The Impact of Prosumers and their Clusters on the Energy System

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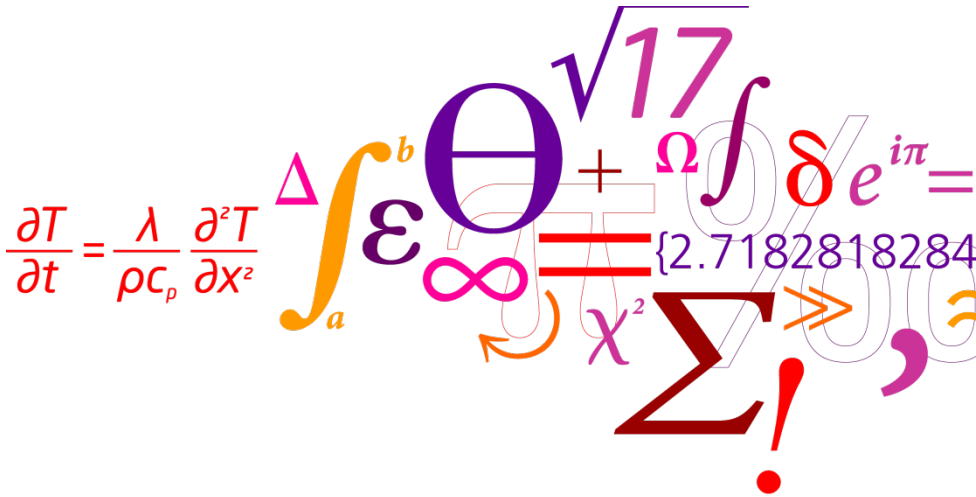
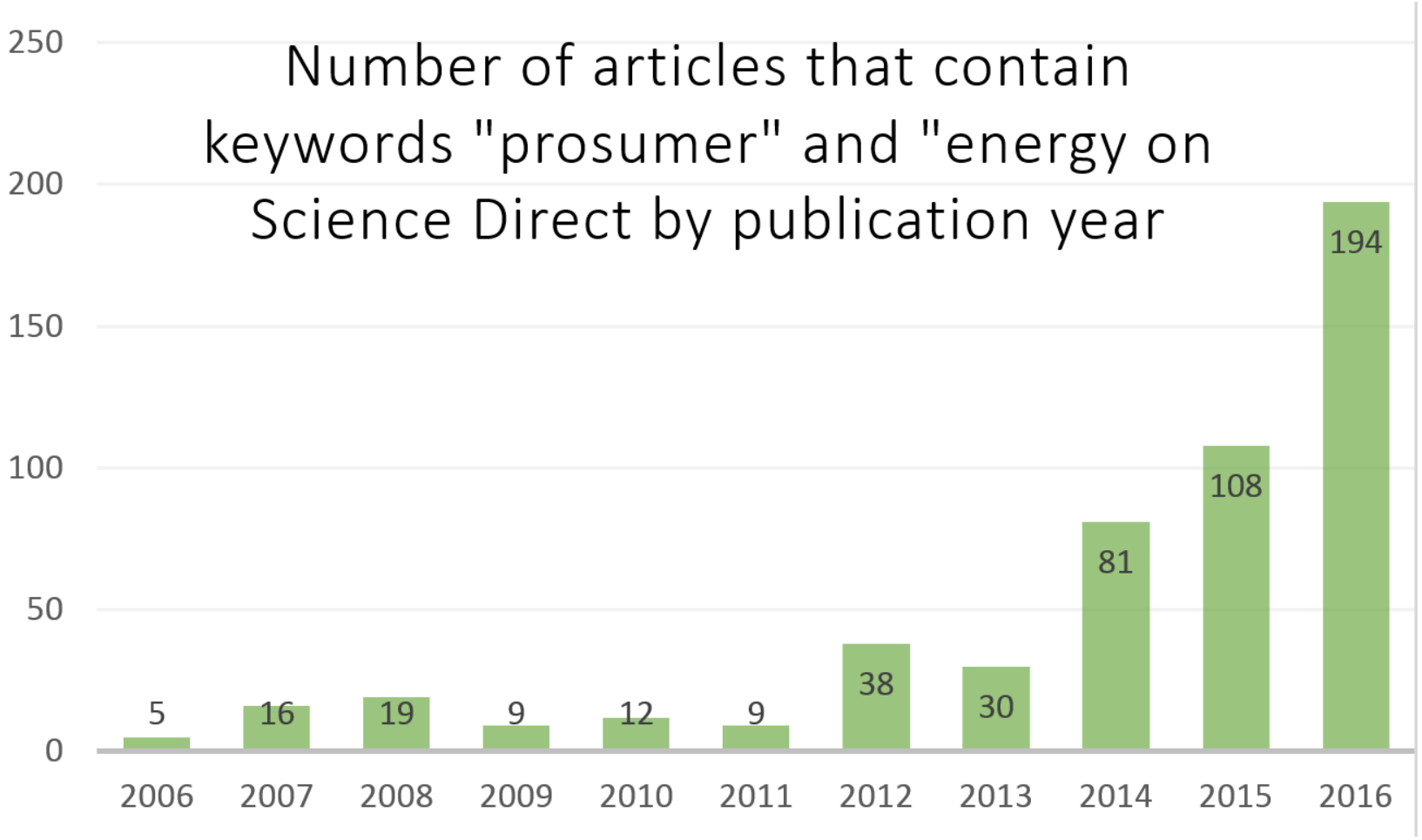
WP3



