linear

Intelligent Networks

Local Intelligent Networks and Energy Active Regions

imec IBBT eandis infrax fifthplay VIESMANN climate of innovation Miele

vito vision on technology KATHOLIEKE UNIVERSITEIT LEUVEN LABORELEC GDF SUEZ EDF luminus belgacom telenet SIEMENS Energy Ville

LINEAR - Agenda

1. Background
2. Objectives
3. Test User Interaction
4. Field test architecture
5. Business Cases Tested

Background

"Local Intelligent Networks and Energy Active Regions"

1. Flemish Government decision
   'dd. 8 mei 2009 VR 2009 0805 DOC.0671'
2. Official start: 1st of May 2009 –December 2014
3. Total budget of about 40M€:
   - Flemish government: about 10M€
   - Industry: about 30M€ (personnel, hardware, ...)
4. Residential Demand Response
   - Technological breakthrough: research and development
   - Implementation breakthrough: field test
   - Top-5 innovative regions within Europe, concerning smart grids

www.linear-smartgrid.be

Target

What makes LINEAR different ?

- Focus on residential consumers, domestic appliances
  - No industrial consumption
  - No High / Medium Voltage Grid
    - Transformer: low voltage side
    - Feeders
  - Include wind production
  - Include domestic PV production

- Focus on Demand Side Management with Comfort Protection

- Automated Demand Response via Energy Management gateway
  - Central unit between house and server
  - Integration with domestic appliances, smart meter and sub metering

Partners

Research Partners

KATHOLIEKE UNIVERSITEIT LEUVEN

vito vision on technology

ibbt

imec

Additional Members Steering Committee

AGORIA

Vlaams netwerk van ondernemingen

EWI

vreg

Linear acknowledges the Flemish Government for its support

iwt

Industrial Partners

EDF luminus

eandis

infrax

LABORELEC GDF SUEZ

belgacom

VIESMANN climate of innovation

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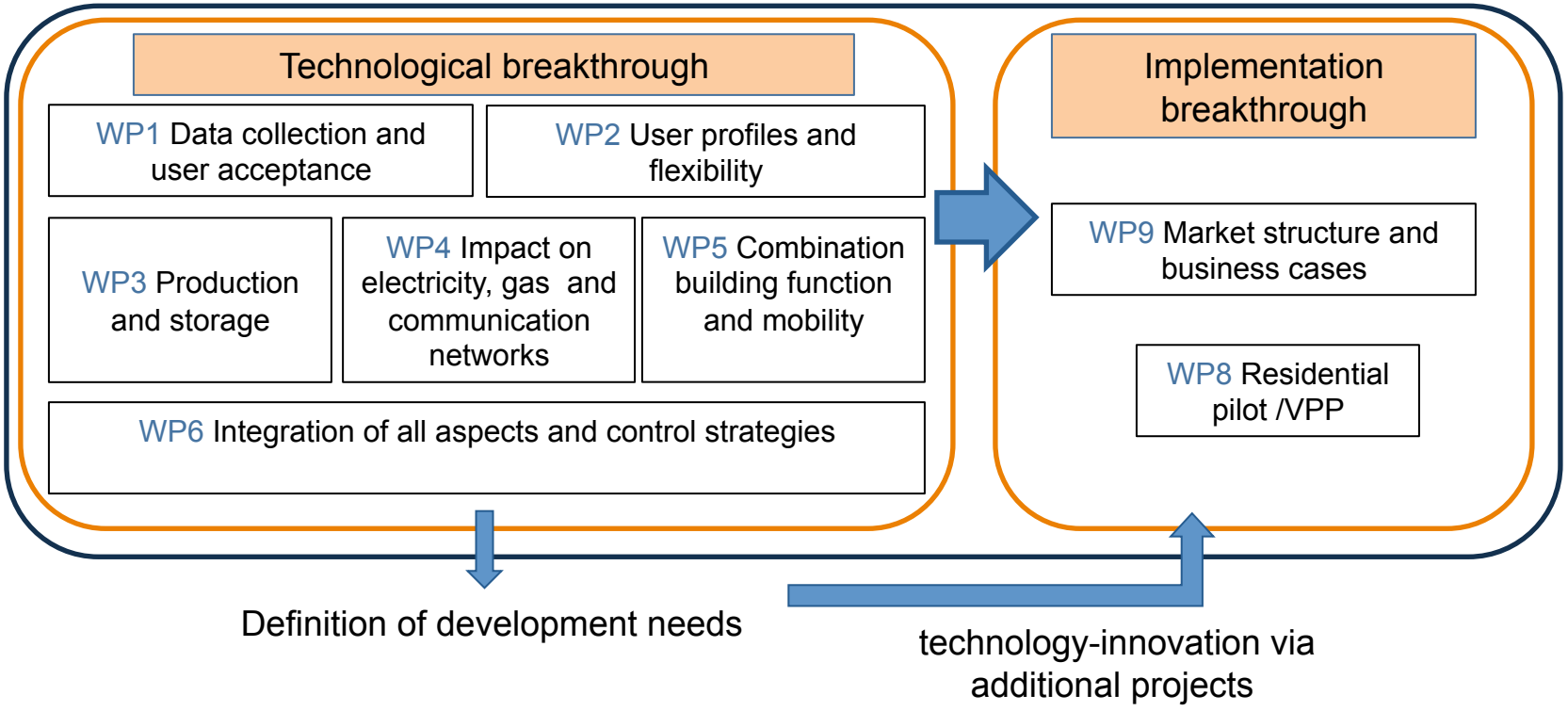
telenet

SIEMENS

Miele

Work plan and objectives



Business Cases tested in Field Test

Use DEMAND RESPONSE for:

1. Portfolio Management
   - Make customers shift consumption in function of the day ahead market and nominations

2. Wind Balancing
   - Reduce unbalance cost for retailer, caused by deviation between prediction and reality

3. Transformer Load/Aging
   - Spread load in time in order to avoid accelerated aging

4. Line Voltage profiles
   - Avoid quality issues with voltage deviations

Business Cases

Retailer Business Cases

EDF luminus

Phase 2

Geographically spread: Flanders

DSO Business Cases

infrax eandis

Phase 3

Geographically concentrated: Hombeek-Leest

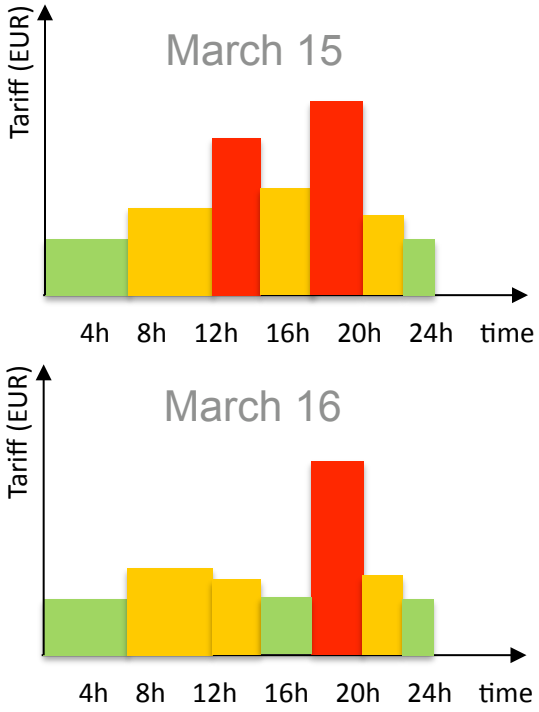
Attitude change expected from test users:

