STRATEGY PAPER

abacus strategy paper on the EU Electrification Action Plan

Bidirectional charging as infrastructure for system-friendly electrification

abacus eWall GmbH | As of 17 July 2026

Basis: COM(2026) 595 final of 17 July 2026 and German electricity and price data for 2025.

1. Background: Why the EU wants to electrify

The Electrification Action Plan COM(2026) 595 final makes accelerated and efficient electrification a matter of European sovereignty, competitiveness and security of supply. It responds to structural dependence on fossil-fuel imports, high energy prices, limited grid capacity and the excessively slow market uptake of new energy technologies.

More than half of EU energy consumption is still supplied by imported fossil fuels. At the same time, around 70% of European electricity already comes from domestic clean sources. The Commission therefore views electrification as the most effective lever for reducing gas and oil imports, fossil-fuel expenditure and CO2 emissions while strengthening European industry.

The central gap is not in the electricity mix but in final energy use: the electrification rate has stagnated at around 23%. The Commission cites 32% for 2030 and is assessing an indicative value of 46% for 2040. Electrification must be system-friendly: new electrical loads should absorb renewable surpluses, avoid demand peaks and provide controllable flexibility to the power system.

> **EU target vision**
> **Not merely more electricity consumption, but system-friendly electrification: consumers and storage respond to renewable generation, prices and grid constraints. Electric vehicles connect mobility, buildings and the energy market through a battery that already exists.**

1.1 Digital metering and grid infrastructure as a bottleneck

Germany still has considerable catching-up to do in intelligent metering systems, time-resolved billing and automated flexibility control. At the same time, the Action Plan explicitly identifies digitalisation, data exchange and AI as key enablers of demand-side flexibility, including V2G.

V2G does not replace the necessary expansion of the grid. It can, however, reduce connection and system peaks, improve utilisation of existing infrastructure and reduce or defer investment where flexible vehicle batteries can bridge time-dependent bottlenecks. This requires measurable, secure and interoperable control systems.

> **Role of abacus**
> **abacus provides the operational metering, control and data layer at the charging point: vehicle, parking space, building connection, energy management, simulator and aggregator are connected so that flexibility becomes technically usable, verifiable and marketable.**

EU measure	Specific relevance for V2G and abacus
Industrial target market	The Commission cites around 120 million BEVs by 2040. It also sees major industrial opportunities for European manufacturers of digital energy-management systems.
V2G requirements 2027/2030	Interoperable V2G requirements are to be adopted by the end of 2027 and apply to new electric vehicles placed on the EU internal market from 2030.
Private and public charging points	The AFIR specifications are to be updated to ensure technical interoperability and bidirectional charging capability explicitly at private charging points as well.
Smart charging and V2G business models	Smart charging is to become standard in EV electricity contracts. Regulatory sandboxes and living labs are to test new V2G business models in the Member States.
Digitalisation, data and AI	Digitalisation, data exchange and AI are identified as key factors for demand-side flexibility - a direct point of connection for eControl and the abacus simulator.
Demonstration and first-of-a-kind	The EU announces support for demonstration and first-of-a-kind projects, standardised solutions and the reduction of project risk.
Financing	The EIB is to mobilise more than EUR 75 billion for electrification over three years, supplemented by Horizon Europe, the Innovation Fund, cohesion funding and State aid.
Storage and customer benefit	The Plan sets targets of 200 GW of storage capacity by 2030 and 500 GW by 2040. Smart charging and V2G could save BEV owners more than EUR 44 billion annually by 2040, in addition to system benefits.

The decisive combination is: V2G-capable vehicles from 2030, interoperable private charging points, digital control and a viable user incentive. Only at a regularly used parking space does the vehicle battery become measurable, controllable and aggregatable.

Strategic core message

The EU is now creating a credible market timetable. abacus can provide the missing cost-efficient implementation layer at private and existing AC charging points: 11-kW AC-BPT, retrofit, metering, control, building integration, simulator, interoperability and aggregator connectivity.

2.1 Strategic assessment for abacus

Strategic lever	Implication for abacus
11-kW AC-BPT for multi-family buildings	Three-phase AC-BPT uses the power electronics in the vehicle and can reduce cost, space requirements and installation complexity compared with external DC technology. The Plan remains technology-neutral; abacus should work to ensure that AC-BPT is not discriminated against.
Sandboxes, living labs and AFIR	Submit a real end-to-end use case with ElaadNL, Bidirex, an OEM and a multi-family-building or fleet partner, and participate in AFIR and interoperability consultations.
Digital energy management and AI	eControl and the simulator provide the data, forecasting and control layer required by the EU: building load, user reserve, prices, generation, grid signals and aggregator requirements are brought together.
EIB, EIC and first-of-a-kind	The demonstrator, certification, OEM interoperability, Elaad testing, initial pilot series and first property or fleet customer must be financed as one coherent European scaling project.
Made in EU, cybersecurity and installation	European server control, controlled data flows, secure updates and standardised installation are both procurement arguments and a response to the shortage of skilled labour.
Market positioning	abacus is not merely a wallbox provider, but the interoperable infrastructure and control platform that makes V2G usable in existing buildings, underground garages, neighbourhoods and company fleets.
The calculation does not work without the users. **The EU can mandate V2G capability and charging infrastructure, but the required storage fleet emerges only if enough people switch from combustion vehicles to EVs and connect their vehicles regularly. Bidi4free turns abstract system flexibility into an immediately understandable benefit: free or substantially reduced-cost driving electricity as remuneration for controllable availability.**	

Bidi4free therefore becomes more than a revenue model; it becomes an adoption instrument for e-mobility: more EV users create more connected batteries, and more connected batteries increase the flexibility value and enterprise value of abacus.

3. Data basis and correct interpretation

Dataset	Source and scope
Grid load	SMARD filter 410, Germany, hourly.
Wind	SMARD filters 4067 onshore plus 1225 offshore.
Solar	SMARD filter 4068 photovoltaic.
Wholesale price	EPEX Day-Ahead DE-LU via SMARD filter 4169.
Period	Calendar year 2025, Europe/Berlin local time.
Generation and load	January complete; February to December approximately two representative weeks per month. The profiles are suitable for patterns and orders of magnitude, not as an official full-year total.
Price and arbitrage data	Complete 8,760 hours and 365 daily rows.

A month-hour cell is an arithmetic mean, not an extreme value. Actual surplus hours, negative residual loads and extreme prices are therefore smoothed. Each of the following tables is shown once and interpreted immediately below it.

Methodological boundary
The models show technical and economic potential. They do not provide guaranteed customer revenue: grid charges, taxes, levies, aggregation costs, forecasting errors, battery ageing and the price-flattening effect of large fleets are not fully modelled.

4. The 2025 power system: generation, load and flexibility demand

4.1 Solar: the recurring midday window

Solar Germany 2025 — Average output (MW) by month × hour

Photovoltaics; hourly generation; all recorded days per month and time of day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	8	7	7	7	7	7	8	14	581	3,260	6,867	9,694	10,722	9,899	7,274	3,486	565	22	16	13	10	9	8	8	**2,187**
Feb	7	7	7	7	6	7	10	304	3,654	10,115	16,634	21,134	22,845	21,829	18,042	11,579	4,244	352	24	21	14	10	8	7	**5,453**
Mär	7	7	7	7	7	8	374	5,376	16,053	27,090	35,021	39,313	39,991	37,991	33,625	25,688	14,531	4,025	200	31	19	12	10	7	**11,642**
Apr	9	7	7	6	6	10	465	4,117	11,696	20,471	28,354	33,550	35,855	35,858	34,048	30,578	25,165	17,488	8,578	2,181	132	17	12	8	**12,026**
Mai	9	9	9	9	10	215	2,527	8,732	17,962	27,037	33,190	36,202	37,055	36,530	34,538	31,471	26,673	20,084	12,009	4,814	960	47	17	11	**13,755**
Jun	36	32	31	30	40	595	3,577	9,860	18,365	26,476	32,330	35,533	37,108	36,950	35,723	32,954	28,706	22,382	14,293	6,802	2,187	222	49	37	**14,347**
Jul	35	31	30	31	32	179	1,904	6,001	11,989	18,401	23,845	27,397	29,338	29,958	29,419	27,203	23,367	18,124	11,679	5,618	1,601	146	48	34	**11,100**
Aug	11	9	9	8	14	23	930	5,646	14,160	23,577	30,882	35,579	37,730	37,927	36,608	33,490	28,334	20,785	11,587	3,883	492	51	16	11	**13,407**
Sep	10	9	8	8	8	9	85	2,272	9,206	18,089	25,720	30,538	32,529	32,525	30,688	27,015	21,138	13,102	4,882	656	61	20	11	9	**10,358**
Okt	14	14	13	13	12	13	15	172	2,048	6,113	10,297	13,236	14,455	14,089	12,498	9,633	5,671	1,873	160	60	30	16	14	13	**3,770**
Nov	8	8	8	8	8	8	11	372	3,613	9,237	14,326	17,251	17,435	14,878	9,977	4,068	462	49	31	20	11	10	11	8	**3,826**
Dez	7	6	7	7	7	7	8	18	704	3,770	7,434	9,964	10,404	8,579	5,139	1,497	72	38	24	14	10	8	8	7	**1,989**
Ø Std	**13**	**12**	**12**	**12**	**13**	**90**	**826**	**3,574**	**9,169**	**16,136**	**22,075**	**25,783**	**27,122**	**26,418**	**23,965**	**19,889**	**14,911**	**9,860**	**5,290**	**2,009**	**461**	**47**	**18**	**13**	**8,655**

Einheit: MW mittlere eingespeiste Leistung (1000 MW = 1 GW). Zeitraum: 2025, Ortszeit Europe/Berlin.

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Solar generation has a pronounced and strongly seasonal midday profile. In spring and summer, broad high-output blocks occur during the day, while no solar power is available at night. The sample shows an annual mean of around 8.7 GW.

Relevance for abacus: Smart charging should systematically use the predictable solar midday window. V2G shifts part of this energy into morning and evening hours.

