PEOPLE POWER
ATTRACTIVE DIRECT POWER MARKETING, INCLUDING FOR SMALL RESIDENTIAL PV PLANTS, ON LOCAL POOL LEVEL

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ABSTRACT: With significantly reduced PV electricity feed-in tariffs it became challenging to implement and operate grid-connected residential solar PV in the majority of the European countries by 2014. The decline in investment costs did not keep track with the decline in feed-in tariffs regulated on national level. New legal and fiscal barriers further slowdown PV system implementation. This framework fostered the development of a new business model in Germany that allows end-users pooling their electricity under one roof and to market it directly within the building's grid. In consequence PV electricity, starting from low digit kW level installations, may again become economically viable. In the pilot case discussed herein direct marketing of PV energy increases annual revenues by 9% while lowering electricity costs for the tenants. And there is a further benefit for the society: peaks in production and demand are minimized and the transformation process in the energy sector is supported.
Keywords: direct power marketing, financing, grid integration.

1 INTRODUCTION AND MOTIVATION

With the recent reforms of the German EEG - the Renewable Energy Sources Act - and especially since August 2014 it became challenging to pay-back new grid-connected residential PV systems. Even at "ideal" conditions revenues for smaller PV systems are low (irradiation conditions of Southern Germany; favourable orientation; no shadow; system degradation and O&M not considered).

Especially for rented multi-family houses, where the PV electricity cannot be consumed directly by the PV system owner, financing is challenging. All electricity would have to be fed into the public grid but by EEG merely 90% of the production would be remunerated with the feed-in tariff.

Table 1 depicts the annual revenues for two PV system sizes: Case 1 a PV system for a typical one family house and Case 2 a PV system for a multi-family house.

Case 2 with a system size of 14 kWp is selected because it corresponds to the size of the pilot case discussed below, which is a rented 14 family house.

For both cases revenues are acceptable only with higher direct self-consumption rates, since investment costs, even for standard cost-efficient PV systems, normally exceed 1,200 €/kWp.

Table 1: Financial viability of PV systems in Germany (status 09/2014).

	Annual revenues (1) [€ per kWp]	Financial viability given?
Case 1: 4 kW PV system		
No direct self-consumption(2)	127	Very challenging
20% direct self-consumption(3)	146	Challenging
Case 2: 14 kW PV system		
No direct self-consumption	126	Very challenging
33% direct self-consumption(4)	150	Viable

(1) Assumed optimal annual AC yield: 1,000 kWh/kWp.
Framework conditions [1]:
(2) Guaranteed feed-in tariff 12.69 €ct/kWh for capacity < 10 kWp; 12.34 €ct/kWh for capacity ≥ 10 kWp and < 40 kWp. Systems < 10 kWp: Feed-in tariff payments may be reduced to 70% of installed capacity on days with high solar PV production.
(3) Assumed end-user electricity price is 26.50 €ct/kWh incl. 19% VAT and 22.27 €ct/kWh excl. VAT.
(4) 100% EEG surcharge (6.24 €ct/kWh) to be deducted for every directly marketed kWh; 40% EEG surcharge (40% of 6.24 €ct/kWh) to be deducted for every self-consumed kWh from 2017 (35% from 2016; 30% from 2015)

To increase revenues generated by PV systems installed on rented multi-family houses in Germany there is a need to market the on-site PV electricity directly, within the privately owned grid of the building, to the individual tenants. *buzzn* is the first company in Germany to offer a service package for comparatively small pools of electricity suppliers and consumers on a comparatively low volume level. In our pilot case the annual electricity demand of the 14 families in the multi-family house is approximately 21 MWh; approx. 24 MWh of Combined Heat and Power (CHP) and PV electricity are exported to the public grid; approx. 3 MWh are imported from the public grid. The direct marketing service package is named "Localpool" [2].