Retailer		DSO	
Give Flexibility	Move to Tariff	Give Flexibility	Move to Tariff
Phase 2a	Phase 2b	Phase 3a	Phase 3b

Attitude expected from Test Users

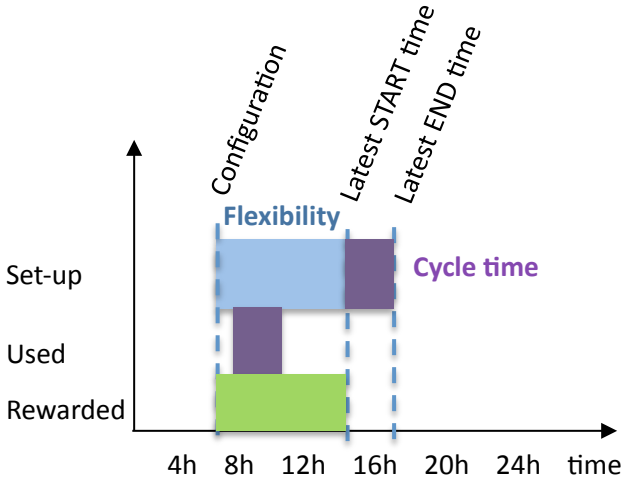
Adapt your consumption to the **Time of Use** tariff

Move to Tariff



Offer flexibility to your Energy Management System

Give Flexibility



Goal

Goal = implement automated active demand control

- Respect (improve) comfort of our users
- Align electricity consumption with variances in wind and solar related production

Flexible loads

Selected appliances:

- Washing machine, drying tumbler, dish washer
- Electric boiler, heat pump

Installation

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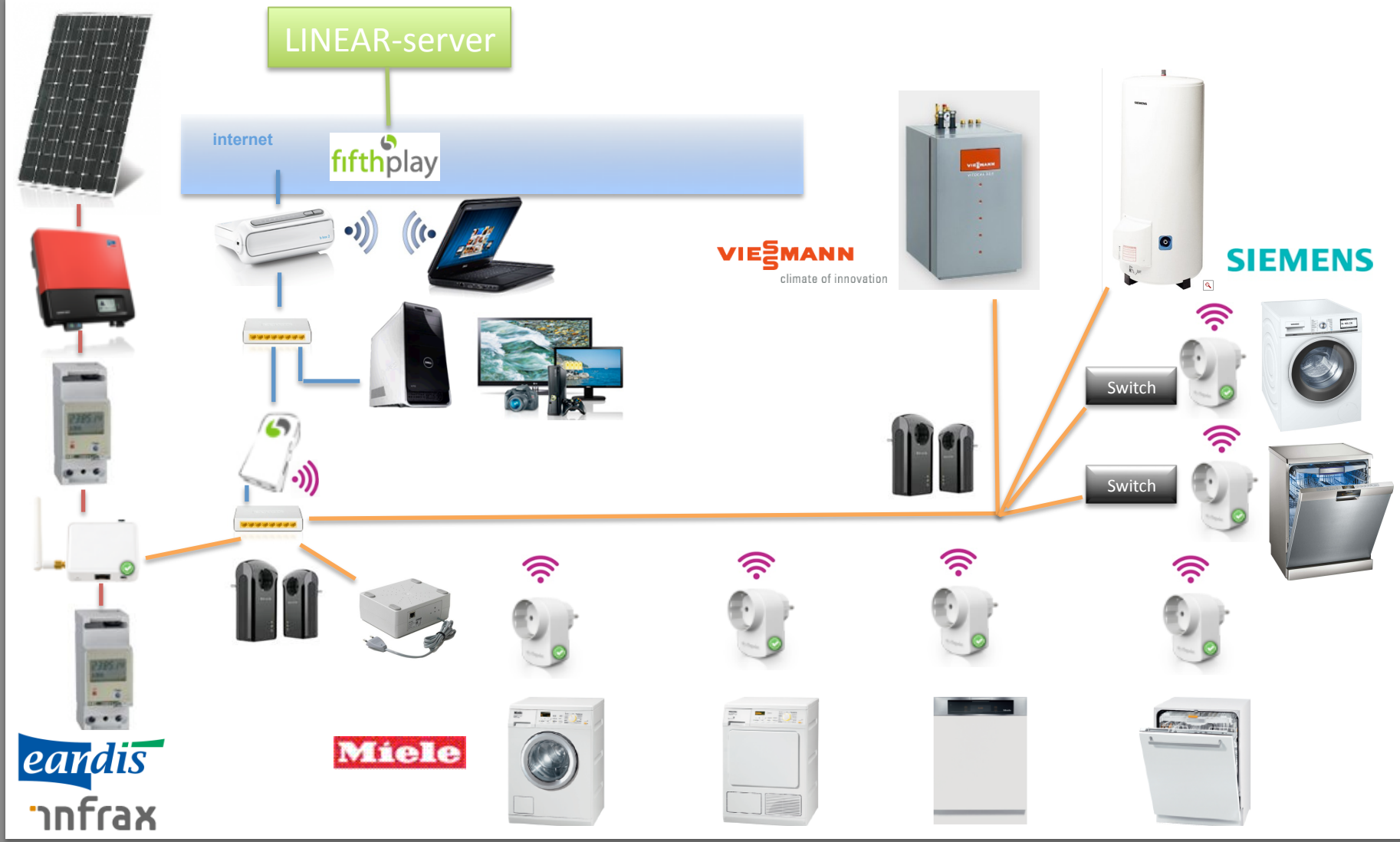
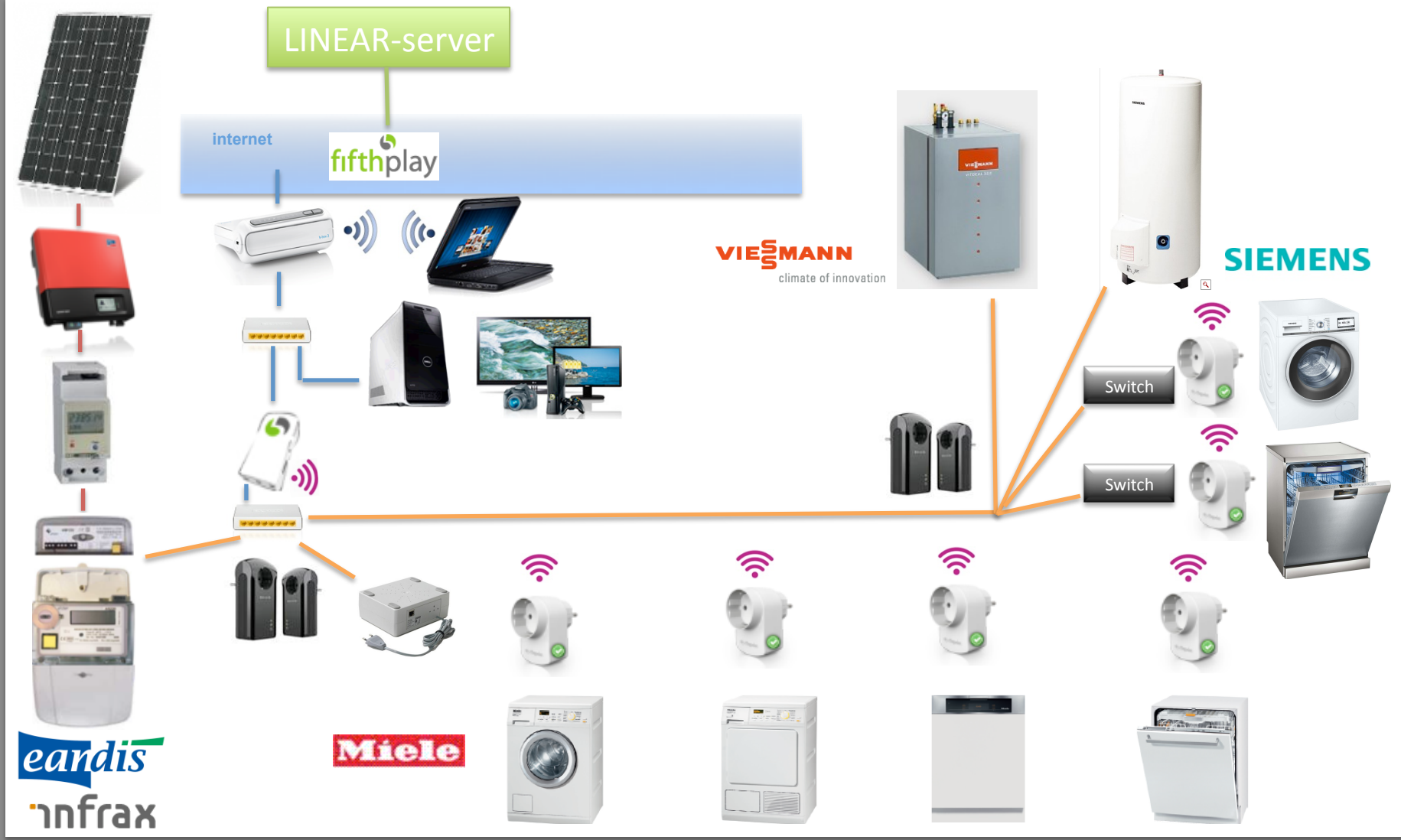
Intelligent Networks