4.2 Wind: complementary generation without a fixed time of day

Wind Germany 2025 — Average output (MW) by month × hour

Onshore + offshore wind; hourly generation; all recorded days per month and time of day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	21,343	21,235	21,041	20,779	20,711	20,821	21,609	21,770	21,844	21,370	21,056	20,770	20,540	20,506	20,421	20,399	20,830	21,453	21,720	22,013	22,012	21,776	21,055	20,700	**21,157**
Feb	15,942	15,738	15,383	15,323	15,357	15,291	15,632	15,577	15,076	13,729	12,326	11,617	11,278	11,247	11,504	11,898	12,652	14,646	17,108	18,436	18,606	18,418	17,793	17,718	**14,929**
Mär	16,747	16,230	15,824	15,453	15,097	15,133	15,529	14,819	13,332	10,895	8,911	8,193	7,976	8,169	9,119	10,020	10,565	10,748	12,272	14,131	15,424	15,938	15,449	15,005	**12,957**
Apr	11,792	11,263	10,703	10,307	10,021	9,749	9,582	8,667	6,957	5,898	5,824	6,116	6,303	6,676	7,129	7,633	8,303	8,860	8,891	8,648	9,635	11,202	11,793	11,839	**8,908**
Mai	13,528	13,383	13,087	12,937	12,753	12,496	11,990	10,715	9,485	9,367	9,723	10,273	10,662	10,846	10,930	11,747	12,645	14,210	14,769	14,289	13,654	14,364	14,872	15,228	**12,415**
Jun	11,697	12,081	12,311	12,475	12,548	13,046	13,175	12,338	11,316	10,991	11,261	11,952	12,367	12,223	12,168	12,623	13,548	14,308	13,712	12,641	11,669	11,597	11,917	12,916	**12,370**
Jul	9,664	9,418	9,188	9,061	9,120	9,231	9,166	8,390	7,976	8,003	8,223	8,571	9,020	9,496	10,202	11,102	11,737	12,154	11,728	10,754	9,612	8,862	8,683	8,956	**9,513**
Aug	12,751	12,400	12,040	11,725	11,317	11,137	11,210	10,463	8,838	8,217	8,597	8,996	9,683	10,104	10,705	11,601	12,353	13,234	13,251	12,057	11,146	11,400	11,851	12,054	**11,130**
Sep	22,307	22,522	22,092	21,800	21,672	21,890	22,772	22,433	21,007	19,159	17,738	17,176	16,865	16,490	16,488	17,215	17,681	18,248	17,273	16,965	18,140	20,070	20,937	21,635	**19,607**
Okt	23,921	23,921	24,992	24,528	25,000	25,491	26,538	26,712	26,525	25,744	25,223	24,821	24,472	24,239	24,120	24,154	23,962	23,831	23,771	23,541	23,992	23,884	22,960	22,576	**24,538**
Nov	16,861	16,609	16,616	16,666	16,634	16,632	17,019	17,023	16,438	15,103	13,782	13,185	13,091	13,343	13,378	13,786	15,117	16,758	17,912	18,326	18,398	18,078	17,022	16,710	**16,020**
Dez	19,541	19,561	19,520	19,545	19,515	19,583	19,911	19,677	19,560	18,691	17,250	15,767	14,439	13,610	13,572	14,636	16,720	18,740	20,373	21,389	22,060	22,282	21,594	21,396	**18,706**
Ø Std	**16,341**	**16,197**	**16,066**	**15,883**	**15,812**	**15,875**	**16,178**	**15,715**	**14,863**	**13,931**	**13,326**	**13,120**	**13,058**	**13,079**	**13,311**	**13,901**	**14,676**	**15,599**	**16,065**	**16,099**	**16,196**	**16,489**	**16,327**	**16,394**	**15,188**

Einheit: MW mittlere eingespeiste Leistung (1000 MW = 1 GW). Zeitraum: 2025, Ortszeit Europe/Berlin.

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Wind complements solar, particularly at night and during autumn and winter, but varies considerably with the weather. Fixed charging times are therefore insufficient; the control system must process actual generation, price or grid signals.

Relevance for abacus: eControl requires dynamic signals and must not reduce V2G to a rigid time schedule.

4.3 Wind plus solar: available renewable output

Wind + solar Germany 2025 — Average output (MW) by month × hour

Wind + solar; hourly generation; all recorded days per month and time of day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	21,351	21,242	21,048	20,786	20,718	20,828	21,617	21,784	22,425	24,629	27,924	30,465	31,262	30,405	27,695	23,885	21,395	21,475	21,736	22,026	22,022	21,785	21,063	20,708	**23,345**
Feb	15,949	15,745	15,390	15,330	15,363	15,298	15,641	15,881	18,731	23,844	28,960	32,750	34,123	33,076	29,547	23,478	16,896	14,998	17,132	18,457	18,620	18,428	17,801	17,725	**20,382**
Mär	16,753	16,236	15,831	15,459	15,104	15,141	15,903	20,196	29,385	37,985	43,932	47,506	47,967	46,160	42,744	35,708	25,096	14,774	12,472	14,162	15,442	15,951	15,458	15,012	**24,599**
Apr	11,800	11,270	10,709	10,313	10,027	9,759	10,047	12,784	18,653	26,369	34,178	39,666	42,158	42,534	41,177	38,211	33,468	26,349	17,469	10,829	9,768	11,219	11,805	11,847	**20,934**
Mai	13,538	13,392	13,096	12,946	12,763	12,712	14,517	19,446	27,447	36,405	42,913	46,475	47,717	47,375	45,467	43,218	39,318	34,295	26,778	19,103	14,614	14,411	14,889	15,238	**26,170**
Jun	11,734	12,113	12,342	12,505	12,588	13,640	16,752	22,199	29,680	37,467	43,591	47,485	49,475	49,173	47,890	45,577	42,254	36,689	28,004	19,443	13,856	11,818	11,965	12,953	**26,716**
Jul	9,699	9,449	9,218	9,092	9,152	9,410	11,070	14,390	19,965	26,403	32,068	35,968	38,358	39,454	39,621	38,305	35,104	30,278	23,407	16,371	11,212	9,008	8,731	8,990	**20,613**
Aug	12,762	12,408	12,049	11,733	11,331	11,160	12,140	16,109	22,999	31,794	39,479	44,575	47,413	48,031	47,313	45,091	40,687	34,019	24,838	15,940	11,637	11,451	11,867	12,065	**24,537**
Sep	22,318	22,531	22,099	21,808	21,680	21,899	22,857	24,705	30,213	37,248	43,458	47,714	49,393	49,015	47,176	44,230	38,819	31,350	22,155	17,621	18,201	20,090	20,948	21,644	**29,966**
Okt	23,935	23,935	25,005	24,541	25,012	25,504	26,554	26,884	28,574	31,858	35,520	38,056	38,928	38,328	36,618	33,787	29,633	25,704	23,932	23,601	24,022	23,900	22,974	22,589	**28,308**
Nov	16,869	16,616	16,623	16,674	16,642	16,640	17,031	17,396	20,052	24,341	28,108	30,436	30,526	28,221	23,355	17,854	15,579	16,807	17,942	18,346	18,409	18,088	17,033	16,718	**19,846**
Dez	19,548	19,567	19,527	19,552	19,522	19,590	19,919	19,695	20,264	22,461	24,684	25,731	24,842	22,188	18,712	16,133	16,792	18,777	20,397	21,403	22,070	22,290	21,602	21,403	**20,695**
Ø Std	**16,355**	**16,209**	**16,078**	**15,895**	**15,825**	**15,965**	**17,004**	**19,289**	**24,032**	**30,067**	**35,401**	**38,902**	**40,180**	**39,497**	**37,276**	**33,790**	**29,587**	**25,460**	**21,355**	**18,109**	**16,656**	**16,537**	**16,345**	**16,408**	**23,843**

Einheit: MW mittlere eingespeiste Leistung (1000 MW = 1 GW). Zeitraum: 2025, Ortszeit Europe/Berlin.

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Together, wind and solar average around 24 GW in the sample. The highest values often occur around midday, while low-wind evenings remain significantly lower. The combination highlights daily and seasonal storage requirements.

Relevance for abacus: Vehicle batteries can absorb renewable electricity when it is available instead of charging uncontrollably only after the working day.

4.4 Grid load: the existing morning and evening peaks

Electricity consumption (grid load) Germany 2025 — Average load (MW) by month × hour

SMARD grid load; hourly mean by month and time of day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	50,631	48,985	48,216	48,265	48,964	51,170	56,192	60,686	63,547	64,767	65,615	66,173	65,978	64,907	63,623	63,268	64,226	66,732	66,811	65,202	62,059	59,058	56,498	53,289	59,369
Feb	51,260	49,752	48,932	49,041	49,815	51,843	56,635	60,737	63,393	64,676	65,354	65,476	64,478	62,817	61,329	60,444	60,919	63,816	66,031	64,760	61,726	58,853	56,485	53,515	58,837
Mär	47,754	46,166	45,573	45,830	47,149	49,912	55,014	58,699	61,141	61,627	60,706	59,647	57,918	56,411	55,515	55,046	55,591	58,650	61,622	61,714	58,565	55,514	52,933	49,713	54,934
Apr	43,308	41,586	40,749	40,804	41,817	44,366	49,023	52,709	55,670	56,910	57,196	57,007	55,716	54,133	52,463	51,672	51,372	52,423	54,001	54,616	54,135	52,414	49,436	46,086	50,401
Mai	42,505	40,894	40,116	40,147	41,057	43,573	48,804	52,847	55,689	56,183	55,883	55,999	55,367	54,016	52,639	52,217	51,916	52,891	53,831	53,946	52,796	51,432	48,742	45,394	49,954
Jun	42,400	40,693	39,621	39,347	39,838	41,573	46,353	50,545	53,432	54,221	54,449	54,604	54,091	52,972	51,986	51,566	51,495	52,313	53,023	53,056	51,904	49,964	48,010	45,025	48,853
Jul	42,310	40,664	39,625	39,516	40,137	42,214	46,967	51,040	54,066	55,387	56,089	56,384	55,690	54,444	53,212	52,496	52,175	52,817	53,412	52,969	51,540	49,797	47,672	44,515	49,381
Aug	41,181	39,645	38,695	38,442	38,989	41,428	45,924	49,708	52,417	53,245	53,268	53,183	52,274	50,926	49,911	49,414	49,494	50,737	51,959	52,143	50,943	49,598	46,571	43,563	47,652
Sep	41,836	40,504	39,603	39,491	40,162	43,061	49,079	52,723	55,536	56,701	57,162	56,897	55,613	54,033	52,720	52,122	52,203	53,622	54,650	55,030	54,144	50,754	47,357	44,106	49,963
Okt	45,601	43,785	42,578	42,803	44,015	46,947	53,077	57,815	60,551	61,723	62,391	62,966	62,331	61,170	59,437	58,625	58,307	59,761	61,223	61,010	58,039	54,800	51,714	48,335	54,959
Nov	48,493	46,784	46,124	46,314	47,372	50,212	56,430	60,850	63,406	63,965	64,472	64,551	63,887	62,613	61,625	62,114	63,704	66,506	66,424	64,775	61,614	58,360	55,191	51,808	58,233
Dez	49,468	47,727	46,843	46,900	48,015	50,758	56,486	61,454	64,398	65,071	65,261	65,387	64,846	63,686	62,927	63,293	65,031	66,862	66,549	64,745	61,598	58,510	55,592	52,009	58,892
Ø Std	45,562	43,932	43,056	43,075	43,944	46,421	51,665	55,818	58,604	59,540	59,821	59,856	59,016	57,677	56,449	56,023	56,369	58,094	59,128	58,664	56,589	54,088	51,350	48,113	53,452

Einheit: MW (1000 MW = 1 GW). Werte = mittlere Netzlast (Stromverbrauch inkl. Netzverluste, ohne Kraftwerkseigenverbrauch/Pumpspeicher-Bezug im engeren Sinn).

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Average grid load is around 53.5 GW. The highest month-hour value is approximately 66.9 GW in December at 17:00; the lowest is approximately 38.4 GW in August at 03:00. Uncontrolled home charging after work would therefore reinforce the existing evening peak.

Relevance for abacus: Even unidirectional smart charging has substantial value; bidirectional charging can additionally reduce the peak actively.