2 THE CONCEPT OF DIRECT POWER MARKETING

The direct power marketing concept of *buzzn* named "Localpool" includes the following services:

- bundling of end-users (tenants) and producers (house owner or investor) within a privately owned grid at the grid connection point;
- electricity metering on grid connection point, producer- and tenant-level;
- electricity supply/purchase to/from the grid-connection point;

- accredited accounting for all involved parties
- local and environmental friendly electricity at very competitive costs

The service does, however, not include the following effort/ risks:

- to convince a relevant majority of parties within this privately owned grid to join the "Localpool" – every end user has the liberty to decide in favour or against participation;
- to reimburse the electricity costs from the involved parties.

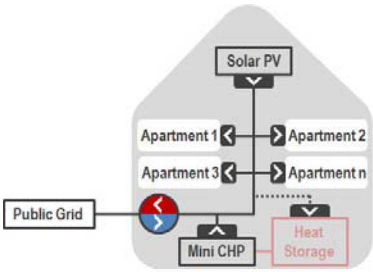
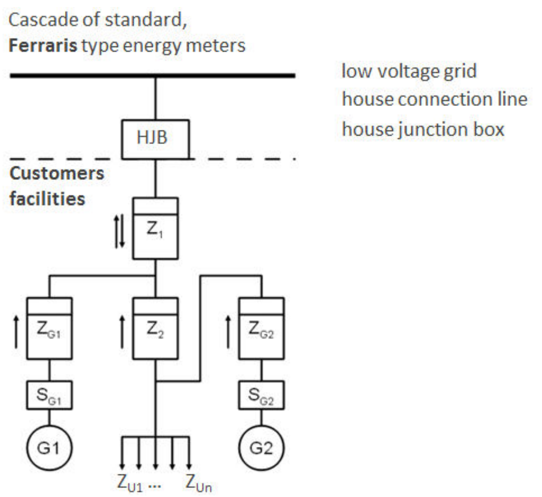


Figure 1: "Localpool" of electricity producers and consumers within privately owned grid of a building.

To keep metering costs at an acceptable low level while guaranteeing for an instantaneous metering of the self-consumption from on-site generation *buzzn* is applying Ferraris type electricity meters in a cascade configuration for small systems. But the recent sharp decline in costs for smart meters will soon allow profiting from the advanced features of such meters too.



Z_1 Main meter for electricity import & export
Z_2 Meter to delimitate return feed with return stop
Z_{G1}, Z_{G2} Production meters for the generators
S_{G1}, S_{G2} Generator protection/ isolation unit
G_1, G_2 Generator (G1 with higher feed-in tariff)
Z_U Further distribution to independent consumers via sub-meters U_1, U_2 to U_n

Figure 2: Cascade concept applied for instantaneous power metering via Ferraris type energy meters (generation, self-consumption, export and import) [3].

2.1 Why is direct energy marketing on small "Localpool" level only financially viable in combination with a CHP?

The cost advantage for direct power marketing of PV electricity within the own grid is relevant and can lead to the financial viability of a grid connected PV system.

Residential customer end-user prices in our pilot case are 22.27 €ct/kWh, excl. VAT, which is very competitive (status 09/2014). After deduction of the EEG surcharge of 6.24 €ct/kWh resulting revenues per kWh are 16.03 €ct. Revenues of a PV system directly connected to the public grid are 12.59 €ct/kWh. Thus, the margin between the revenues obtained via (a) directly marketed PV electricity and (b) public-grid feed-in is 3.44 €ct/kWh. Resulting additional annual revenues via direct marketing in our pilot case implementing a high performance PV system - details as per **Table 2** - are thus 187 € or 13 €/kWp for a pool including a CHP and 250 € or 18 €/kWp for a pool not including a CHP. Annual revenues thus increase from 149 €/kWp to 162 €/kWp and 171 €/kWp, or 9% and 15%, respectively.