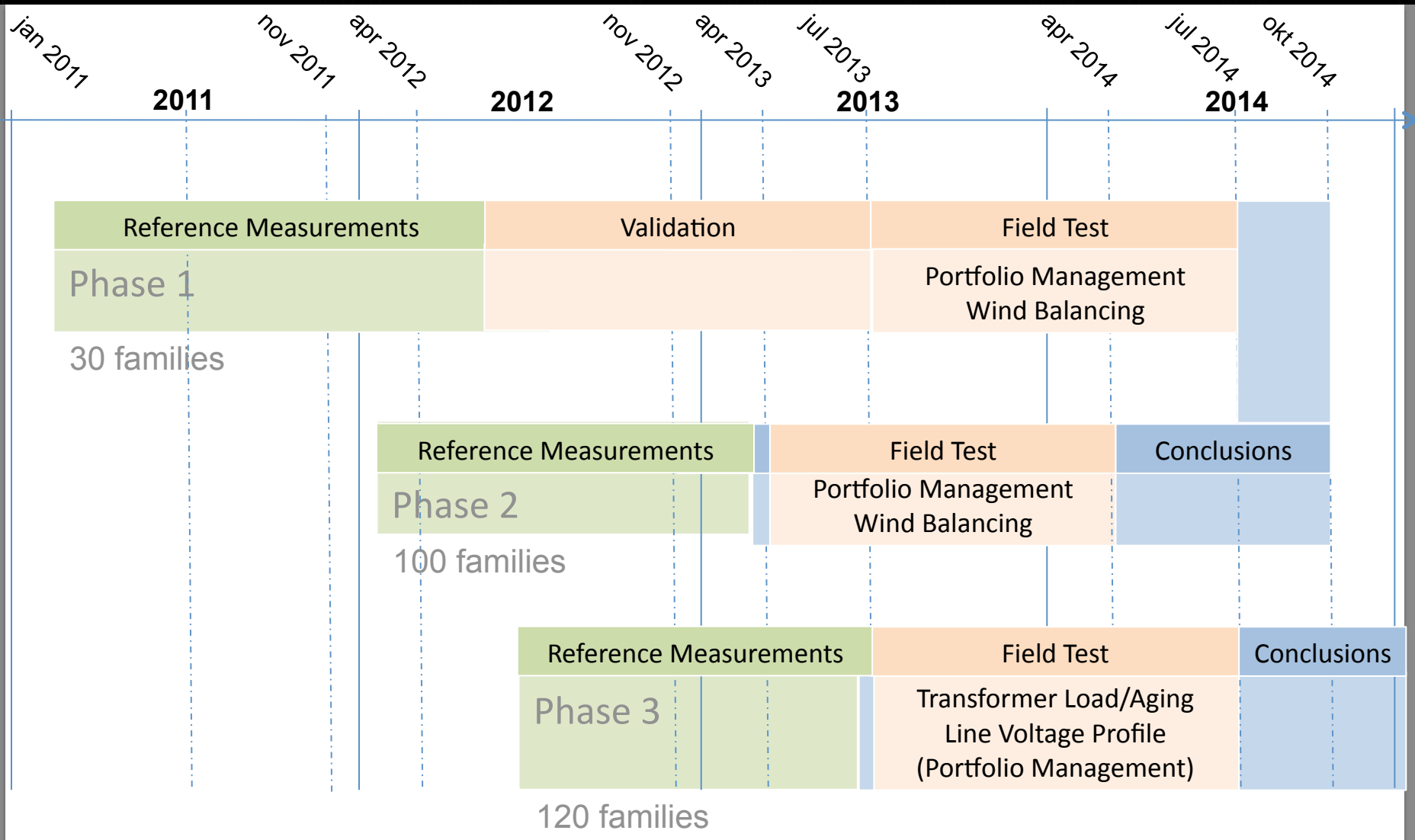
Installation



Installation Phase 3



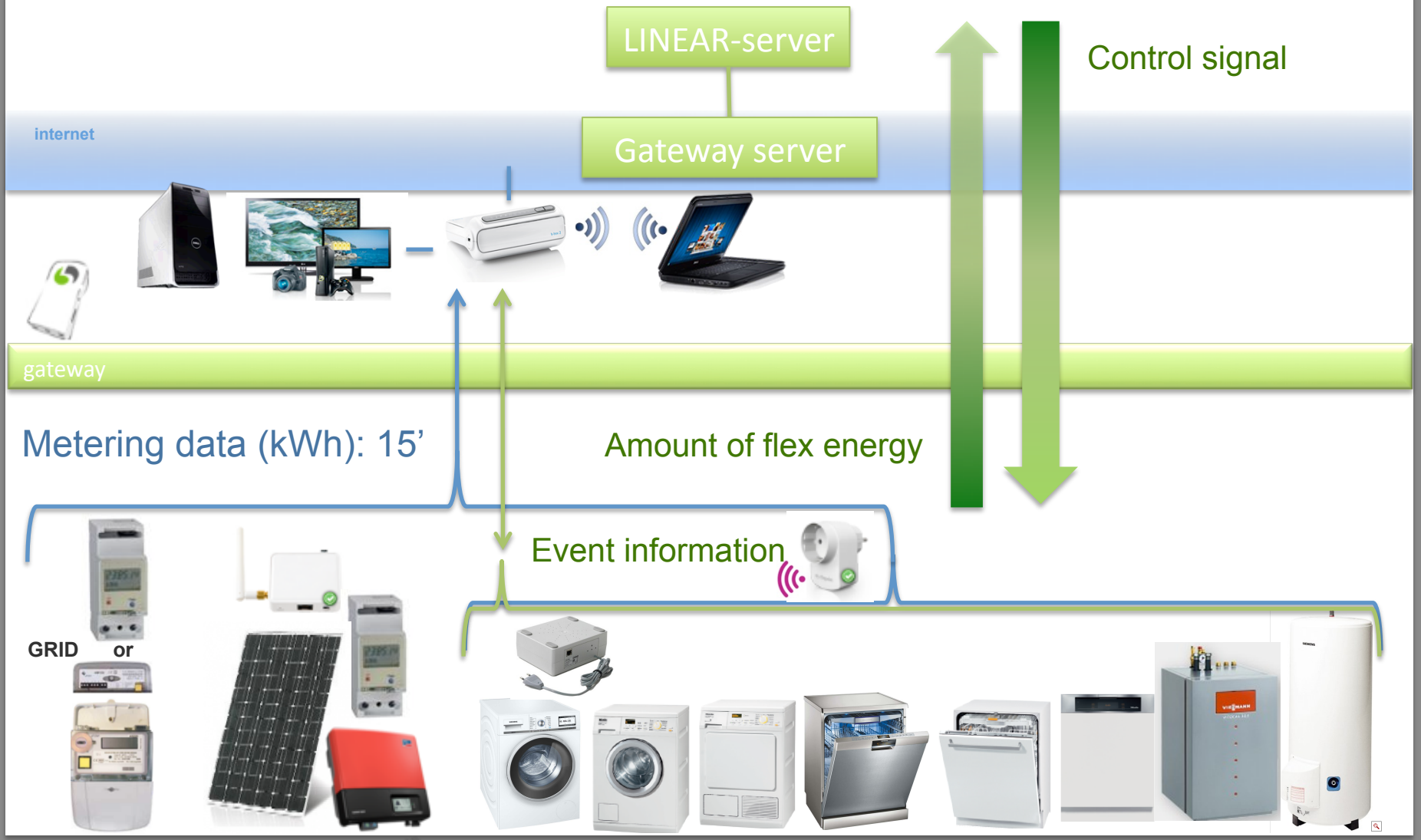
Field test: time schedule



Status Recruitment

Number of Test Users	P1 Sub Metering	P2 Supplier	P3 DSO	Total
Target	30	100	120	250
Amount of Smart Appliances	**P1 Validation**	**P2 Supplier**	**P3 DSO**	**Total**
Washing Machines	10	70	12 (+16...)	92 >150