4.5 Wind-and-solar coverage: not the same as total renewable coverage

Wind-and-solar coverage 2025 — Share of grid load (%) by month × hour

Wind + solar divided by grid load; other renewable generation is not included.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	42.2	43.4	43.7	43.1	42.3	40.7	38.5	35.9	35.3	38.0	42.6	46.0	47.4	46.8	43.5	37.8	33.3	32.2	32.5	33.8	35.5	36.9	37.3	38.9	**39.5**
Feb	31.1	31.6	31.5	31.3	30.8	29.5	27.6	26.1	29.5	36.9	44.3	50.0	52.9	52.7	48.2	38.8	27.7	23.5	25.9	28.5	30.2	31.3	31.5	33.1	**34.4**
Mär	35.1	35.2	34.7	33.7	32.0	30.3	28.9	34.4	48.1	61.6	72.4	79.6	82.8	81.8	77.0	64.9	45.1	25.2	20.2	22.9	26.4	28.7	29.2	30.2	**44.2**
Apr	27.2	27.1	26.3	25.3	24.0	22.0	20.5	24.3	33.5	46.3	59.8	69.6	75.7	78.6	78.5	73.9	65.1	50.3	32.3	19.8	18.0	21.4	23.9	25.7	**40.4**
Mai	31.8	32.7	32.6	32.2	31.1	29.2	29.7	36.8	49.3	64.8	76.8	83.0	86.2	87.7	86.4	82.8	75.7	64.8	49.7	35.4	27.7	28.0	30.5	33.6	**50.8**
Jun	27.7	29.8	31.2	31.8	31.6	32.8	36.1	43.9	55.5	69.1	80.1	87.0	91.5	92.8	92.1	88.4	82.1	70.1	52.8	36.6	26.7	23.7	24.9	28.8	**52.8**
Jul	22.9	23.2	23.3	23.0	22.8	22.3	23.6	28.2	36.9	47.7	57.2	63.8	68.9	72.5	74.5	73.0	67.3	57.3	43.8	30.9	21.8	18.1	18.3	20.2	**40.1**
Aug	31.0	31.3	31.1	30.5	29.1	26.9	26.4	32.4	43.9	59.7	74.1	83.8	90.7	94.3	94.8	91.3	82.2	67.0	47.8	30.6	22.8	23.1	25.5	27.7	**49.9**
Sep	53.3	55.6	55.8	55.2	54.0	50.9	46.6	46.9	54.4	65.7	76.0	83.9	88.8	90.7	89.5	84.9	74.4	58.5	40.5	32.0	33.6	39.6	44.2	49.1	**59.3**
Okt	52.5	54.7	58.7	57.3	56.8	54.3	50.0	46.5	47.2	51.6	56.9	60.4	62.5	62.7	61.6	57.6	50.8	43.0	39.1	38.7	41.4	43.6	44.4	46.7	**51.6**
Nov	34.8	35.5	36.0	36.0	35.1	33.1	30.2	28.6	31.6	38.1	43.6	47.2	47.8	45.1	37.9	28.7	24.5	25.3	27.0	28.3	29.9	31.0	30.9	32.3	**34.1**
Dez	39.5	41.0	41.7	41.7	40.7	38.6	35.3	32.0	31.5	34.5	37.8	39.4	38.3	34.8	29.7	25.5	25.8	28.1	30.6	33.1	35.8	38.1	38.9	41.2	**35.6**
Ø Std	**35.8**	**36.8**	**37.2**	**36.8**	**35.9**	**34.2**	**32.8**	**34.7**	**41.4**	**51.2**	**60.1**	**66.1**	**69.5**	**70.0**	**67.8**	**62.3**	**54.5**	**45.4**	**36.9**	**30.9**	**29.1**	**30.3**	**31.6**	**34.0**	**44.4**

Einheit: Prozent des Stromverbrauchs (Netzlast), das rechnerisch durch Wind + Solar gedeckt wird. Gelb = 100 % (Volldeckung), grün > 100 % (Überschuss), rot = wenig.

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The sheet shows only wind plus solar divided by grid load. Biomass, hydropower and other renewable sources are not included. The average of the month-hour cells is around 44-45%, with a maximum cell of approximately 94.8%.

Relevance for abacus: High midday coverage and low night-time and evening coverage justify time shifting through smart charging and V2G.

4.6 Residual load: the remaining system demand

Residual load Germany 2025 — Consumption minus wind + solar (MW), month × hour

Positive values indicate remaining demand after wind and solar; low values indicate surplus conditions.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	29,280	27,743	27,168	27,479	28,246	30,342	34,575	38,902	41,121	40,137	37,692	35,709	34,716	34,502	35,928	39,383	42,831	45,257	45,075	43,176	40,037	37,274	35,435	32,581	**36,025**
Feb	35,310	34,007	33,543	33,711	34,452	36,545	40,993	44,856	44,662	40,832	36,394	32,725	30,355	29,741	31,782	36,966	44,023	48,818	48,899	46,303	43,107	40,425	38,684	35,789	**38,455**
Mär	31,000	29,930	29,742	30,370	32,044	34,771	39,112	38,503	31,757	23,642	16,773	12,141	9,950	10,251	12,770	19,338	30,494	43,877	49,150	47,552	43,123	39,564	37,474	34,701	**30,335**
Apr	31,507	30,316	30,039	30,491	31,790	34,607	38,976	39,925	37,017	30,541	23,018	17,341	13,558	11,598	11,287	13,462	17,904	26,075	36,532	43,787	44,367	41,195	37,631	34,239	**29,467**
Mai	28,968	27,502	27,021	27,201	28,295	30,861	34,287	33,401	28,242	19,779	12,970	9,524	7,650	6,641	7,172	9,000	12,598	18,596	27,052	34,843	38,182	37,021	33,853	30,155	**23,784**
Jun	30,666	28,580	27,279	26,842	27,250	27,933	29,601	28,346	23,752	16,755	10,858	7,119	4,617	3,798	4,096	5,989	9,241	15,623	25,018	33,614	38,048	38,146	36,045	32,072	**22,137**
Jul	32,612	31,215	30,407	30,424	30,985	32,804	35,897	36,649	34,101	28,983	24,021	20,416	17,331	14,990	13,591	14,191	17,071	22,539	30,005	36,597	40,327	40,789	38,941	35,525	**28,767**
Aug	28,420	27,237	26,646	26,709	27,658	30,268	33,784	33,599	29,418	21,451	13,789	8,608	4,861	2,895	2,597	4,324	8,807	16,718	27,121	36,202	39,306	38,147	34,704	31,498	**23,115**
Sep	19,518	17,973	17,504	17,683	18,482	21,162	26,221	28,019	25,323	19,452	13,705	9,183	6,220	5,018	5,544	7,892	13,384	22,272	32,495	37,409	35,943	30,664	26,409	22,462	**19,997**
Okt	21,667	19,850	17,572	18,263	19,003	21,443	26,524	30,932	31,977	29,865	26,871	24,910	23,403	22,842	22,819	24,838	28,674	34,058	37,292	37,409	34,017	30,900	28,740	25,746	**26,651**
Nov	31,624	30,167	29,501	29,640	30,730	33,572	39,399	43,454	43,354	39,624	36,364	34,115	33,361	34,393	38,270	44,260	48,125	49,699	48,482	46,429	43,205	40,273	38,158	35,090	**38,387**
Dez	29,920	28,159	27,317	27,348	28,493	31,168	36,566	41,759	44,134	42,610	40,577	39,656	40,004	41,498	44,215	47,159	48,238	48,085	46,152	43,342	39,529	36,219	33,990	30,606	**38,198**
Ø Std	**29,208**	**27,723**	**26,978**	**27,180**	**28,119**	**30,456**	**34,661**	**36,529**	**34,572**	**29,473**	**24,419**	**20,954**	**18,836**	**18,181**	**19,173**	**22,234**	**26,783**	**32,635**	**37,773**	**40,555**	**39,933**	**37,551**	**35,005**	**31,705**	**29,610**

Einheit: MW. Positiv = Restlast, die nach Wind+Solar aus konventionellen Kraftwerken, Import oder Speichern gedeckt werden muss. Grün = wenig Restbedarf, rot = viel.

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: After subtracting wind and solar, an average of around 29.6 GW remains. The month-hour values range from approximately 2.6 GW in August at 14:00 to 49.7 GW in November at 17:00. This range of roughly 47 GW is the directly visible flexibility demand.

Relevance for abacus: The control logic must charge at low residual load and avoid consumption or feed electricity back at high residual load.

Model boundary	**40 kWh per EV and day remains an analytical upper bound. Practical operation uses a 25/5/20 Bidi4free profile: a 25.00-kWh usable battery swing, comprising 5.00 kWh for mobility and 20.00 kWh of battery-side V2G flexibility.**

5. 40-kWh single-cycle reference model: an illustrative upper bound

5.1 Wholesale price: the market signal for scarcity

Average wholesale price (Day-Ahead, EUR/MWh) 2025 — Month × hour

Green = low/negative prices; red = high prices. Source: SMARD DE-LU day-ahead market.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	90	86	82	80	82	88	102	127	151	137	123	114	108	107	111	127	142	162	154	138	122	110	105	94	**114**
Feb	113	109	106	105	107	110	125	152	166	144	126	114	108	107	113	125	142	165	173	161	144	130	125	116	**129**
Mär	96	90	91	87	89	97	118	126	111	87	61	44	37	32	41	68	96	129	162	157	134	115	108	98	**95**
Apr	90	84	83	82	83	91	110	124	105	77	50	33	15	3	4	20	38	70	108	139	144	118	104	94	**78**
Mai	91	85	81	80	83	89	101	102	84	54	24	10	-4	-12	-10	3	20	49	90	117	145	128	110	96	**67**
Jun	90	83	80	78	79	84	92	87	71	44	20	8	-2	-10	-11	-2	11	42	79	108	143	143	119	100	**64**
Jul	102	95	91	89	90	95	105	105	100	84	69	58	47	38	35	43	60	81	97	117	138	138	122	108	**88**
Aug	92	87	84	82	84	92	101	102	91	70	50	31	19	12	14	25	39	72	101	133	145	121	106	96	**77**
Sep	76	72	70	69	72	81	102	126	110	84	60	42	31	26	29	40	58	92	142	196	146	107	94	81	**84**
Okt	69	65	62	60	61	66	84	109	115	96	81	70	61	58	63	75	87	112	143	144	106	87	82	71	**85**
Nov	81	77	74	73	75	79	91	115	121	109	100	97	96	100	108	124	139	148	135	121	106	98	94	84	**102**
Dez	77	73	71	70	70	75	84	97	109	106	98	95	93	96	104	114	120	119	112	105	98	91	89	80	**94**
Ø/Σ Std	**89**	**84**	**81**	**80**	**81**	**87**	**101**	**114**	**111**	**91**	**72**	**60**	**51**	**46**	**50**	**64**	**79**	**103**	**125**	**136**	**131**	**116**	**105**	**93**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The lowest average prices occur mainly around midday in spring and summer; the highest often occur in the morning or evening. Across the 288 common cells, price correlates with residual load at around 0.91 and with wind-and-solar coverage at approximately -0.83.

Relevance for abacus: Price optimisation is generally system-friendly, but must be supplemented by local building and grid constraints.

5.1.1 Negative electricity prices in 2025: frequency and distribution

EPEX 2025 — Frequency of negative prices (hours by month × time of day)

Number of hours with a day-ahead price below EUR 0/MWh. Source: SMARD 4169 (DE-LU), 2025.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Monat
Jan	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	**14**
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Mär	0	0	0	0	0	0	0	0	1	1	2	4	8	8	2	2	1	1	0	0	0	0	0	0	**30**
Apr	0	0	0	0	0	0	0	0	0	0	2	8	13	15	15	15	7	0	0	0	0	0	0	0	**75**
Mai	0	0	0	0	0	0	0	0	0	1	8	17	21	22	22	21	15	2	0	0	0	0	0	0	**129**
Jun	0	0	0	0	0	0	0	0	0	5	9	17	21	23	23	21	16	4	2	0	0	0	0	0	**141**
Jul	0	0	0	0	0	0	0	0	0	0	0	1	2	4	2	2	1	0	0	0	0	0	0	0	**12**
Aug	0	0	0	0	0	0	0	0	0	1	7	7	9	12	12	10	5	1	0	0	0	0	0	0	**64**
Sep	1	1	1	1	1	1	0	0	0	2	3	6	9	10	11	8	4	1	0	0	0	0	0	0	**60**
Okt	1	2	2	2	3	2	2	2	3	3	3	3	3	4	4	3	2	1	0	0	0	1	1	1	**48**
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Dez	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Σ Stunde	**2**	**3**	**3**	**4**	**5**	**4**	**3**	**3**	**5**	**14**	**35**	**64**	**87**	**99**	**92**	**83**	**52**	**10**	**2**	**0**	**0**	**1**	**1**	**1**	**573**

Context: In 2025, 573 hours had a day-ahead price below EUR 0/MWh, equivalent to 6.54% of the year. 425 negative-price hours, or 74.17%, occurred between 11:00 and 15:00. April to June alone accounted for 345 hours, or 60.21%. The concentration in solar midday hours shows that the month-hour averages in Section 5.1 significantly smooth the actual surplus and extreme hours.

