INCENTIVIZING DEMAND-SIDE MANAGEMENT, CHANCES AND RISKS FOR MEDIUM-SIZED INDUSTRIES

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Motivation and objective

Demand-side management (DSM) is proposed as a cost-efficient measure to deal with increasing fluctuation of electricity supply [1]. Current efforts to study and to develop DSM potential focus on large energy-intensive industries, household appliances, and energy technologies in buildings [2] due to either their sizeable energy demand or technological homogeneity. Small or medium-sized industries whose processes are often specific and interconnected were given little to no attention. In this paper, a gravel plant with diverse flexibility options and production-related constraints is modelled and analysed under time-varying electricity tariffs, a widely proposed incentive for DSM.

Methodology

The semi-automatic gravel plant is modelled using the local energy system model DISTRICT [3, 4] coupled with a generic model for flexible processes [5] whose objective is the minimization of costs. The coupled model allows crossed effects of technology expansion, price signals, flexibility options, and production constraints to be investigated by means of a scenario-based analysis. The double-shift operating plant contains three process clusters: extraction of raw gravels, gravel processing, and auxiliary processes. Flexible processes (e.g. floating grabbers, water pumps or sieve machines) and their flexibility options are identified and characterized using corresponding measured load profiles.

Scenarios are devised under three variations: electricity tariffs, flexibility options, and expansion potential of Photovoltaics (PV), as shown in Table 1 (left). In a *Flat* tariff, the plant purchases electricity from the utility at a flat price 17.96 ct€/kWh and in a *Dyn+* tariff, procurement and network fees components with an average of 8.02 ct€/kWh are time dependent. With options *Daily* and *Weekly PP*, a production may freely deviate from plan as long as daily and respectively weekly production targets are met. Water pumps offer flexibility though a short-term adjustment of flow rate. Furthermore, the plant manager may adjust the beginning of work shifts. The operation in July – September is analysed under economic assumptions of 2018.

Table 1 Scenario framework (left) and key results (right); abbr. PP – Production planning

Scenario	Tariff	Flexibility options	PV Potential [kW]	Total costs [k€]	CO_2 Emission [tons]	Operation complexity [-]	PV installed capacity [kW]
Business-as-Usual (BAU)	Flat	-	-	156.0	379	1.00*	-
Reference (REF)	Dyn+	-	-	161.8	379	1.00*	-
Active tariff+ (ATP)	Dyn+	Daily PP	-	158.2	367	0.80	-
Flexible Production (FPX)	Dyn+	Weekly PP, flexible water pumps	-	155.5	360	0.85	-
Flexible Production+ (FPP)	Dyn+	+ flexible shift	-	155.0	364	0.87	-
Active energy+ (AEP)	Dyn+	Weekly PP, flexible water pumps	1831	122.3	207	0.82	1831

* A base operation plan in *BAU* and *REF* scenarios was realized without the consideration of the operation complexity.

Results and conclusion

Table 1 (right) presents key results – total costs (including electricity costs, annuities and operation costs), CO_2 emissions from electricity imports, and operation complexity (defined as times of powering-on relative to the *REF* scenario). With a *Dyn+* tariff, the plant is exposed to high electricity prices as it operates during day- to evening time, which results in higher costs in the *REF* scenario

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compared to the *BAU* scenario. The deployment of flexibility options can reduce costs by 2.2 – 4.2 % and coincidentally reduce CO_2 emissions by 3.2 – 5.0 %.

Figure 1 shows an average profile on weekdays. It is observable that the demand during midday is increased significantly as prices are lower. The utilization of flexibility does not always lead to reduced emissions, as evidenced by the *FPP* scenario, in which demand increases at dawn when the emission intensity is high due to the dominance of coal-fired power plants. The operation complexity in *ATP*, *FPX*, and *FPP* scenarios increases as more flexibility options are available to react to the price fluctuation. Despite a total feed-in on weekend at spot market prices without additional premiums, in the *AEP* scenario, an investment in PV is already economic in the base year and leads to the reduction of total costs, emissions, and peak grid-withdrawal power.

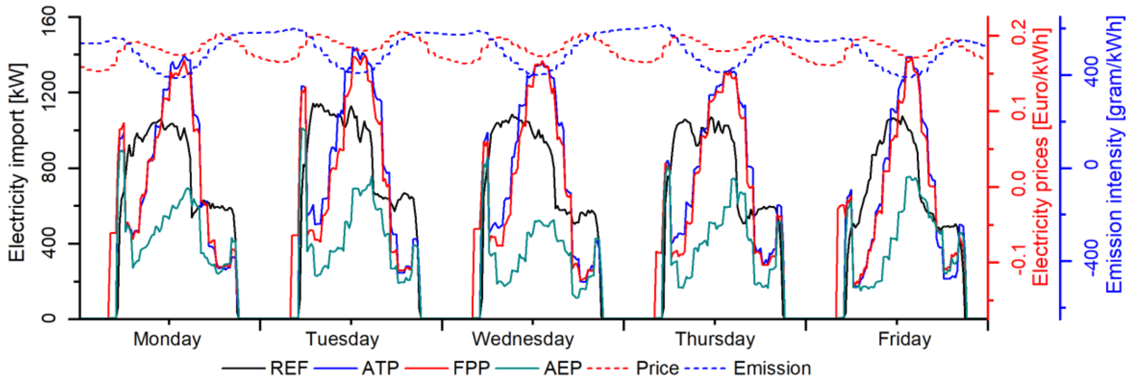

Figure 1 Electricity import profiles of selected scenarios (solid lines) and electricity price and emission intensity profiles (dashed lines); profiles are averaged over the modelled period.

Based on the results, medium-sized industries subject to time-varying electricity prices should deploy the flexibility potential from an active production planning or adjustable operating parameters to reduce energy related costs or invest in generation technologies. However, incentivizing DSM by time-varying prices must be carefully applied as some firms may unavoidably operate during period with high demand and respective high prices.

References

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