DTU Civil Engineering
Department of Civil Engineering

Literature study



Literature Study

Prosuming buildings – produce and consume energy (renewable energy from PV, solar heat, wind…)

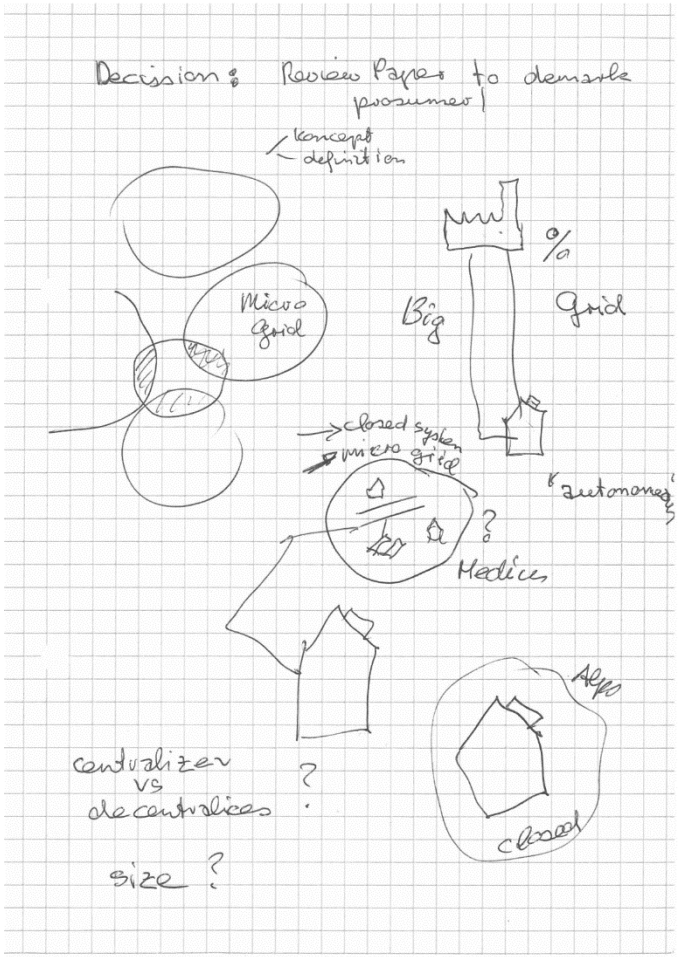
- Defintion:

An energy prosumer is considered a consumer that produces a shareable form of energy from a primary energy source, but can also store energy by local means.