Relevance for abacus: eControl must therefore process hourly day-ahead, intraday and grid signals. A rigid charging window is insufficient. Negative prices provide a particularly clear release signal for absorbing renewable surpluses, provided that vehicle reserve, building connection and local grid limits are respected.

5.1.2 Depth of negative prices and quantified arbitrage contribution

EPEX 2025 — Average price during negative-price hours (EUR/MWh)

Average only across hours with price below zero; zero means no negative-price hour in the cell.

	Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3																									
5	Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0
6	Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Mär	0	0	0	0	0	0	0	0	0	0	-3	-4	-5	-6	-16	-7	-4	0	0	0	0	0	0	0
8	Apr	0	0	0	0	0	0	0	0	0	0	-2	-9	-20	-31	-30	-13	-4	0	0	0	0	0	0	0
9	Mai	0	0	0	0	0	0	0	0	0	0	-2	-8	-20	-30	-28	-13	-3	0	0	0	0	0	0	0
10	Jun	0	0	0	0	0	0	0	0	0	0	-2	-7	-13	-19	-19	-12	-6	-8	-1	0	0	0	0	0
11	Jul	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-2	-1	-2	0	0	0	0	0	0	0
12	Aug	0	0	0	0	0	0	0	0	0	0	-1	-3	-7	-10	-9	-4	-2	-1	0	0	0	0	0	0
13	Sep	0	0	0	-1	-1	0	0	0	0	-1	-3	-6	-9	-11	-8	-6	-3	-1	0	0	0	0	0	0
14	Okt	-1	-1	-2	-2	-2	-3	-3	-1	0	-1	-1	-1	-1	-1	-1	-2	0	0	0	0	0	0	0	0
15	Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Dez	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Metric	Value	Interpretation
Weighted average of all 573 negative-price hours	**-10.95 EUR/MWh**	Typical direct remuneration for additional electricity consumption, weighted by the actual frequency of the hours.
Lowest individual price in 2025	**-250.32 EUR/MWh**	May, 13:00. Individual extreme hours are far below the month-hour average visible in Section 5.1.
Theoretical intake in all negative-price hours at 11 kW	**6,303 kWh and EUR 69.02**	Technical upper bound with continuous availability; not a realistic daily battery operating pattern.
25/5/20 profile: days with at least one hour below zero	**101 days; EUR 265.25**	Gross arbitrage on these days; 52.43% of the annual arbitrage of EUR 505.96/EV calculated in the daily backtest.
25/5/20 profile: average of the four charging hours below zero	**89 days; EUR 37.99 charging revenue**	Direct credit for electricity intake alone; total gross arbitrage on these days: EUR 238.50/EV.

Correct interpretation: Direct revenue from a negative purchase price is only one part of the value. The larger contribution results from the combination of a negative or very low charging price and subsequent sale at positive prices. The EUR 265.25 is therefore already included in total arbitrage and must not be added again to the annual value.

Model boundary: 2025 price backtest, one cycle per day, perfect foresight of day-ahead prices, 85.00% round-trip efficiency, 27.12 kWh grid intake and 18.44 kWh grid feed-in in the 25/5/20 profile. Grid charges, taxes, aggregation costs, battery ageing and market impact are not included.

5.2 Energy flow per vehicle: absorb at midday and return later

V2G net energy per EV (kWh, average day) 2025 — Month × hour

Negative values = charging; positive values = feed-in. One reference cycle per day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Tag
Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	4.0	3.2	0.0	-7.2	-8.1	-9.4	-7.4	-1.9	1.7	5.4	6.3	4.1	0.5	0.0	0.3	0.0	**-6.0**
Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	6.4	2.7	-1.1	-7.9	-10.0	-10.0	-8.6	-2.1	0.9	5.8	7.0	6.4	1.5	0.0	0.0	0.0	**-6.0**
Mär	0.0	0.0	0.0	0.0	0.0	0.0	2.2	4.4	1.6	0.3	-0.4	-8.1	-9.7	-10.0	-9.4	-1.9	-0.3	3.6	7.4	8.2	4.9	0.3	0.3	0.0	**-6.5**
Apr	0.0	0.0	0.0	0.0	0.0	0.0	2.3	5.1	2.3	0.0	-0.3	-0.7	-10.0	-10.0	-10.0	-9.0	0.0	0.0	1.7	7.9	7.9	5.1	2.3	0.0	**-5.4**
Mai	0.0	0.0	0.0	0.0	0.0	0.0	3.6	3.6	0.3	0.0	0.0	-1.6	-8.7	-10.0	-10.0	-8.4	-1.3	0.0	0.3	6.0	8.0	7.7	4.4	0.3	**-6.0**
Jun	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.0	0.6	0.0	0.0	-1.0	-8.0	-10.0	-10.0	-9.0	-2.0	0.0	0.3	4.2	7.4	8.2	7.4	1.4	**-6.0**
Jul	0.0	0.0	0.0	0.0	0.0	0.0	1.1	3.0	1.1	0.3	0.0	-1.9	-7.1	-10.0	-10.0	-8.1	-2.9	0.0	0.0	3.6	7.7	8.2	7.1	1.9	**-6.0**
Aug	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.7	0.5	0.0	0.0	-2.9	-9.4	-9.7	-10.0	-7.1	-1.0	0.3	1.1	7.1	8.2	6.9	4.4	0.0	**-6.5**
Sep	0.0	0.0	0.0	0.0	0.0	0.0	1.4	5.1	3.4	0.0	0.0	-3.7	-10.0	-10.0	-10.0	-6.3	0.0	1.4	5.4	8.5	7.1	2.0	0.0	0.0	**-5.7**
Okt	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.0	2.9	1.0	-0.7	-5.2	-9.0	-9.7	-9.0	-4.2	1.1	4.9	7.4	7.1	3.8	0.0	0.3	0.0	**-5.7**
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.1	-1.0	-4.9	-7.8	-8.7	-6.7	-4.0	-0.3	6.0	5.9	6.8	3.4	0.3	0.0	0.0	0.0	**-6.8**
Dez	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.9	2.9	-5.7	-6.9	-9.4	-8.1	-2.6	-0.3	6.0	5.8	6.0	3.8	0.0	0.0	0.3	0.0	**-5.2**
Ø/Σ Std	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**15.8**	**38.6**	**26.0**	**9.4**	**-13.2**	**-54.9**	**-108.0**	**-113.4**	**-101.0**	**-58.7**	**8.1**	**33.1**	**49.7**	**70.5**	**57.4**	**38.3**	**26.6**	**3.6**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Negative values represent electricity drawn by the vehicle; positive values represent feed-in. The reference model may charge only between 08:00 and 17:00 and selects the four cheapest hours within that window. No charging therefore appears between 00:00 and 06:00. Energy intake is concentrated mainly between 11:00 and 15:00, while return occurs in the morning and evening. The daily total of approximately -6 kWh corresponds to the modelled round-trip loss.

Relevance for abacus: The temporal shift follows the needs indicated by generation, grid load and the price structure.

5.3 Value contribution per vehicle and hour

V2G EUR balance per EV (monthly sum by hour) 2025 — Month × hour

Revenue in feed-in hours and cost in charging hours; annual sum is the sum of all cells.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Monat
Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	21.5	16.8	3.5	-25.0	-26.1	-29.1	-25.4	-6.7	15.2	33.1	33.2	20.4	2.5	0.0	0.8	0.0	**45.7**
Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	31.9	13.1	-1.4	-24.4	-30.1	-30.1	-28.0	-7.1	4.0	27.8	34.9	28.6	6.2	0.0	0.0	0.0	**40.0**
Mär	0.0	0.0	0.0	0.0	0.0	0.0	9.8	20.8	7.9	1.1	-0.1	-8.9	-10.6	-9.8	-11.8	-4.0	-0.8	15.8	39.1	40.8	20.7	0.9	0.3	0.0	**111.3**
Apr	0.0	0.0	0.0	0.0	0.0	0.0	9.3	22.8	9.5	0.0	-0.9	0.0	-4.6	-0.9	-1.3	-4.9	0.0	0.0	6.0	33.2	34.8	18.3	7.1	0.0	**128.4**
Mai	0.0	0.0	0.0	0.0	0.0	0.0	13.8	14.4	1.1	0.0	0.0	-2.7	1.1	3.8	3.1	2.0	0.1	0.0	0.9	22.8	36.4	30.9	15.2	0.9	**143.8**
Jun	0.0	0.0	0.0	0.0	0.0	0.0	8.5	6.9	1.9	0.0	0.0	-0.2	1.5	3.0	3.1	0.9	-0.2	0.0	0.9	15.9	33.4	35.7	26.8	3.9	**141.9**
Jul	0.0	0.0	0.0	0.0	0.0	0.0	4.1	11.2	4.4	1.1	0.0	-2.4	-8.8	-11.7	-10.8	-10.5	-5.1	0.0	0.0	14.8	33.5	35.2	27.3	6.6	**88.7**
Aug	0.0	0.0	0.0	0.0	0.0	0.0	7.7	9.9	2.1	0.0	0.0	-3.2	-5.3	-2.8	-4.4	-4.2	-1.6	1.1	4.2	31.0	37.4	26.4	14.9	0.0	**113.2**
Sep	0.0	0.0	0.0	0.0	0.0	0.0	5.0	23.2	14.4	0.0	0.0	-4.8	-9.2	-7.7	-8.7	-6.1	0.0	4.7	25.2	50.1	31.9	7.0	0.0	0.0	**124.9**
Okt	0.0	0.0	0.0	0.0	0.0	0.0	2.1	15.4	17.8	6.0	-0.5	-10.7	-19.0	-17.1	-16.9	-9.2	4.1	17.8	34.9	34.7	12.8	0.0	0.0	0.0	**72.3**
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	9.0	0.3	-12.9	-18.1	-22.4	-18.9	-14.7	-3.1	26.8	27.7	27.5	13.3	0.7	0.0	0.0	0.0	**29.1**
Dez	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	8.9	11.6	-15.3	-18.4	-27.0	-23.5	-7.8	-0.8	22.8	20.8	21.0	13.1	0.0	0.0	0.8	0.0	**11.0**
Ø/Σ Std	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**60.4**	**168.8**	**130.4**	**50.1**	**-27.6**	**-118.9**	**-160.5**	**-144.9**	**-123.5**	**-53.6**	**65.3**	**148.9**	**227.7**	**318.5**	**250.5**	**154.3**	**93.2**	**11.4**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The sheet allocates the reference model gross balance by month and hour. Revenue occurs in discharge hours and costs in charging hours. The chart shows when value is created, not the net remuneration paid to the vehicle owner.

Relevance for abacus: abacus should not derive a fixed payout from this table, but should market billable technical flexibility as the basis of a value stack.