Drying Tumbler	9	75	8 (+12...)	92 > 150
Dish Washer	4	54	3 (+13...)	61 >100
Subtotal Domestic Appliances	23	199	23 (+...150)	245 > 400
Electrical Boiler	2	4	2	8 >15
Heat Pumps	0	15	0	15
Electrical Vehicles	0	0	(10)	(10)

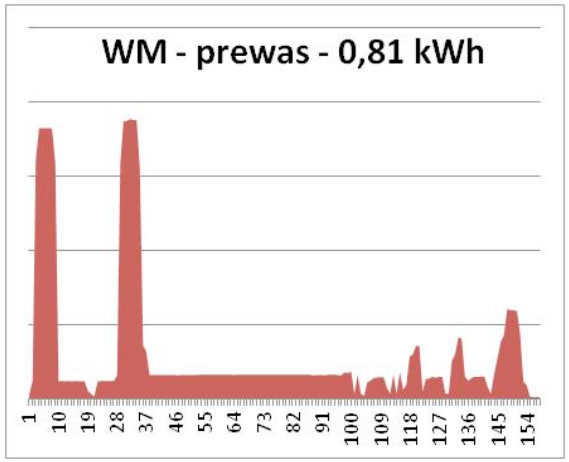
LINEAR Architecture

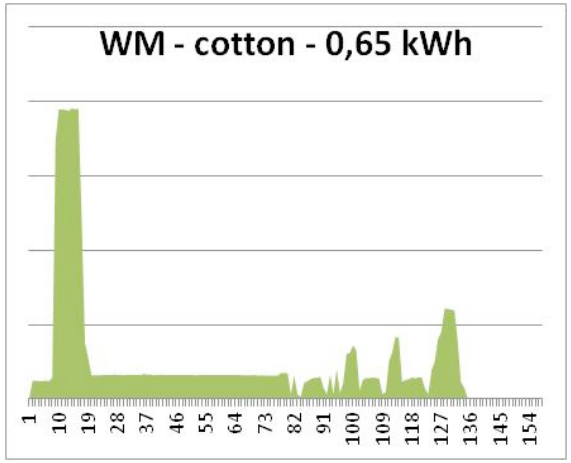


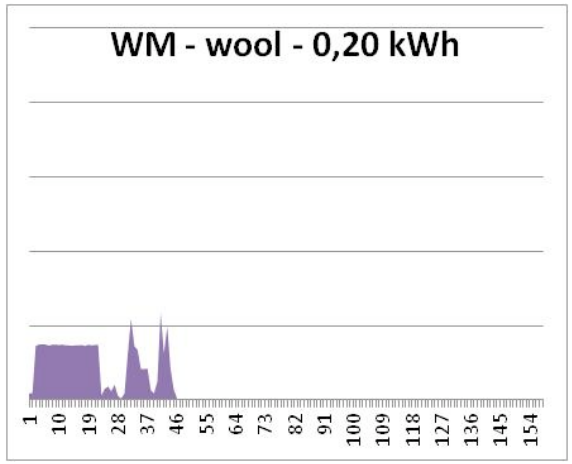
Appliance Messages

Domestic Appliances:

1. Latest end > latest start: 06 am
2. Estimated power train:
   consumption in function of time



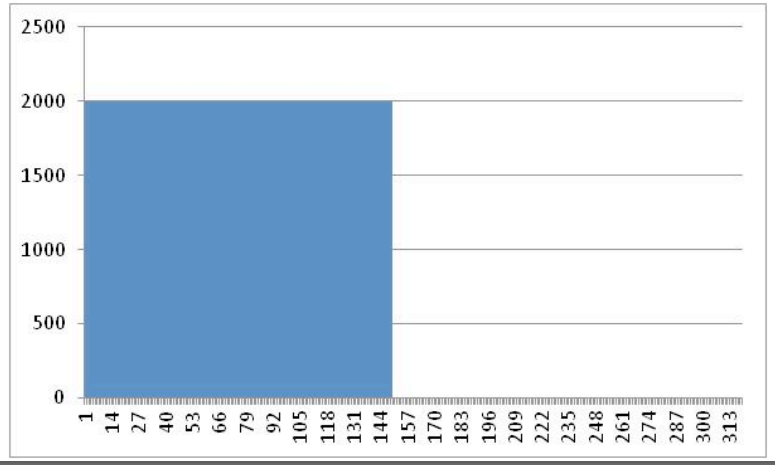


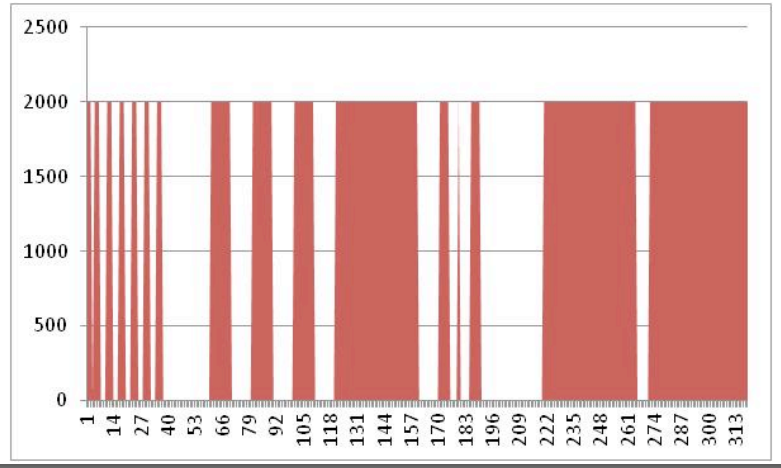


Buffer Messages

Domestic Hot Water Buffer

1. Emax: energy needed to charge to Tmax (SoC 100%)
   e.g., 5 kWh
2. State of Charge: e.g., 60%
   > to evaluate comfort protection (>SoC_min e.g., 30%)
3. Power rate: 2000W
   > e.g., 2h30 total charging time to reach SoC 100%





Business Cases tested in Field Test

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Linear - business cases

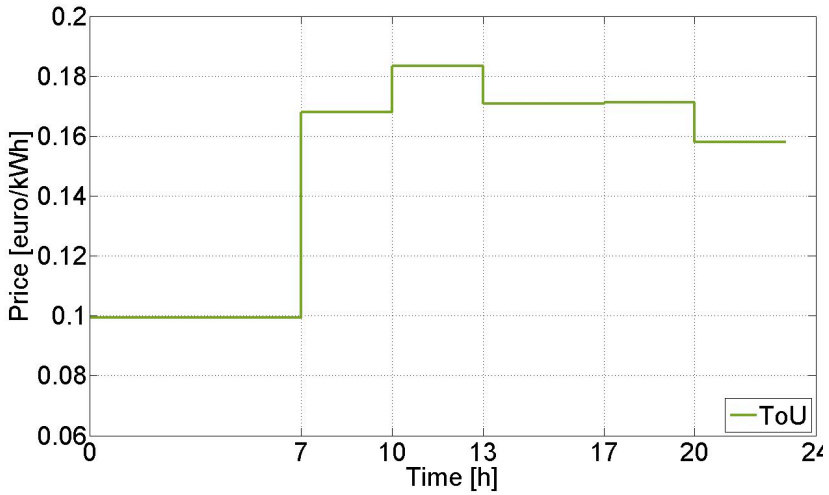
Portfolio management

Dynamic	Energy component Distribution fee
Fixed	Transmission fee Charges

Dynamic tariffs can be used to incentivize consumers to reschedule their consumption

Tariffs used:

- 6 time blocks a day
- Based on Belpex DAM + prediction sun/wind (scenario 2020)
- Communicated DA for the next day



Objective: *coincide as much as possible periods with low generation costs (based on high availability of renewable generation by wind and/or sun) with consumption by applying dynamic tariffs to residential consumers*