- This definition excludes from the term energy prosumer the application of
  - demand shift only
  - pure energy storage
  - island mode

- Not excluded with this definition:
  - microgrids
  - grids (size criterion)

Literature Study



Literature Study

Initial search

Practical screen

- Inclusion criteria:
  - Search terms ”prosumer” AND ”energy” (stemmed)
  - Published in Q1 or Q2 journal
  - 2013 – 2017 (2017 in separate folder for update)
- Exclusion criteria:
  - Definition not adhering to what was defined before
  - Focus not on energy
- Folders for deleted files specifying reason for deletion

Literature Study

Organization of remaining papers from initial search based on abstracts

- Optimization studies
  - on individual prosumers (4+)
  - on groups of prosumers acting together/interactions within a group (30+)
- Case studies and feasibility studies (10+)
- Papers on prosumer group formation methods (6+)
- Papers focusing on the system viewpoint and the implications of prosumer integration (26+)

- Related literature studies (by different key words e.g. residential PV or DER)
- Forward and Backward referencing for highly relevant papers

Literature Study

Optimization studies

- Optimization/Control method (sometimes e.g. a scenario with rule-based and one with cost optimal strategy applied)
- Method for Calculation
- Objective Function - cost minimization or maximizing self-consumption
- Time step – most often 1h
- Time window – horizon mostly 24h – sometimes simulation over 1 year
- Location
- Grid context
- Input sources – not always explicit
- Advantages, limitations, outcomes for each study