5.4 Selection of charging hours

Charging frequency — Days per month when the hour was one of four charging hours

Higher value = this time of day was selected more often for charging.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Tage
Jan	0	0	0	0	0	0	0	0	3	1	6	25	25	29	23	6	5	1	0	0	0	0	0	0	**124**
Feb	0	0	0	0	0	0	0	0	0	0	4	22	28	28	24	6	0	0	0	0	0	0	0	0	**112**
Mär	0	0	0	0	0	0	0	0	0	0	2	25	30	31	29	6	1	0	0	0	0	0	0	0	**124**
Apr	0	0	0	0	0	0	0	0	0	0	1	2	30	30	30	27	0	0	0	0	0	0	0	0	**120**
Mai	0	0	0	0	0	0	0	0	0	0	0	5	27	31	31	26	4	0	0	0	0	0	0	0	**124**
Jun	0	0	0	0	0	0	0	0	0	0	0	3	24	30	30	27	6	0	0	0	0	0	0	0	**120**
Jul	0	0	0	0	0	0	0	0	0	0	0	6	22	31	31	25	9	0	0	0	0	0	0	0	**124**
Aug	0	0	0	0	0	0	0	0	0	0	0	9	29	30	31	22	3	0	0	0	0	0	0	0	**124**
Sep	0	0	0	0	0	0	0	0	0	0	0	11	30	30	30	19	0	0	0	0	0	0	0	0	**120**
Okt	0	0	0	0	0	0	0	0	2	2	4	17	28	30	28	13	0	0	0	0	0	0	0	0	**124**
Nov	0	0	0	0	0	0	0	0	7	9	18	26	26	20	12	1	0	1	0	0	0	0	0	0	**120**
Dez	0	0	0	0	0	0	0	0	7	3	22	24	29	25	8	1	1	4	0	0	0	0	0	0	**124**
Ø/Σ Std	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**19**	**15**	**57**	**175**	**328**	**345**	**307**	**179**	**29**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The four selected charging hours are concentrated mainly between 11:00 and 15:00. The solar window is used almost every day in summer, while favourable hours are distributed more broadly in winter.

Relevance for abacus: The frequency distribution provides a clear rationale for automated AC charging control at workplaces and private parking spaces.

5.5 Selection of feed-in hours

Feed-in frequency — Days per month when the hour was one of four discharge hours

Higher value = this time of day was selected more often for feed-in.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Tage
Jan	0	0	0	0	0	0	0	9	18	13	7	3	0	0	0	0	12	21	23	15	2	0	1	0	**124**
Feb	0	0	0	0	0	0	0	10	21	9	1	0	0	0	0	0	3	19	23	21	5	0	0	0	**112**
Mär	0	0	0	0	0	0	8	16	6	1	1	0	0	0	0	0	0	13	27	30	18	1	1	0	**122**
Apr	0	0	0	0	0	0	8	18	8	0	0	0	0	0	0	0	0	0	6	28	28	18	8	0	**122**
Mai	0	0	0	0	0	0	13	13	1	0	0	0	0	0	0	0	0	0	1	22	29	28	16	1	**124**
Jun	0	0	0	0	0	0	9	7	2	0	0	0	0	0	0	0	0	0	1	15	26	29	26	5	**120**
Jul	0	0	0	0	0	0	4	11	4	1	0	0	0	0	0	0	0	0	0	13	28	30	26	7	**124**
Aug	0	0	0	0	0	0	8	10	2	0	0	0	0	0	0	0	0	1	4	26	30	25	16	0	**122**
Sep	0	0	0	0	0	0	5	18	12	0	0	0	0	0	0	0	0	5	19	30	25	7	0	0	**121**
Okt	0	0	0	0	0	0	2	11	13	6	2	1	0	0	0	0	4	18	27	26	14	0	1	0	**125**
Nov	0	0	0	0	0	0	0	11	12	7	4	3	0	0	0	0	21	22	24	12	1	0	0	0	**117**
Dez	0	0	0	0	0	0	0	4	15	14	5	3	0	0	0	0	23	26	22	14	0	0	1	0	**127**
Ø/Σ Std	**0**	**0**	**0**	**0**	**0**	**0**	**57**	**138**	**114**	**51**	**20**	**10**	**0**	**0**	**0**	**0**	**63**	**125**	**177**	**252**	**206**	**138**	**96**	**13**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Feed-in is concentrated in the morning peak and, in particular, the evening peak. The economically selected operating pattern therefore largely coincides with a reduction in high residual load.

Relevance for abacus: Available power must be released automatically while taking account of departure time, range reserve and the building connection.

5.6 Daily evaluation: actual variability instead of an average day

Bidirectional EV arbitrage 2025 — surplus charging, morning/evening sale (per vehicle)

Reference model: 40 kWh charged, 85% round-trip efficiency, four cheapest charging hours and four highest sale hours.

Datum	Tag	Lade-Std	Ø Kauf €/MWh	Min €/MWh	neg.Std	kWh rein	Kosten €	Verkauf-Std (ab/mo)	Ø Verkauf €/MWh	Max €/MWh	kWh raus	Erlös €	Spread €/MWh	Gewinn €/EV
2025-01-01	Mi	11-15	-0.3	-1.0	14	40	-0.0	0ab/4mo	123.8	127.2	34	4.2	124.1	4.2
2025-01-02	Do	8-9 ,11-14	117.8	113.9	0	40	4.7	4ab/0mo	145.9	152.9	34	5.0	28.1	0.3
2025-01-03	Fr	10-14	74.0	69.9	0	40	3.0	0ab/4mo	129.4	130.8	34	4.4	55.5	1.4
2025-01-04	Sa	8-9 ,11-14	129.1	128.3	0	40	5.2	4ab/0mo	143.8	151.2	34	4.9	14.6	-0.3
2025-01-05	So	14-18	58.7	49.9	0	40	2.4	4ab/0mo	58.1	66.3	34	2.0	-0.6	-0.4
2025-01-06	Mo	13-17	26.9	25.6	0	40	1.1	0ab/4mo	80.3	85.1	34	2.7	53.5	1.7
2025-01-07	Di	11-15	65.4	62.4	0	40	2.6	1ab/3mo	109.6	128.2	34	3.7	44.1	1.1
2025-01-08	Mi	10-14	95.5	90.0	0	40	3.8	2ab/2mo	156.4	164.9	34	5.3	61.0	1.5
2025-01-09	Do	13-17	124.1	121.2	0	40	5.0	2ab/2mo	135.5	139.5	34	4.6	11.4	-0.4
2025-01-10	Fr	11-15	109.0	105.0	0	40	4.4	4ab/0mo	140.7	144.1	34	4.8	31.6	0.4
2025-01-11	Sa	11-15	96.1	93.2	0	40	3.8	2ab/2mo	120.0	122.3	34	4.1	23.9	0.2
2025-01-12	So	11-15	103.2	99.6	0	40	4.1	1ab/3mo	181.4	223.1	34	6.2	78.2	2.0
2025-01-13	Mo	11-15	106.9	103.0	0	40	4.3	1ab/3mo	160.4	184.0	34	5.5	53.5	1.2
2025-01-14	Di	11-15	109.0	103.1	0	40	4.4	0ab/4mo	309.5	315.0	34	10.5	200.6	6.2
2025-01-15	Mi	8-9 ,11-12 ,14-1	299.9	285.8	0	40	12.0	4ab/0mo	326.6	378.0	34	11.1	26.7	-0.9
2025-01-16	Do	11-15	135.2	130.6	0	40	5.4	3ab/1mo	191.0	208.1	34	6.5	55.8	1.1
2025-01-17	Fr	11-15	131.0	124.0	0	40	5.2	4ab/0mo	175.8	179.9	34	6.0	44.7	0.7
2025-01-18	Sa	11-15	118.7	115.0	0	40	4.8	4ab/0mo	164.0	167.8	34	5.6	45.3	0.8
2025-01-19	So	11-15	114.5	107.5	0	40	4.6	0ab/4mo	309.1	432.0	34	10.5	194.6	5.9
2025-01-20	Mo	11-15	181.7	171.4	0	40	7.3	4ab/0mo	438.6	583.4	34	14.9	256.9	7.6
2025-01-21	Di	11-15	150.5	142.8	0	40	6.0	3ab/1mo	251.0	301.1	34	8.5	100.5	2.5
2025-01-22	Mi	10-14	171.8	165.0	0	40	6.9	4ab/0mo	188.9	209.0	34	6.4	17.1	-0.5
2025-01-23	Do	13-17	88.5	85.9	0	40	3.5	2ab/2mo	111.0	116.2	34	3.8	22.5	0.2
2025-01-24	Fr	13-17	74.7	74.5	0	40	3.0	3ab/1mo	90.3	92.0	34	3.1	15.6	0.1
2025-01-25	Sa	9-11 ,12-14	84.5	82.0	0	40	3.4	4ab/0mo	145.5	151.0	34	5.0	61.0	1.6
2025-01-26	So	11-15	95.5	90.0	0	40	3.8	4ab/0mo	117.0	132.8	34	4.0	21.5	0.2
2025-01-27	Mo	10-14	39.9	35.7	0	40	1.6	0ab/4mo	132.2	147.5	34	4.5	92.3	2.9
2025-01-28	Di	10-14	117.3	114.8	0	40	4.7	2ab/2mo	145.1	149.6	34	4.9	27.9	0.2
2025-01-29	Mi	11-15	86.9	85.0	0	40	3.5	1ab/3mo	153.6	160.3	34	5.2	66.8	1.8
2025-01-30	Do	11-15	120.5	113.3	0	40	4.8	3ab/1mo	170.5	180.4	34	5.8	50.0	1.0
2025-01-31	Fr	11-15	121.8	119.8	0	40	4.9	4ab/0mo	179.2	185.3	34	6.1	57.4	1.2

Context: The January extract shows that spreads and daily results vary considerably and that individual days are unprofitable. The complete sheet covers 365 days. A real control system would trade only when expected revenue exceeds efficiency losses, costs and safety margins.

Relevance for abacus: eControl requires a clear trading release and must be able to suspend operation on unattractive days.

5.7 Annual result of the reference model

Summary — Bidirectional EV V2G arbitrage Germany 2025

Reference model annual summary; values are gross before taxes, grid charges, aggregation and battery costs.

Tage mit lohnender Arbitrage (Gewinn > 0)		341	
Tage mit Überschuss-Stunde (Ladepreis ≤ 0 €/MWh)		112	
Negative Preisstunden im Jahr (gesamt)		573 von 8760 (6,5%)	
Ø Kaufpreis an Gewinntagen		44.0 €/MWh	
Ø Verkaufspreis an Gewinntagen		143.2 €/MWh	
Ø Spread (Verkauf − Kauf)		99.2 €/MWh	
Geladene Energie pro Zyklus		40 kWh (Ø ~10 kW über 4 h)	
Entladene Energie pro Zyklus (85% Round-Trip)		34 kWh	
Jahres-Gewinn pro BiDi-EV (Summe Gewinntage)		≈ 1060 €	
Hochrechnung: 1 Mio. BiDi-EVs laden je 40 kWh		40 GWh	
Hochrechnung Jahres-Erlöspotenzial 1 Mio. EVs		≈ 1.1 Mrd. €	

Monat	Gewinntage	Ø Spread €/MWh	Summe €/EV
Jan	26	71.8	48
Feb	27	62.8	40
Mär	31	115.0	114
Apr	30	124.9	125
Mai	31	135.4	144
Jun	30	138.0	142
Jul	31	91.2	89
Aug	31	112.4	115
Sep	30	127.2	124
Okt	31	78.1	71
Nov	24	57.6	34
Dez	19	35.5	13

Context: The 40 kWh is assumed per vehicle and modelled day: four selected hours with 10 kWh of energy intake in each hour. It is neither the battery capacity nor a recommended customer tariff, but a deliberately large reference transaction used to illustrate the time-dependent price and system effect. Daily use would amount to 14,600 kWh of charging energy per year, which is excessive for a normal private car. The model assumes 34 kWh of feed-in at 85% round-trip efficiency; 341 of 365 days are mathematically profitable and monthly aggregation produces around EUR 1,060 per EV and year.