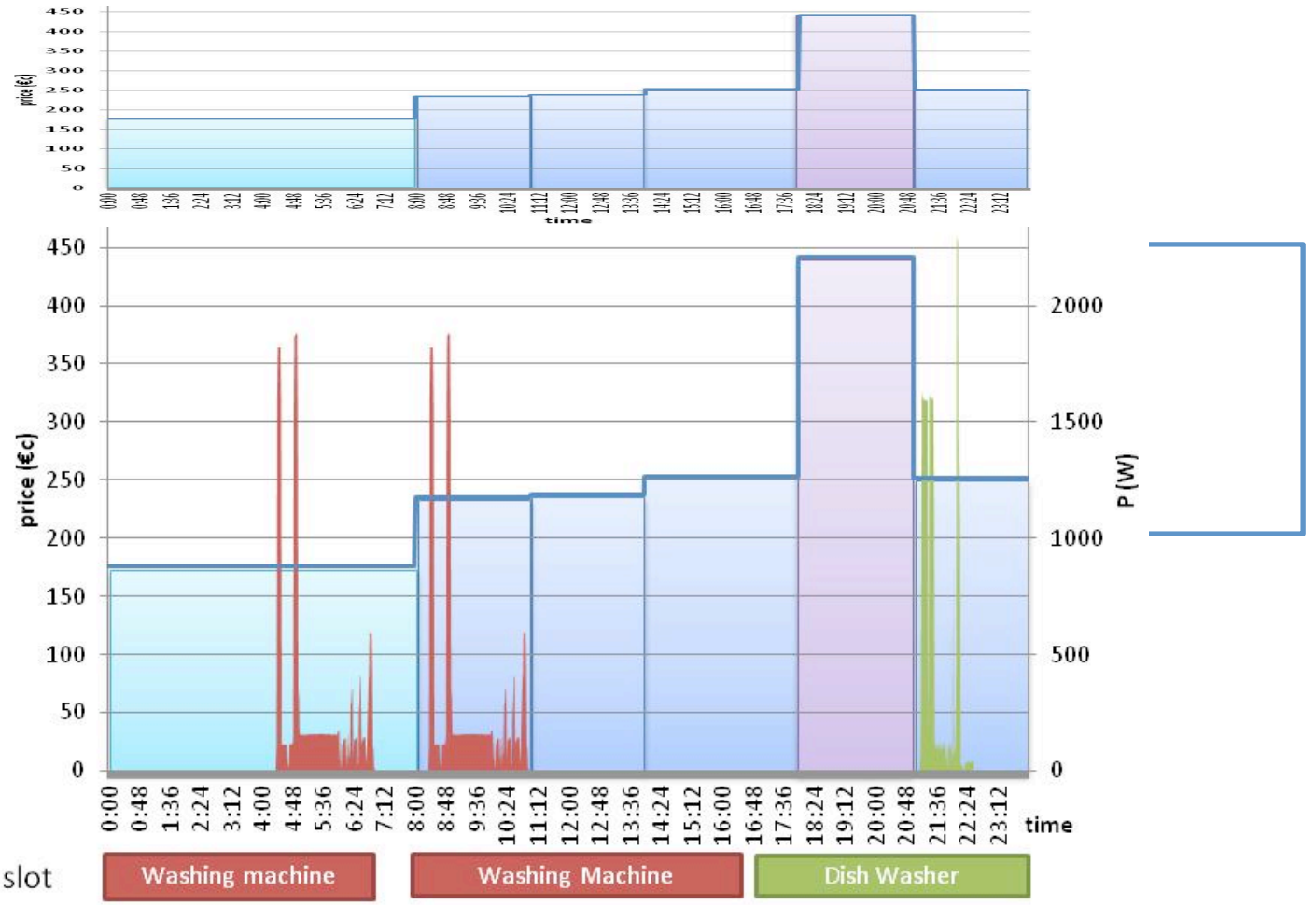
Portfolio Management

Target

✓ Schedule start in order to keep power train in cheapest tariff block

Control signal

Reaction



Portfolio Management

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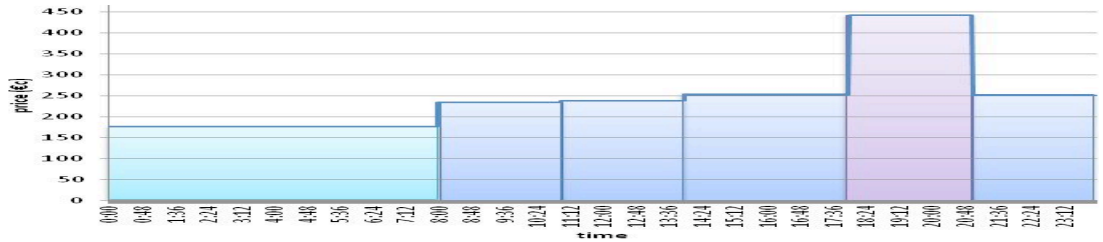
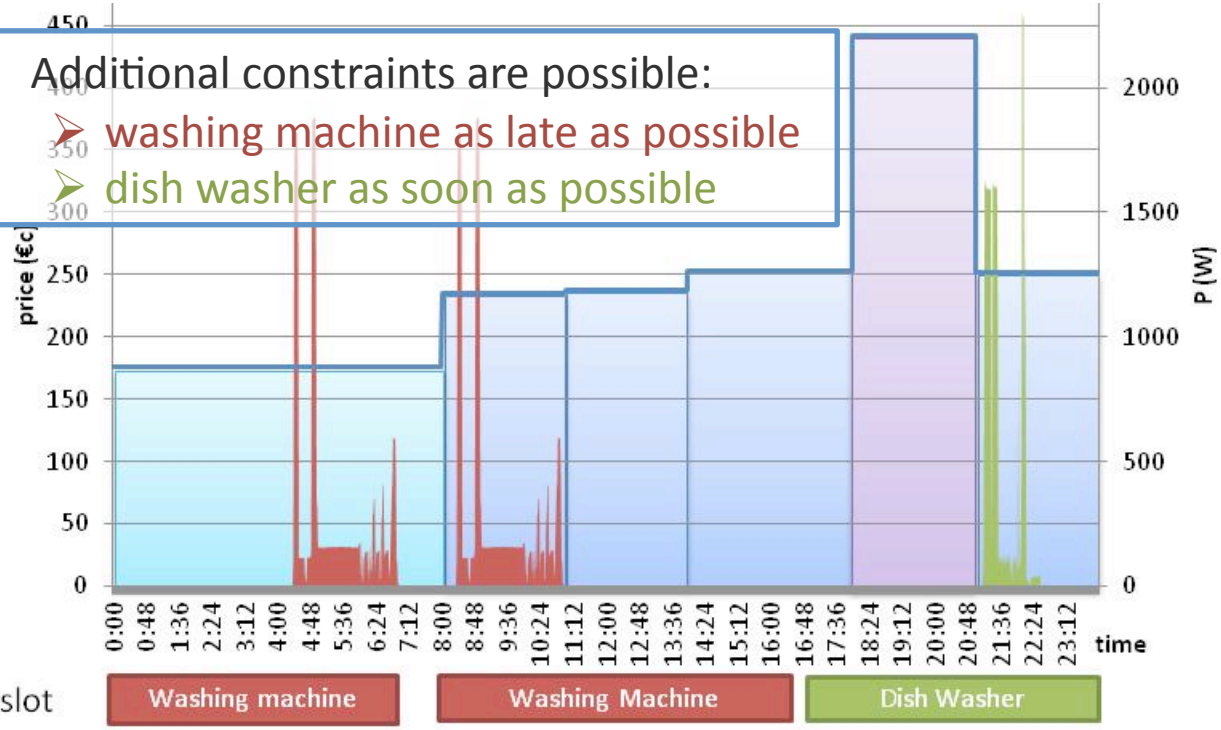


Reaction

✓ Additional constraints are possible:

- washing machine as late as possible
- dish washer as soon as possible

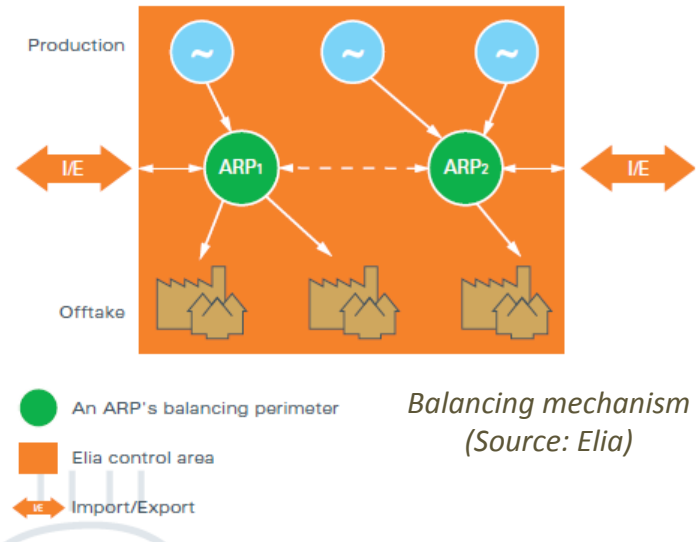


Wind balancing

- BRP = responsible for the balance of injection + offtake in their perimeter on a quarter-hourly basis
- TSO manages the instantaneous imbalances (that the BRPs are not able to control), by making use of power reserves

⇒ Costs involved for making use of power reserves are transferred to the BRPs

⇒ BRP with wind production in its portfolio: higher imbalance risk + higher imbalance cost



Balancing mechanism (Source: Elia)

Objective: *decrease the imbalance cost of the BRP by decreasing the unpredicted imbalance caused by wind production (intraday) in its portfolio by making use of the flexibility available at residential consumers' premises*

Wind Balancing

Target

- ✓ Use Demand Response as balancing resource for BRP
  (Balancing Responsible Party)