At current PV system costs the above additional margin obtained (minimum 13 €/kWp) is often required to finance the PV system. The higher PV electricity self-consumption rate obtained when implementing only a small PV system and no CHP, resulting in additional revenues of 5 €/kWp, does still not leave room to co-finance the direct energy marketing service, which includes installation/ purchasing costs for tenant-level meters, periodic metering fees, invoicing. A solution is available for those houses, where a CHP is an option. The market introduction scheme for mini-CHP installations in Germany is more attractive than for PV. CHP financing can be realized when implementing a direct energy marketing model.

2.2 Pilot case - match between PV and CHP system production profile

To determine the PV electricity self-consumption rate for different "Localpool" configurations WIP analysed monitoring data of the pilot Case 2 covering the period from 06/2013 to 05/2014. In this 14 family house located in Southern Germany the obsolete natural gas fired boiler had been replaced by a natural gas powered CHP with a nominal electric output of 5.5 kW and a nominal thermal output of 12.5 kW. The pure heat based control of the CHP turns the CHP on whenever heat is required, independent of peak electricity consumption periods in the building. In part this operation profile is related to the comparatively small heat storage system of 1 m³.

PV production data of the same period from a nearby grid-connected roof-top PV system were used to simulate the resulting PV electricity self-consumption rates for varying PV system capacities and varying CHP operation modes. For simplicity this paper discusses the results obtained for a 14 kWp PV system.

It was found that in general a good match can be realised and well sized system combinations reach high electricity self-consumption rates. For the CHP it was found that the actual annual average electricity self-consumption rate is 48% and ranges between 44% and 54% on a monthly basis, as depicted in **Figure 3**. Simulations show that the corresponding PV electricity self-consumption rate can vary significantly between an annual average of 24% - in this case the PV system is simply added without optimizing CHP control or enlarging the heat storage, as per **Figure 4** - and an annual average of 44%, as per **Figure 5 -** in this case full priority is given to the self-consumption of PV electricity.

The target was to maintain or improve the self-consumption rate of CHP electricity via both, an optimized CHP operation mode and an increased thermal energy storage system, while maximising the self-consumption rate of PV electricity.

Table 2: Resulting economic benefit of direct power marketing for "pilot case" (status 09/2014).

	Annual generation [kWh/a]	Received remmuneration[(1)] [€ct/kWh]	Additional margin of directly traded electricity [€/kW$_{el}$a]
CHP production with feed-in priority[(2)]			
Direct electricity marketing in building (48%)	12,144	16.03	
Electricity fed into public grid (52%)[(3)]	13,274	3.12	
⇨ Resulting margin "self-consumption"		12.91	285
PV production[(4)]			
Direct electricity marketing in building (33%)	5,447	16.03	
Electricity fed into public grid (67%)	11,076	12.59[(5)]	
⇨ Resulting margin "self-consumption"		3.44	13

The end-user electricity price is 26.50 €ct/kWh incl. 19% VAT and 22.27 €ct/kWh excl. VAT. No monthly metering fees are charged.
(1) EEG surcharge of 6.24 €ct deducted from electricity price.
(2) CHP systems additionally receive a CHP electricity production support and energy tax exemptions.
(3) Average CHP grid feed-in tariff in Germany/ Q2, 2014 (Baseload power; EPEX spot market).
(4) High performance PV system in region with highest solar irradiation in Germany. Annual ac yield: 1,180 kWh/kWp.
(5) Resulting feed-in tariff for 14 kWp PV system.

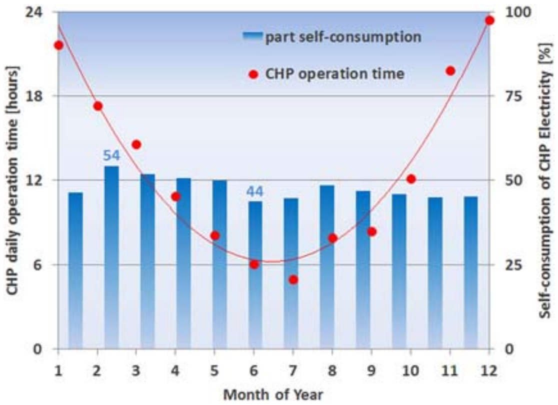


Figure 3: Average daily operation time and electricity self-consumption rate of heat demand controlled CHP.