Relevance for abacus: This amount is the gross upper bound of a large reference cycle. It must not be used as a standard daily operating pattern or as a promised customer return. The practical Bidi4free model therefore uses a more realistic daily profile: a 25.00-kWh usable energy swing in the battery, comprising a 5.00-kWh mobility credit and 20.00 kWh of battery-side V2G flexibility.

6. Optimised multi-cycle model: technical potential and limitations

6.1 State of charge: multiple cycles within one day

Average battery state of charge (SoC, %) 2025 — Month × hour (per EV)

End-of-hour state of charge; the optimisation model permits several cycles per day.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Ø Tag
Jan	12	17	27	60	82	85	89	77	38	22	21	25	52	79	89	94	91	52	13	3	3	7	2	12	**44**
Feb	9	18	32	66	89	89	89	63	15	3	7	12	45	85	95	98	96	72	28	0	0	0	0	4	**42**
Mär	12	22	44	63	77	76	54	17	3	0	0	5	39	84	98	100	100	97	50	4	2	3	3	7	**40**
Apr	2	15	40	64	76	76	58	21	2	0	0	0	6	52	95	100	100	100	100	55	5	0	0	0	**40**
Mai	0	10	34	57	63	63	37	3	0	0	2	2	11	53	89	99	100	100	100	86	39	4	0	0	**40**
Jun	0	10	28	52	60	60	37	6	0	0	0	0	5	39	84	98	100	100	100	93	60	18	0	0	**40**
Jul	0	2	13	51	68	68	45	11	0	0	0	0	8	40	83	97	100	100	100	97	62	13	0	0	**40**
Aug	0	7	25	54	65	65	42	8	0	0	0	0	3	45	87	98	100	100	96	70	23	2	0	0	**37**
Sep	7	14	42	72	85	85	79	35	0	0	0	0	14	60	99	100	100	100	87	32	2	2	2	5	**43**
Okt	8	17	34	60	76	86	86	61	19	7	5	9	21	66	97	99	97	90	46	3	0	7	3	8	**42**
Nov	9	16	35	69	84	90	98	79	45	33	36	55	84	96	96	92	73	28	5	2	2	2	3	9	**47**
Dez	6	16	33	66	84	92	99	96	68	47	46	54	76	85	82	76	54	21	5	3	3	3	3	5	**47**
Ø/Σ Std	**5**	**14**	**32**	**61**	**76**	**78**	**68**	**40**	**16**	**9**	**10**	**13**	**30**	**65**	**91**	**96**	**93**	**80**	**61**	**37**	**17**	**5**	**1**	**4**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The mean state of charge shows repeated charging and discharging phases. Particularly pronounced midday charging and evening discharging occur in summer; other months use additional night-time and morning windows.

Relevance for abacus: The pattern demonstrates controllability, but a standard customer tariff must limit it through SoC, cycle and comfort constraints.

6.2 Fleet energy drawn from the grid

Energy drawn from the grid (charging), GWh — 40 million EVs, month × hour

Monthly sum across all hours; linear extrapolation to 40 million EVs.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Monat
Jan	1,680.0	1,240.0	2,600.0	8,600.0	5,960.0	800.0	880.0	0.0	80.0	440.0	0.0	1,160.0	7,120.0	6,720.0	2,560.0	1,520.0	880.0	0.0	0.0	0.0	0.0	880.0	0.0	3,080.0	**46,200.0**
Feb	1,160.0	2,040.0	3,040.0	7,640.0	5,240.0	0.0	0.0	0.0	0.0	0.0	800.0	1,160.0	7,480.0	8,760.0	2,400.0	720.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	880.0	**41,320.0**
Mär	1,680.0	2,600.0	5,000.0	5,040.0	3,640.0	0.0	0.0	0.0	880.0	440.0	880.0	2,920.0	9,480.0	11,760.0	3,920.0	1,320.0	440.0	440.0	0.0	0.0	0.0	440.0	0.0	880.0	**51,760.0**
Apr	440.0	3,120.0	6,040.0	5,680.0	2,840.0	360.0	0.0	0.0	0.0	0.0	880.0	3,520.0	7,160.0	11,560.0	11,040.0	7,760.0	3,080.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**63,480.0**
Mai	0.0	2,400.0	5,960.0	5,760.0	1,520.0	0.0	0.0	0.0	0.0	440.0	3,520.0	7,480.0	10,600.0	12,760.0	11,120.0	10,120.0	6,600.0	880.0	0.0	0.0	0.0	0.0	0.0	0.0	**79,160.0**
Jun	0.0	2,400.0	4,280.0	5,680.0	2,120.0	0.0	0.0	0.0	0.0	2,200.0	3,960.0	7,480.0	9,600.0	11,720.0	12,600.0	10,400.0	7,040.0	1,760.0	880.0	0.0	0.0	0.0	0.0	0.0	**82,120.0**
Jul	0.0	440.0	2,680.0	9,560.0	4,280.0	0.0	0.0	0.0	0.0	0.0	0.0	440.0	2,760.0	8,520.0	10,880.0	4,280.0	800.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**44,640.0**
Aug	0.0	1,600.0	4,560.0	7,320.0	2,600.0	0.0	0.0	0.0	0.0	440.0	3,080.0	3,080.0	4,320.0	12,080.0	11,720.0	5,560.0	2,640.0	440.0	0.0	0.0	0.0	0.0	0.0	0.0	**59,440.0**
Sep	1,320.0	2,200.0	6,960.0	7,280.0	3,280.0	440.0	0.0	0.0	0.0	880.0	1,320.0	2,640.0	6,200.0	11,840.0	10,360.0	3,880.0	1,760.0	440.0	0.0	0.0	0.0	0.0	0.0	880.0	**61,680.0**
Okt	1,320.0	3,480.0	5,320.0	7,600.0	4,360.0	2,560.0	880.0	880.0	880.0	960.0	880.0	2,200.0	4,280.0	11,920.0	8,120.0	1,760.0	880.0	440.0	0.0	0.0	0.0	1,680.0	360.0	1,760.0	**62,520.0**
Nov	0.0	1,680.0	4,560.0	8,240.0	3,560.0	1,440.0	2,040.0	440.0	0.0	0.0	800.0	4,360.0	7,440.0	2,760.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	360.0	1,320.0	**39,000.0**
Dez	800.0	2,400.0	4,200.0	8,240.0	4,520.0	1,800.0	1,760.0	360.0	0.0	0.0	0.0	1,880.0	5,480.0	2,320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	360.0	**34,120.0**
Ø/Σ Std	**8,400.0**	**25,600.0**	**55,200.0**	**86,640.0**	**43,920.0**	**7,400.0**	**5,560.0**	**1,680.0**	**1,840.0**	**5,800.0**	**16,120.0**	**38,320.0**	**81,920.0**	**112,720.0**	**84,720.0**	**47,320.0**	**24,120.0**	**4,400.0**	**880.0**	**0.0**	**0.0**	**3,000.0**	**720.0**	**9,160.0**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Unlike the reference model, the optimisation model has no charging window from 08:00 to 17:00 and evaluates all 24 hours. It can therefore charge from 21:00 and during the night when the price is low and a sufficiently high subsequent selling price is expected. For 40 million vehicles, it shows annual grid intake of around 665 TWh. This is not a realistic forecast, but a linear extrapolation of a price-taking fleet with perfect foresight and high cycling intensity.

Relevance for abacus: The relevant point for abacus is the scalability of control; physical and market constraints must be modelled explicitly in real fleet scenarios.

6.3 Fleet energy fed back into the grid

Energy fed back into the grid (discharging), GWh — 40 million EVs, month × hour

Monthly sum across all hours after efficiency losses; linear extrapolation to 40 million EVs.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Monat
Jan	1,564.0	0.0	0.0	374.0	374.0	68.0	0.0	2,516.0	8,228.0	3,740.0	374.0	0.0	374.0	68.0	0.0	374.0	1,292.0	8,296.0	8,228.0	1,972.0	0.0	0.0	1,122.0	306.0	39,270.0
Feb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,964.0	9,282.0	2,142.0	0.0	0.0	0.0	0.0	0.0	0.0	374.0	4,692.0	8,364.0	5,304.0	0.0	0.0	0.0	0.0	35,122.0
Mär	374.0	0.0	0.0	0.0	0.0	374.0	4,624.0	7,820.0	3,570.0	1,054.0	748.0	1,496.0	816.0	476.0	374.0	748.0	374.0	986.0	9,860.0	9,690.0	612.0	0.0	0.0	0.0	43,996.0
Apr	0.0	0.0	0.0	0.0	0.0	306.0	3,570.0	7,650.0	3,876.0	306.0	748.0	2,992.0	4,862.0	476.0	544.0	5,610.0	2,618.0	0.0	0.0	9,214.0	10,268.0	918.0	0.0	0.0	53,958.0
Mai	0.0	0.0	0.0	0.0	0.0	0.0	5,610.0	7,072.0	612.0	374.0	2,618.0	6,358.0	7,106.0	1,972.0	1,870.0	6,562.0	5,304.0	748.0	0.0	2,890.0	9,928.0	7,344.0	918.0	0.0	67,286.0
Jun	0.0	0.0	0.0	0.0	0.0	0.0	4,692.0	6,324.0	1,292.0	1,870.0	3,366.0	6,358.0	7,242.0	3,026.0	1,428.0	5,950.0	5,610.0	1,496.0	748.0	1,530.0	6,562.0	8,738.0	3,570.0	0.0	69,802.0
Jul	0.0	0.0	0.0	0.0	0.0	0.0	4,930.0	7,276.0	2,210.0	0.0	0.0	374.0	748.0	442.0	136.0	748.0	0.0	0.0	0.0	680.0	7,344.0	10,234.0	2,822.0	0.0	37,944.0
Aug	0.0	0.0	0.0	0.0	0.0	0.0	4,760.0	7,242.0	1,666.0	374.0	2,618.0	2,618.0	3,060.0	1,394.0	1,020.0	2,448.0	1,870.0	374.0	918.0	5,372.0	9,996.0	4,488.0	306.0	0.0	50,524.0
Sep	748.0	374.0	374.0	68.0	0.0	374.0	1,292.0	8,942.0	7,140.0	748.0	1,122.0	2,244.0	2,380.0	646.0	1,020.0	2,992.0	1,496.0	374.0	2,754.0	11,084.0	6,256.0	0.0	0.0	0.0	52,428.0
Okt	1,122.0	1,122.0	1,122.0	748.0	374.0	136.0	748.0	5,984.0	9,622.0	3,400.0	1,054.0	1,122.0	1,122.0	510.0	510.0	1,054.0	1,122.0	1,734.0	9,384.0	9,044.0	612.0	0.0	1,122.0	374.0	53,142.0
Nov	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,284.0	6,868.0	2,516.0	0.0	0.0	306.0	0.0	0.0	680.0	3,876.0	9,248.0	4,692.0	680.0	0.0	0.0	0.0	0.0	33,150.0
Dez	374.0	0.0	0.0	0.0	0.0	0.0	0.0	918.0	5,848.0	4,318.0	306.0	0.0	0.0	0.0	612.0	1,360.0	4,624.0	6,936.0	3,332.0	374.0	0.0	0.0	0.0	0.0	29,002.0
Ø/Σ Std	4,182.0	1,496.0	1,496.0	1,190.0	748.0	1,258.0	30,226.0	70,992.0	60,214.0	20,842.0	12,954.0	23,562.0	28,016.0	9,010.0	7,514.0	28,526.0	28,560.0	34,884.0	48,280.0	57,834.0	51,578.0	31,722.0	9,860.0	680.0	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: After efficiency losses, the model shows around 566 TWh of feed-in. The fact that the same month-hour cell is sometimes occupied in the charging and feed-in tables does not mean that the same vehicle charges and discharges simultaneously. The cell aggregates many different days: on some days that hour is cheap and used for charging; on other days it is expensive and selected for feed-in. The difference between intake and feed-in is the energy loss from repeated cycling. This figure is also a theoretical system quantity, not a sales plan.