Control signal

- ✓ BRP sends request for delta P (switch on/off consumption)

Reaction

- ✓ Aggregator shifts flexible loads in function of request:
  - ➢ Cluster Control:
    - ▪ All Smart Appliances aggregated at BRP level
      (not household level)
    - ▪ BRP level: only appliances in the control zone of the BRP
    - ▪ DR Control does not include non Smart Appliances: stochastic behaviour managed by BRP at lower risk in larger portfolio

Linear - business cases

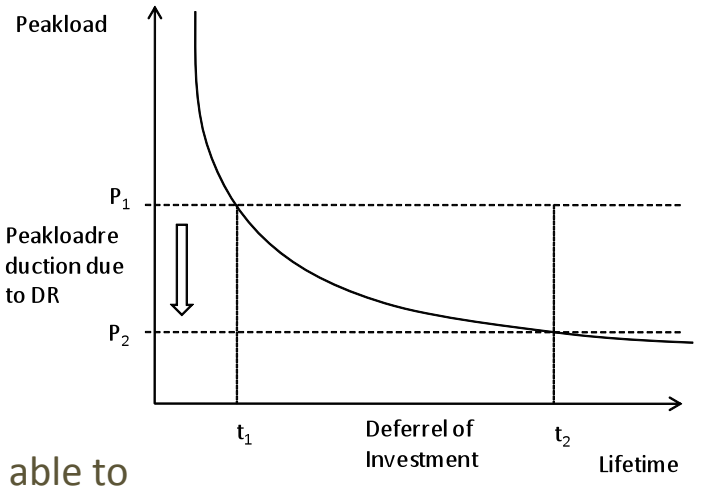
LV transformer load

Future distribution grid:

- More residential consumption
  => higher *offtake peaks* on LV transformers
- More intermittent (renewable) generation
  => *injection peaks* on LV transformers

⇒ Aging of transformer will be accelerated during these peak periods

⇒ If DSOs succeed in lowering these peaks, they are able to allow a higher share of local generation and extra demand without the need for new network investments



Objective: *decrease the peak load on a transformer in two directions (both for offtake and injection) by the application of automated active demand to defer/ decrease network investments (investments in transformers)*

Transformer Aging

Target

- ✓ Use Demand Response to reduce peak loads in both directions in order to decrease / defer network investments

Control signal

- ✓ Schedule flexible loads in function of forecasted and actual peak loads

Reaction

- ✓ Aggregator shifts flexible loads in function of request:
  - ➢ Cluster Control:
    - All Smart Appliances aggregated at transformer level (not household level)
    - Transformer level: all appliances fed by transformer
    - DR control takes both smart and non-smart appliances into account

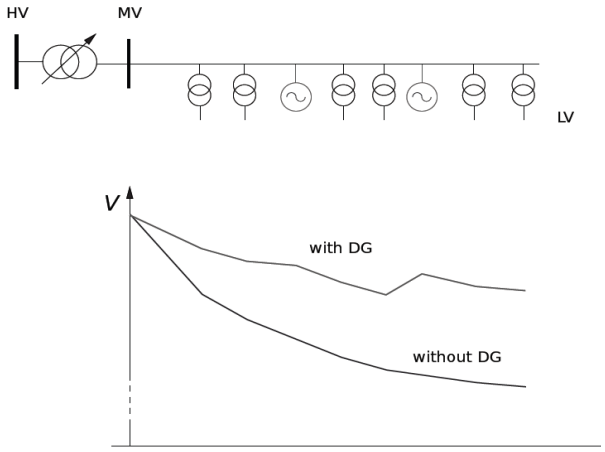
LV feeder voltage profile

Future distribution grid:

- More residential consumption
  => *voltage drops* in feeders
- More intermittent (renewable) generation
  => *voltage increases* in feeders

⇒ Predictability of the voltage profile of a feeder decreases

⇒ Situations can occur where the voltage levels either become too high or too low

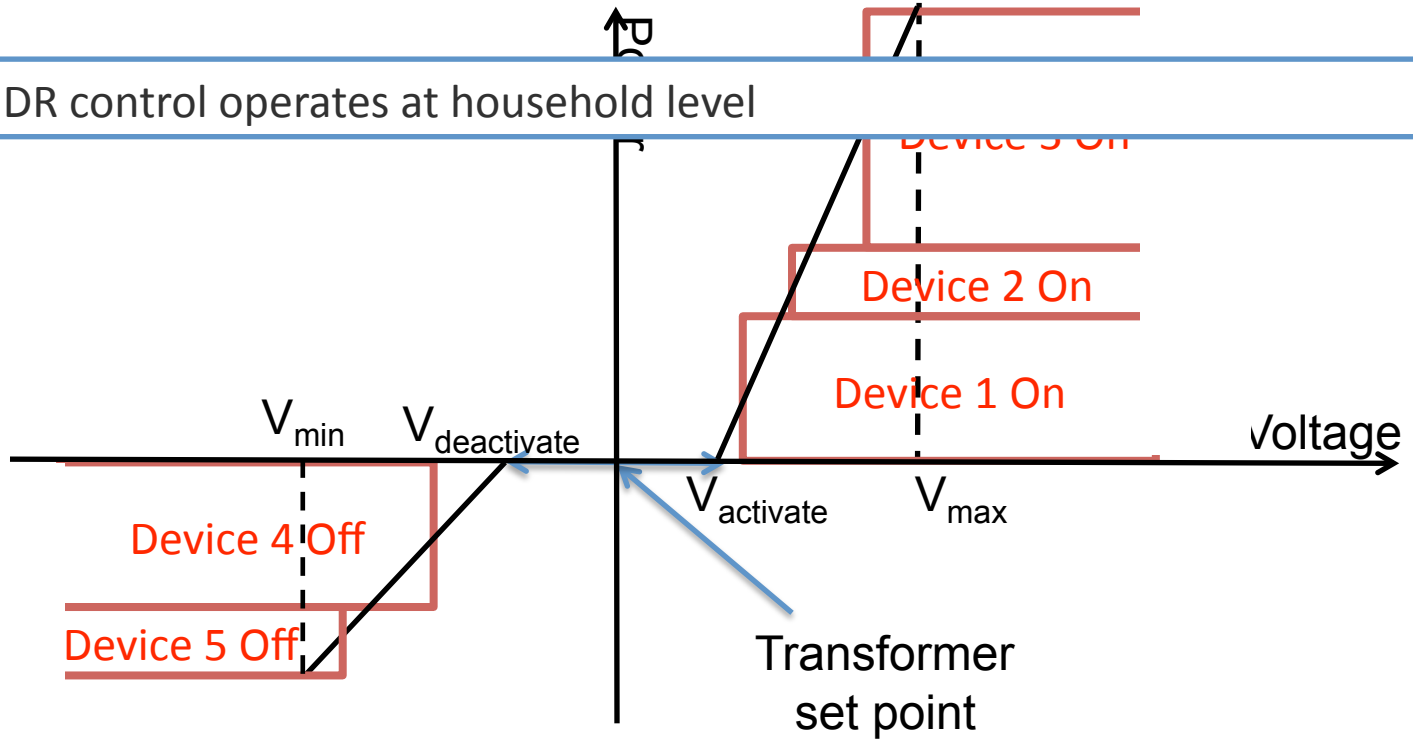


Voltage profile with and without DG (Source: EELAB)

Objective: *keep the voltage profile of the different low voltage lines within permitted limits by the application of automated active demand to defer/ decrease network investments (investments in new lines / transformers)*

Line Voltage Profile

Target	✓ Use Demand Response to ameliorate voltage profiles in the feeders in order to decrease / defer network investments
Control signal	✓ Voltage measured at the connection of the local Smart Meter
Reaction	✓ DR control operates at household level



Bottle Necks

1. Availability of appliances with low cost standard communication interfaces:
   - Demand Response functions
   - Comfort functions:
     - Statistics
     - Service / alarm messages
     - Manual
     - Fault analysis
2. Willingness of consumers to integrate these appliances in their home network

Questions?