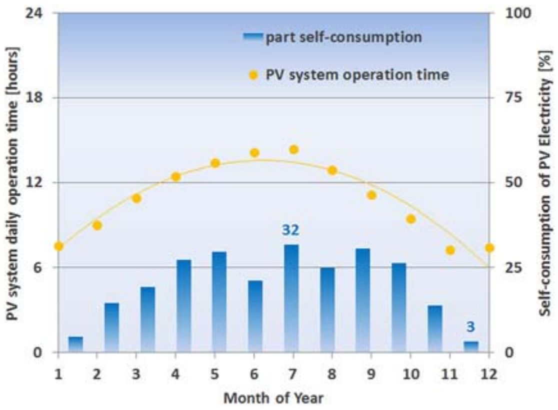


Figure 4: Self-consumption rate of PV electricity with heat demand controlled CHP and electricity self-consumption priority for CHP system.

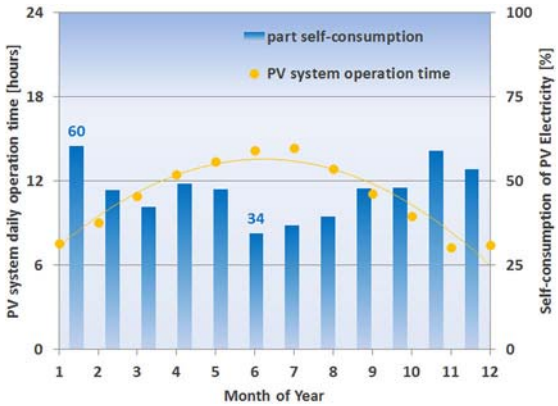
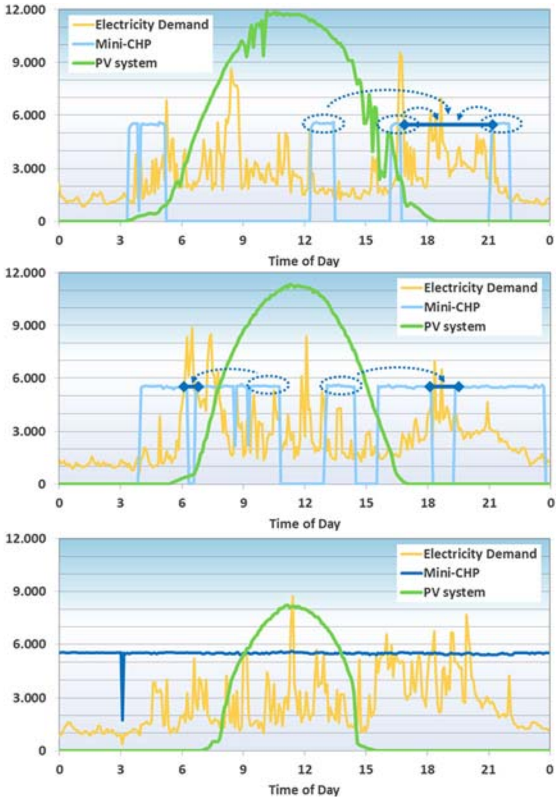


Figure 5: Self-consumption rate of PV electricity with electricity self-consumption priority for PV system.