Relevance for abacus: Operation must optimise losses, battery costs and alternative system services against one another.

6.4 Theoretical fleet arbitrage

Arbitrage revenue (sale minus purchase), EUR million — 40 million EVs, month × hour

Gross arbitrage before taxes, grid charges, aggregation, battery ageing and market impact.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Monat
Jan	-14.3	-81.4	-217.5	-671.4	-461.6	-30.1	-38.7	339.0	1,317.9	543.7	0.0	-47.9	-772.9	-688.4	-167.4	-54.5	163.6	1,481.5	1,289.0	228.4	0.0	-6.1	48.2	-165.3	**1,993.9**
Feb	-95.6	-197.0	-318.4	-800.0	-547.3	0.0	0.0	821.5	1,575.7	329.8	-69.6	-82.5	-781.0	-955.4	-274.4	-86.1	38.7	851.7	1,487.9	843.5	0.0	0.0	0.0	-87.4	**1,654.1**
Mär	-99.7	-208.9	-451.2	-455.5	-360.9	9.4	574.8	1,122.9	471.4	50.8	0.4	-74.0	-255.7	-278.9	-156.8	-29.6	0.3	75.2	1,678.1	1,538.3	95.9	-22.0	0.0	-51.2	**3,172.8**
Apr	-29.5	-245.4	-493.6	-466.3	-230.1	-3.8	426.8	1,087.8	491.9	27.6	0.3	4.5	-41.9	25.7	27.5	-49.8	2.0	0.0	0.0	1,301.4	1,489.1	121.5	0.0	0.0	**3,445.8**
Mai	0.0	-174.9	-502.4	-473.8	-118.5	0.0	672.9	846.8	68.8	0.0	1.3	8.4	-51.4	182.8	213.3	5.7	2.7	0.0	0.0	353.6	1,487.1	985.9	107.0	0.0	**3,615.4**
Jun	0.0	-134.4	-286.5	-451.3	-161.0	0.0	469.9	655.3	134.1	0.1	1.5	7.6	27.9	139.2	116.5	29.0	6.6	2.0	0.1	184.0	1,101.3	1,301.5	392.4	0.0	**3,535.9**
Jul	0.0	-35.1	-236.7	-830.1	-365.5	0.0	543.2	834.2	263.3	0.0	0.0	0.0	-63.2	-263.8	-344.8	-174.6	-17.9	0.0	0.0	99.7	1,098.3	1,393.7	338.3	0.0	**2,239.1**
Aug	0.0	-91.0	-363.7	-625.5	-212.1	0.0	527.5	820.7	197.2	0.0	0.3	1.5	-12.6	-95.7	-107.2	-47.8	-41.7	0.0	110.2	862.8	1,475.6	538.4	29.8	0.0	**2,966.7**
Sep	-66.6	-113.4	-477.1	-437.3	-165.8	0.0	107.7	1,202.1	884.6	0.1	0.6	2.3	-84.5	-283.6	-256.0	2.9	0.7	0.0	511.8	2,188.7	944.2	0.0	0.0	-47.5	**3,913.8**
Okt	-8.5	-214.3	-262.9	-406.9	-161.7	-125.2	46.1	798.2	1,149.5	239.8	-23.8	-66.3	-206.0	-687.2	-457.0	38.5	49.4	164.5	1,390.0	1,394.3	41.4	-36.7	9.9	-56.9	**2,608.2**
Nov	0.0	-125.6	-331.4	-601.1	-234.0	-94.6	-127.5	458.7	949.7	328.0	-126.7	-292.5	-558.6	-298.9	0.0	70.6	613.7	1,453.9	594.0	63.2	0.0	0.0	-32.0	-113.3	**1,595.5**
Dez	-31.1	-169.4	-305.5	-539.4	-292.4	-113.6	-118.8	70.6	699.0	501.0	31.4	-184.4	-467.6	-171.8	86.3	157.6	595.1	837.2	371.6	61.0	0.0	0.0	0.0	-26.4	**990.5**
Ø/Σ Std	**-345.3**	**-1,790.6**	**-4,247.0**	**-6,758.6**	**-3,310.9**	**-358.0**	**3,083.9**	**9,057.9**	**8,203.2**	**2,020.9**	**-184.4**	**-723.3**	**-3,267.5**	**-3,376.0**	**-1,319.9**	**-138.3**	**1,413.1**	**4,866.0**	**7,432.7**	**9,118.9**	**7,732.9**	**4,276.2**	**893.6**	**-548.1**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: The table distributes a calculated annual value of around EUR 31.7 billion across months and hours. A fleet of this size would itself significantly flatten the underlying price spreads and could not trade permanently as a price taker.

Relevance for abacus: The figure indicates the scale of the flexibility potential, not revenue that abacus or an aggregator could capture.

6.5 Charging frequency in optimised operation

Charging — Number of days per month in which charging occurred in the hour

Higher values indicate charging in this hour on more days of the month.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Tage
Jan	4	3	7	21	15	2	2	0	1	1	0	3	18	16	6	4	2	0	0	0	0	2	0	7	**114**
Feb	3	5	8	19	13	0	0	0	0	0	2	3	19	21	6	2	0	0	0	0	0	0	0	2	**103**
Mär	4	7	13	12	9	0	0	0	2	1	2	7	23	28	10	3	1	1	0	0	0	1	0	2	**126**
Apr	1	8	15	14	7	1	0	0	0	0	2	8	17	27	26	18	7	0	0	0	0	0	0	0	**151**
Mai	0	6	15	14	4	0	0	0	0	1	8	17	25	29	26	23	15	2	0	0	0	0	0	0	**185**
Jun	0	6	11	14	5	0	0	0	0	5	9	17	22	27	29	24	16	4	2	0	0	0	0	0	**191**
Jul	0	1	7	23	11	0	0	0	0	0	0	1	7	21	26	11	2	0	0	0	0	0	0	0	**110**
Aug	0	4	12	17	7	0	0	0	0	1	7	7	10	28	29	13	6	1	0	0	0	0	0	0	**142**
Sep	3	5	18	18	8	1	0	0	0	2	3	6	15	28	25	9	4	1	0	0	0	0	0	2	**148**
Okt	3	9	13	18	11	6	2	2	2	3	3	5	11	28	21	4	2	1	0	0	0	4	1	4	**153**
Nov	0	4	12	20	9	4	5	1	0	0	2	11	18	7	0	0	0	0	0	0	0	0	1	3	**97**
Dez	2	6	11	20	11	5	4	1	0	0	0	5	13	6	0	0	0	0	0	0	0	0	0	1	**85**
Ø/Σ Std	**20**	**64**	**142**	**210**	**110**	**19**	**13**	**4**	**5**	**14**	**38**	**90**	**198**	**266**	**204**	**111**	**55**	**10**	**2**	**0**	**0**	**7**	**2**	**21**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: In addition to the solar window, the model uses other favourable hours and therefore performs several cycles per day. The battery is used much more intensively than in the single-cycle reference model.

Relevance for abacus: A marketable product requires configurable cycle budgets and clear remuneration for additional battery use.

6.6 Feed-in frequency in optimised operation

Discharging — Number of days per month in which feed-in occurred in the hour

Higher values indicate feed-in in this hour on more days of the month.

Monat \ Std	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Σ Tage
Jan	5	0	0	1	1	1	0	8	22	12	1	0	1	1	0	1	4	24	24	6	0	0	3	1	116
Feb	0	0	0	0	0	0	0	16	25	7	0	0	0	0	0	0	1	14	24	16	0	0	0	0	103
Mär	1	0	0	0	0	1	14	22	11	3	2	4	3	7	1	2	1	3	28	29	2	0	0	0	134
Apr	0	0	0	0	0	1	11	21	12	1	2	8	13	7	8	15	7	0	0	27	30	3	0	0	166
Mai	0	0	0	0	0	0	17	20	2	1	7	17	19	11	14	20	15	2	0	9	28	22	3	0	207
Jun	0	0	0	0	0	0	14	18	4	5	9	17	21	13	12	20	15	4	2	5	19	25	11	0	214
Jul	0	0	0	0	0	0	15	20	7	0	0	1	2	2	2	2	0	0	0	2	22	29	9	0	113
Aug	0	0	0	0	0	0	14	21	5	1	7	7	9	7	6	9	5	1	3	16	28	14	1	0	154
Sep	2	1	1	1	0	1	4	25	22	2	3	6	8	5	6	8	4	1	9	30	20	0	0	0	159
Okt	3	3	3	2	1	2	2	18	27	10	3	3	3	3	3	3	3	5	28	26	2	0	3	1	157
Nov	0	0	0	0	0	0	0	12	20	8	0	0	1	0	0	2	12	26	14	2	0	0	0	0	97
Dez	1	0	0	0	0	0	0	3	16	13	1	0	0	0	2	4	14	20	10	1	0	0	0	0	85
Ø/Σ Std	**12**	**4**	**4**	**4**	**2**	**6**	**91**	**204**	**173**	**63**	**35**	**63**	**80**	**56**	**54**	**86**	**81**	**100**	**142**	**169**	**151**	**93**	**30**	**2**	

Source and methodology: see the surrounding English text. Values use the original 2025 German data tables.

Context: Discharge events follow several price peaks and are distributed more broadly throughout the day. The economic optimiser uses every profitable window permitted by state of charge and power.

Relevance for abacus: In practice, user availability, grid signals, minimum reserves and prequalification rules must take priority over pure price maximisation.

6.7 Key figures under perfect foresight and correct interpretation

Key figures — Optimised V2G arbitrage 2025 (perfect foresight, LP by month)

Idealised optimisation with perfect day-ahead price foresight and price-taker assumptions.

Nutzbare Kapazität je EV	20 kWh
Lade-/Entladeleistung	11 kW
Round-Trip-Wirkungsgrad	85 %
Flottengröße	40 Mio EVs
Handel zum EPEX Day-Ahead-Preis der Stunde	SMARD DE-LU (4169)
Ergebnis Ø/Jahr	
Voll-Zyklen pro Tag (Ø)	**2,28**
Voll-Zyklen pro Jahr / EV	**≈ 832**
Gewinn pro EV / Jahr	**≈ 793 €**
Erlös pro Zyklus / EV	**≈ 0,95 €**
Gesamt-Arbitrage Flotte / Jahr	**≈ 31,7 Mrd €**
Aus dem Netz gezogen (Flotte)	**≈ 665 TWh**
Ins Netz zurückgespeist (Flotte)	**≈ 566 TWh**

Monat	Zyklen/Tag	Gewinn/EV €	Flotte Mio€	€/Zyklus
Jan	1.86	49.8	1994	0.86
Feb	1.84	41.4	1654	0.8
Mär	2.09	79.3	3173	1.23
Apr	2.65	86.1	3446	1.09
Mai	3.19	90.4	3615	0.91
Jun	3.42	88.4	3536	0.86
Jul	1.8	56	2239	1
Aug	2.4	74.2	2967	1
Sep	2.57	97.8	3914	1.27
Okt	2.52	65.2	2608	0.83
Nov	1.62	39.9	1595	0.82
Dez	1.38	24.8	990	0.58

Methode: lineares Optimierungsmodell je Monat mit perfekter Preis-Voraussicht. Es lädt/entlädt nur, wenn der Verkaufspreis den Kaufpreis inkl. 8

Model note: perfect foresight and price-taker assumptions make these figures theoretical upper bounds, not a customer revenue forecast.