EnergyVille is involved in:

LINEAR

EnergyVille Business Affiliation Program:

- Architecture and Standardization

Industrial Actors:

- Energy Market Studies

EIT KIC InnoEnergy

- Intelligent, Energy-efficient Building and Cities

Wim Cardinaels
Project Leader LINEAR
VITO NV
Boeretang 200
2400 MOL, Belgium

Tel. + 32 14 33 58 89
wim.cardinaels@vito.be

Visit our websites:
www.vito.be
www.energyville.be
www.linear-smartgrid.be

Recruitement of Test Users

Field test budget € 500 000:

- Equipment
- Installation costs

Average cost per house € 10 000:

Goal: >200 Test Users with Smart Appliances

We need partners giving discounts
test users prepared to invest

Scope recruitment F3

1. Original target:
   - 80x smart appliances + 20 smart heat pumps
   - Population: 2900 connections > 1/29
2. Current target:
   - >80 connections smart meter – energy gateway
     - Smart appliances
     - Heat pump
     - Submetering ToU (manual)
   - > 30% of the connections on one feeder
   - > 2 smart appliances per connection
3. Status: 3 transformers selected with 15 feeders: 300 connections

We should convince 1 of 3 to host LINEAR appliances

Practical aspects

We are in Belgium:

- Every house is different
- Most houses are owner-occupied
  > modifications, improvements, ...
  - Up to date building scheme ?
  - A lot of iron and concrete
- Most of them were not originally equipped with:
  - Broadband internet
  - Digital TV
  - Solar panels

Every house is a lab on it's own

Points of attention

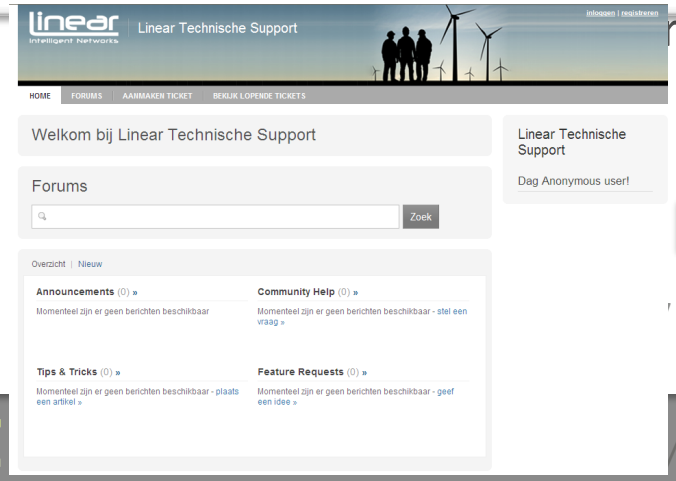
1. Location in the house of:
   - Electrical cabinet
   - Modem
   - PV inverter
2. Wireless communication from basement to attic
3. Power line communication: risk on signal loss
   - Miele KNX: 132,5 kHz
   - Ethernet via PLC: 1..30 MHz
   - 3 phases installations phase bridge
   - Harmonics
   - Interference:
     - Existing for digital TV
     - LINEAR between energy gateway and appliances

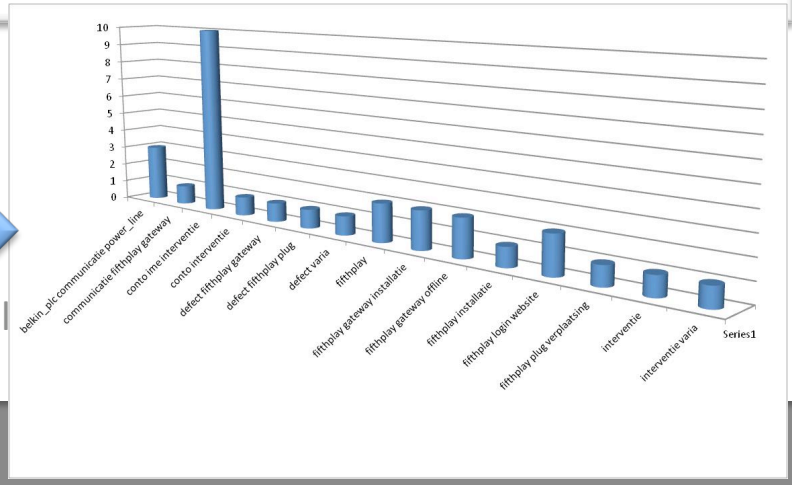
Practical aspects

1. Location in the house of:
   - Electrical cabinet
   - Modem
   - PV inverter

LINEAR Home Labs
LINEAR Support team
LINEAR Test user forum

We will learn !





Installation Cost Sub Metering

Phase 2

- Gateway
- Sub metering plugs
- Energy measurement (pulse counters)
- Extension electrical cabinet
- Work hours

partners

Depends on:
- 1 / 3 phases € 300 .. € 750
- PV yes / no
- location modem and electrical cabinet

Phase 3

- Gateway
- Sub metering plugs
- Energy measurement (smart meter)
- Extension electrical cabinet: N/A
- Work hours

partners

Eandis

Plug&Play ? € 100 .. € 200

Installation Cost Sub Metering

Integration with Smart Meter should give cost savings for end user:
- **on hardware (pulse counters, interface, additional cabinet)**
- **on adaptations in electrical cabinet**

No standard interface defined yet:
- ➢ **will be important for future**
- ➢ **discussions are ongoing**

Phase 3

• Gateway • Sub metering plugs	partners	
• Energy measurement (smart meter)	Eandis	
• Extension electrical cabinet: N/A • Work hours	Plug&Play ?	€ 100 .. € 200

Conclusions

1. We need standards
   now we develop our own solutions (costs time and euro's)
2. It needs to be cost effective
   - Payback time ?
   - Comfort, access, control, ... Good feeling

   interested ≠ prepared to pay the current cost
3. Every house is a lab on it's own:
   - The combination and integration of devices in a house are difficult and often conflicting with present appliances

Conclusions

1. We need standards
   now we develop our own solutions (costs time and euro's)
2. It needs to be cost effective
3. It would be nice,
   if we could integrate an additional appliance
   in a Smart House system
   with the same easiness
   as an usb device on a computer

   difficult and often conflicting with present appliances