Literature Study

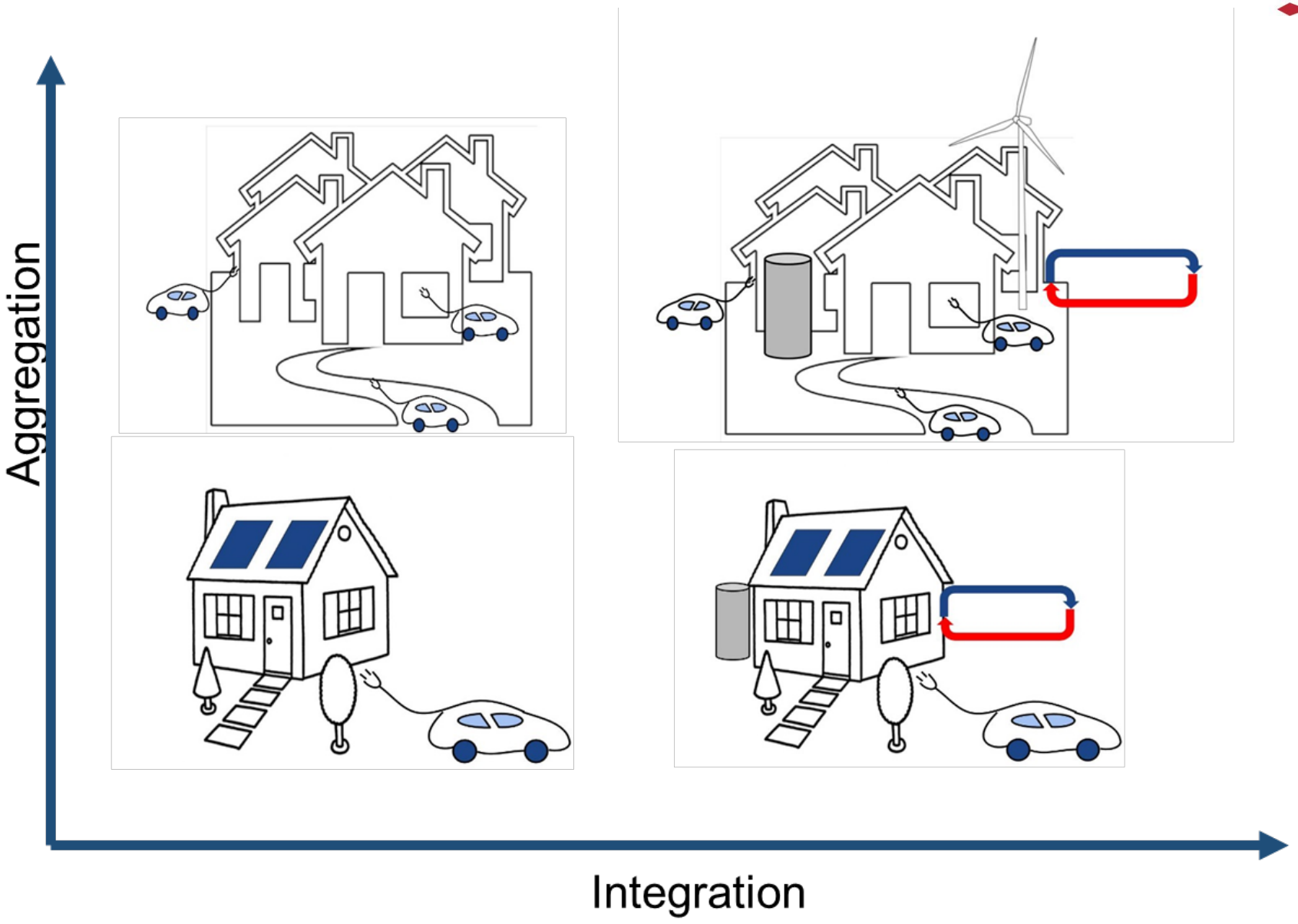
Author and Reference	control method	Method for Calculation	time window	time step	sources for inputs	advantages	limitations	outcomes
Alahäivälä et. al.	cost optimal	Dynamic programming	optimization over 1 month; simulation over 1 year	1 hour	hourly price of electricity from Nord Pool spot - Danish area price (DK1); Gas price for Helsinki region	algorithm is language independent; model with a couple of variations - maybe break down the las one	algorithm is system specific; CHP model not dynamic; heat storage modeled with average temperature	Sensitivity analysis showed larger storage can increase cost due to losses
Di Giorgio and Liberati	event driven MPC	MILP	sequential 24h (5:00 am - 05:00 am)	5 minutes	Italian electricity market price "prezzo unico nazionale" from day ahead trading; measured PV curves from pvoutput.org; non-plannable loads from their other paper	detailed model for DR with respecting user preferences etc; battery aging and losses taken into account as depreciation; non-plannable loads also	battery price projection for 2020	median and average values below; difference of savings between real-time pricing estimates model and day-ahead pricing negligible
Perković et. al.	multi-objective optimization: operating and investment costs - reduced to one year (Netto present value)	Pareto front analysis	optimization for 1 year	1 hour	Nord Pool DK1for 2015; onstant gas price - Central European Gas Hub (2016); solar irradiance - METEONORM Software (2015) - average of four Croatian major cities	industrial prosumer; sensitivity analysis for fuel and electricity price	hypothetic warehouse producing N "products"	Larger fluctuation in MCP can lead to increased saving potential; relative importance factor was closer to the reduction of operating than the investment costs side (f1 = 0.7-0.75)
Salpakari and Lund	cost optimal; cost optimal with no grid feed-in; rule-based (self-consumption)	Dynamic programming for cost optimal control;	sequential 24 h horizon; simulation over 1 year	1 hour	solar radiation, temoerature and 10-min average wind speed from Finnish Meteorological Institute from close-by location(s); hourly day-ahead prices for Finland from Elspot with a utility margin (their ref.66) for cost-optimal control; Average price of for a detached house for rule-based control	physically realistic model simulated over the whole year; quantification of impacts of technologies and comparison of rule-based with cost-optimal control	battery aging is neglected; TS with average temperature (supposed to be conservative though); different reference cases for diferent scenarii	cost decreased by 13-25% and grid feed in by 8-88% (for cost optimal); rule-based can increase total cost (especially with resistance heater); thermal storage with heat pump and battery - effective; shiftable appliances - marginal effect (on the cost); too large TS can increase cost;

Literature Study

	Technologies included							Formulation type	
Author and Reference	PV	µCHP	DR	TS	ES	HP	EH	Deterministic	Stochastic
Alahäivälä et. al.		x		x			x/-	x	
Di Giorgio and Liberati	x		x		x			in Day-ahead scenario	in Real-time pricing scenario
Perković et. al.	x	x	x	x			x	x	
Salpakari and Lund	x		x	x	x	x	x	x	