An optimized operation profile for the CHP in combination with an increased thermal energy storage system leads to a prioritised shift of CHP operation to peak electricity demand periods before and after daytime as illustrated in **Figure 6** to **Figure 8**. During the summer period (**Figure 6**), where 49% of the annual PV electricity is generated, it is possible to shift the CHP operation period without compromising the CHP electricity self-consumption rates and to obtain maximum PV electricity self-consumption rates. Limited but relevant flexibility is given during the transition period between summer and winter as per **Figure 7**. In this period the PV system generates 34% of its annual yield. In the winter period, where the production of the PV system is low, there is very limited flexibility to increase the self-consumption of PV electricity. During cold periods the CHP is continuously operated to produce the required heat as per **Figure 8**. On days with limited heat demand the CHP has to be operated during day time to maintain acceptable CHP electricity self-consumption rates and keep CHP operation profitable.

Further increasing the annual PV self-consumption rate beyond 33% is possible via Demand Side Management (DSM) and the application of Smart Information and Communication Technology (ICT) concepts for energy efficiency in buildings. Such systems were developed and are tested by a consortium around WIP in the framework of the project SmartBuild [4]. The developed web based system monitors and controls the energy demand in buildings.



Figures 6 to 8: Real electricity demand profiles [W], daily CHP operation profiles [W] as well as PV "clear sky" production profiles [W] for working days and three different seasons:
Fig. 6 Summer day on 21.05.2014,
Fig. 7 Transition period on 12.03.2014,
Fig. 8 Deep winter on 30.12.2013.

3 RESULTING FINANCIAL BENEFIT

The resulting overall benefit of the direct marketing model as implemented for the described pilot case, including and optimized CHP operation profile and increased thermal energy storage system, is provided in **Table 2**. Direct revenues of a CHP system directly connected to the public grid are merely 3.12 €ct/kWh. Thus, the margin between the revenues obtained via (a) CHP electricity directly marketed within the private grid and (b) public-grid feed-in is 12.91 €ct/kWh. Resulting additional annual revenues via direct marketing of 12,144 kWh (48% of the generated CHP electricity) in our pilot case are thus 1,567 € or 285 € per kW nominal electric CHP generation capacity installed. Part of these revenues can be spent for direct power marketing services while keeping the CHP operation profitable, even if the tenants are freed from traditional monthly metering fees and are supplied with lowest electricity tariffs. Attractive electricity tariffs are a must to win all tenants to participate.

The monthly metering fees and the accounting effort required for the additional PV system are marginal (one Ferraris-type electricity meter). Consequently, the additional benefit generated via the direct marketing of 5,447 kWh PV electricity can be used for PV system financing and allows for a profitable operation of a PV system too, as detailed above.

Direct marketing of the PV electricity which is not self-consumed within the buildings grid will soon be economically viable too and may help to generate additional revenues, including for small PV systems. With the recent reform of the EEG the technical features of "low cost" smart meters satisfy latest regulations relating energy and power metering for direct energy marketing via the public grid. Even if no direct profit can be generated via this second additional marketing concept a smart meter would support DSM within the building.

4 CONCLUSIONS & OUTLOOK

The "Localpool" direct energy marketing concept to market self-generated electricity within privately owned grids can increase revenues from PV systems and can help achieving profitability, even for small PV systems. In the pilot case described above revenues are increased by 9%. For small PV systems with < 20 kWp, where the additional revenues obtained are normally needed for PV system financing, this direct marketing model can be implemented if a "Localpool" concept can be financed via other sources, such as via a mini-CHP. For larger systems, where non self-consumed PV electricity can be additionally marketed profitably via the public grid, the concept will allow for a profitable PV system operation without any further co-financing sources.

A relevant benefit of this concept, when applied for a combination of PV and CHP systems is that it is ideally suited to stabilize the grid on distribution system level and that it supports the transformation process in the energy sector. Flexible generation capacity is installed (CHP), heat storage capacity is available which could additionally be used to store "peak electricity" via a heating rod, if required, as also discussed by S. Mueller et al. [5], and all instruments for proper financial accounting are in place. Calling-up these features to support the distribution grid would be possible once the "Localpool" receives a financial incentive to (a) reduce production, (b) reduce the demand or (c) increase the production.

5 ACKNOWLEDGEMENTS

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