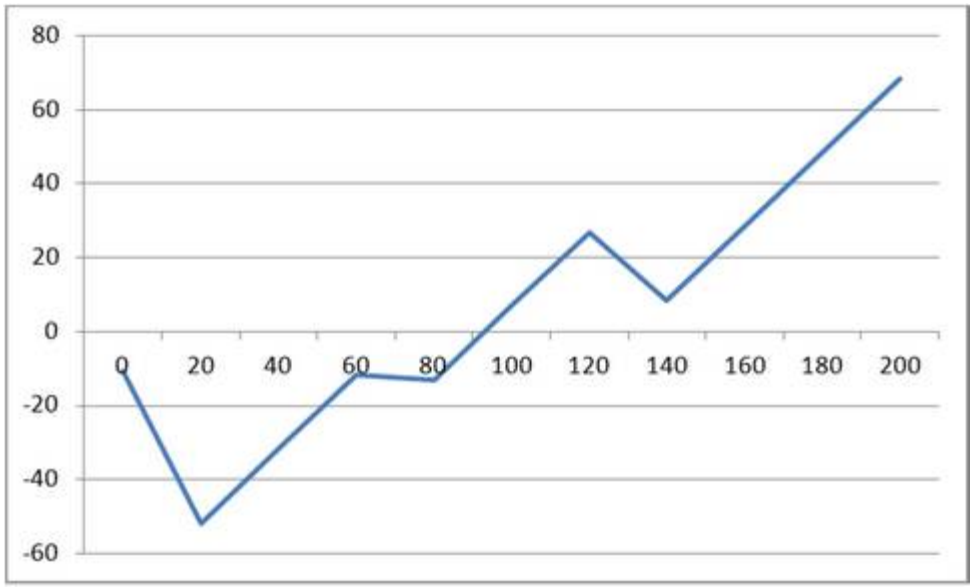
Net profit per incremental user from contract vs value-added service bundle offer (Euros)



Contract duration in month(s)	3
User proposed Msinging service bundle price (euro)	100
User basic bundle (euro)	50

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Results

- General: There are very many interactions to account for,
- Issue 1: Although CO2 emissions due to infrastructure capacity / coverage dominate, the share of generic services and especially of value-added services grows rapidly with service/content richness and real-time performances
- Issue 2: While taking into account spectral system efficiency and frequency bands, emissions get slightly smaller with newer technologies, subject mostly to design and microelectronics progress; critical is the mix of low emissions green technologies in RBS nodes
- Issue 3: New « green » tariffs can be designed by: (a) personalized service characteristics reducing wasted capacity , and (b) incentivizing users to larger renewable power supply grades by OPEX bonus'es. The impact is though mostly from and for high traffic/ content users.

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Further research

- Introduce technology learning curves, esp. from improved multicore DSP's/ASIC's , low power real-time storage, and migration to <0,25 micron designs
- Work and propose in standardization bodies « greener » node architectures
- Finalize a « green tariff » business case and package