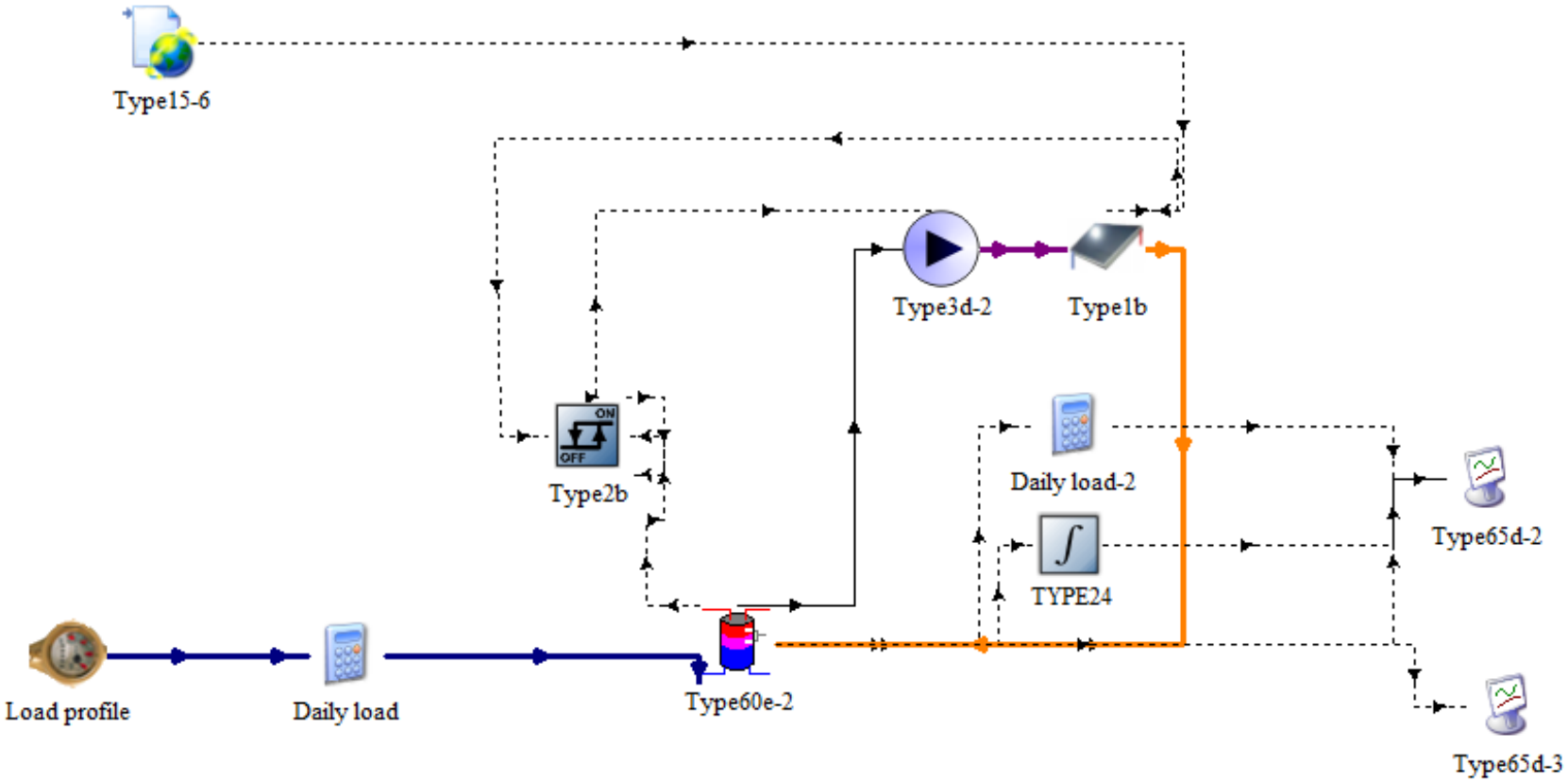
Preliminary findings from literature study

- Individual/small group optimization studies – profit of prosumer – often based on price signal (hypothetical scenario with hourly prices from day-ahead market reflected in end-user price) – indirect control
- System viewpoint – problems in distribution network (overvoltages in low-voltage networks)
- District heating prosumption – not many examples


Aggregation
Integration

Conference paper – Optimizing Renewable Energy Prosumption in Single-family Houses

- Rooftop Photovoltaic and solar thermal production with storage
- Optimal sizing with respect to space constraints
- Sensitivty analysis - influence of grid context (tariff and metering policies), appliances using DHW
- Data from Sønderborg single-family homes
- TRNSYS and GenOpt


Type15-6
Type3d-2
Type1b
Type2b
Daily load-2
Type65d-2
TYPE24
Load profile
Daily load
Type60e-2
Type65d-3

Thank you!