Context: The optimisation model assumes perfect foresight of day-ahead prices and treats the vehicle or fleet as a price taker. Under these idealised conditions, it achieves 2.28 full cycles per day, around 832 cycles per year and approximately EUR 793 per EV and year. Perfect foresight, the high number of cycles and the price-taker assumption explicitly identify this value as a theoretical upper bound.

Relevance for abacus: The strategically important result is not the EUR 31.7 billion extrapolation, but the demonstration that even limited vehicle capacity has substantial, time-controllable system value.

7. The complete value stack per active electric vehicle

Day-ahead arbitrage is only one source of value. A viable V2G model combines a battery-conscious balancing-energy or flexibility product with limited arbitrage, site-specific load management and further portfolio effects. All values in this chapter therefore relate directly to an EV that is actually connected, released and marketable. German total market volumes are not presented as vehicle revenue.

Source of value	Realistic order of magnitude	Assessment
Balancing-energy anchor (aFRR or FCR)	EUR 400.00-900.00/EV/year	Capacity product after prequalification and pooling; aFRR and FCR are alternatives and are not fully additive.
Limited day-ahead and intraday arbitrage	EUR 400.00-600.00/EV/year	Only in available time windows and within a fixed cycle budget; at the average prices used, the 25/5/20 profile produces a pure gross arbitrage margin of EUR 526.94/EV/year.
Peak shaving / site-specific grid relief	EUR 50.00-150.00/EV/year	Particularly relevant for commercial sites, car parks and constrained grid connections; dependent on tariff and location.
Portfolio and balancing-group optimisation	EUR 0.00-150.00/EV/year	Less balancing energy, improved forecasting accuracy and lower procurement risks; monetisable only bilaterally or within the supplier's own portfolio.
Realistically combined gross value	EUR 750.00-1,550.00/EV/year	Not a simple sum of the rows; the range accounts for competing use of the same 11 kW and battery capacity.
Battery, availability and market-access costs	EUR -350.00 to -550.00/EV/year	Compensation for degradation, non-availability, aggregation, trading and risk provision.
Net system value before mobility credit	EUR 400.00-1,000.00/EV/year	Distributable value for electricity supplier/aggregator, abacus and, where applicable, other market roles.

Important: Power and energy products compete for the same vehicle battery. An EV cannot market its full 11 kW simultaneously in aFRR, FCR, arbitrage and peak shaving. eControl must prioritise the products and release only unused power and energy windows.

7.2 Bidi4free: controllable availability as the product

Our product is not kWh - it is controllable availability.
The participant is not remunerated for individual kilowatt-hours fed into the grid. The energy credit is the consideration for allowing eControl to control the battery temporarily within agreed limits and pool it for flexibility products.

The bonus-malus system translates connection time, which is valuable to the electricity supplier and aggregator, into a simple customer benefit. User reserve, minimum range, departure time and safety limits always take priority.

Rule	Energy credit	Purpose
Connected for at least 12 hours per day	+ 5.00 kWh per day	Basic remuneration for reliably predictable daily availability.
Each additional connected hour	+ 0.20 kWh	Bonus for additional flexibility and optimisation windows.
Each missing hour below 12 hours	- 0.10 kWh	Moderate malus where the agreed minimum availability is not met.
Settlement	Bonus usable within 12 months; malus settled within one month	The bonus can be used flexibly, while deviations are offset promptly.
Product logic	Availability rather than kWh sales	eControl prioritises system services and uses only available power and energy windows.

Example at 87% connection time: The vehicle is connected for an average of around 20.88 hours per day, or approximately 7,620 hours per year. This produces an energy credit of around 6.78 kWh per day or approximately 2.48 MWh per year. At a conservative 3 kW of controllable power, the connection time corresponds to an availability equivalent of around 22.86 MWh per year. This is not energy that is actually cycled, but controllable power made available over time.

The calculation does not work without the users: Bidi4free rewards the switch to an electric vehicle and regular connection - precisely the two conditions from which a large marketable vehicle fleet is created.

7.2.1 25-kWh daily profile with a 5-kWh mobility credit

The operational Bidi4free daily profile assumes a usable energy swing of 25.00 kWh in the vehicle battery. Of this, 5.00 kWh remains reserved for the user's daily mobility, while 20.00 kWh is available on the battery side for V2G flexibility. The profile is not a rigid daily mandatory operating pattern, but a maximum release within user and battery-protection limits.

Energy flow at 85.00% round-trip efficiency	kWh/day	Meaning
Grid intake in low-price hours	27.12	Required AC energy at the charging point.
Charging loss	2.12	Assuming a symmetrical charging efficiency of 92.20%.
Additional energy available in the battery	25.00	Usable daily energy swing in the vehicle battery.
User mobility credit	5.00	Daily driving electricity; around 12,166.67 km/year at 15.00 kWh/100 km.
Battery energy for V2G	20.00	Battery-side energy released for feed-in.
Discharging loss	1.56	Loss during feed-in via the bidirectional onboard charger.
Feed-in to the grid	18.44	AC energy marketable by the electricity supplier.
Net grid intake	8.68	5.00 kWh for mobility plus approximately 3.68 kWh of conversion losses.

The system boundary is crucial: 25.00 kWh here denotes the additional energy available in the battery, not the electricity drawn at the AC charging point. With a symmetrically assumed round-trip efficiency of 85.00%, around 27.12 kWh must be drawn at the charging point. Of the 20.00 kWh of battery-side V2G energy, around 18.44 kWh reaches the grid. The difference consists of charging and discharging losses; charging and feed-in do not occur simultaneously.

7.3 Efficiency: 85% is a reasonable baseline, but must be measured

A round-trip loss of 15.00% can be used as a conservative baseline assumption, but must not be understood as a fixed series-production value. Charger, power electronics, cables, cooling and standby consumption affect both directions. The paper therefore uses 80.00%, 85.00% and 90.00% as sensitivities; the actual value must be measured on the specific AC-BPT vehicle and at the power level actually used.

Round-trip efficiency	Grid intake	Grid feed-in	Total loss
80.00%	27.95 kWh/day	17.89 kWh/day	5.06 kWh/day
85.00% - baseline	27.12 kWh/day	18.44 kWh/day	3.68 kWh/day
90.00%	26.35 kWh/day	18.97 kWh/day	2.38 kWh/day

7.4 What remains for the electricity supplier and abacus after 5 kWh of daily driving electricity

The following calculation uses the averages from the 2025 reference model: purchase at EUR 44.00/MWh in low-price hours and sale at EUR 143.00/MWh in high-price hours. It represents the practical 25/5/20 profile: 25.00 kWh of additional battery content, a 5.00-kWh mobility credit and 20.00 kWh of battery-side V2G flexibility. Balancing energy, peak shaving and other sources of value are not yet included.

Daily energy-trading calculation	per day	per year
Purchase of 27.12 kWh at EUR 44.00/MWh	EUR 1.19	EUR 435.49
Sale of 18.44 kWh at EUR 143.00/MWh	EUR 2.64	EUR 962.43
Gross arbitrage margin after driving electricity and losses	EUR 1.44	EUR 526.94
User mobility credit	5.00 kWh	1,825.00 kWh
Battery-side V2G flexibility	20.00 kWh	7,300.00 kWh
Note	already included	no second deduction of driving electricity

The 5.00-kWh mobility credit is not deducted a second time in this calculation: it is already included in the total charging intake of 27.12 kWh. After selling 18.44 kWh, 5.00 kWh of driving energy remains in the vehicle; approximately 3.68 kWh of conversion losses are also incurred. The resulting pure gross arbitrage margin is therefore already stated after driving electricity and losses.

Allocation of the pure arbitrage margin per EV/year	Conservative	Normal	Strong
Gross arbitrage margin after driving electricity and losses	EUR 526.94	EUR 526.94	EUR 526.94
abacus share	20.00%	27.50%	35.00%
abacus revenue before own costs	EUR 105.39	EUR 144.91	EUR 184.43
Electricity supplier/aggregator before own costs	EUR 421.55	EUR 382.03	EUR 342.51
Additional value-stack revenue	not included	not included	not included

The allocation is a business-model assumption, not a market guarantee. The electricity supplier must still cover balancing-group, trading, prequalification, customer, metering and risk costs; abacus must cover platform operation, communications, billing, service and sales. The customer promise of 5 kWh per day may apply only to days on which the vehicle is actually connected and released, or must be secured through an annual credit with a bonus-malus rule.

Additional source of value	Benefit	Monetisation
Avoided starts of fossil peak and reserve power plants	Less start-up fuel, minimum-load operation, wear and failed starts; rapidly available EV power can cover short peaks.	Directly effective for the provider only where its procurement or generation portfolio actually avoids these costs.
Fuel savings	Lower gas, coal or oil consumption during high-price and congestion hours.	Partly already reflected in electricity prices, redispatch or portfolio results; do not double count.
Avoided CO2 allowances	Lower fossil generation reduces demand for EU ETS allowances.	Value depends on the displaced power plant, its emission factor and the allowance price; not a flat EV payment.
Balancing-group and forecast optimisation	Less balancing energy and smaller deviations between procurement and consumption.	Bilateral portfolio effect for the supplier or aggregator.
Redispatch and local grid congestion	Site-specific load intake or feed-in can reduce congestion-management measures.	Currently mostly case-specific and dependent on pilots or regulation.
Avoided grid expansion and connection capacity	Peaks are limited and existing infrastructure is used more effectively.	Usually a system or site value; transferable to EV fleets only through contracts, tariffs or connection costs.

These values are real, but they are not automatically additional revenue. Fuel, CO2, electricity price, redispatch and balancing-group effects can describe the same avoided power-plant operation from different perspectives. A robust revenue calculation may count the same effect only once.

7.6 Consequence for the abacus business model

abacus should not finance customer benefit solely from arbitrage. A robust model combines: (1) hardware and retrofit margin, (2) recurring eControl, metering and operating fees, (3) a contractual share of realised flexibility-market revenue and (4) participation in demonstrable site-specific or portfolio-specific savings. Bidi4free is the easily understood customer promise; internally, each day must be released on the basis of driving demand, efficiency, available power, market value and costs.

8. What the tables prove collectively

The tables form a consistent causal chain: solar reduces residual load at midday; grid load rises in the morning and evening; wholesale prices reflect this scarcity; a price-based algorithm therefore charges mainly at midday and feeds back mainly during morning and evening peaks. The economic incentive and the power-system effect are largely aligned.

Core demonstration
V2G is not merely buying cheaply and selling at a higher price. It is a technical method of shifting renewable electricity from hours of low residual load to hours of high residual load while simultaneously accessing market revenue.

The models answer different questions. The 40-kWh single-cycle model shows the temporal logic and a deliberately high upper bound. The optimised multi-cycle model shows theoretical flexibility density with perfect price knowledge and high cycling intensity. By contrast, the Bidi4free cycle represents a more practical customer day with a 25.00-kWh usable battery swing, 5.00 kWh of driving electricity and 20.00 kWh of battery-side feed-in flexibility. External communications must always state clearly which model and which system boundary are being used.

EU or market requirement	Contribution by abacus
Private, interoperable charging points	AC charging infrastructure and eControl for multi-family buildings, underground garages, car parks and company parking spaces.
Cost-efficient bidirectionality	11-kW AC-BPT uses the power electronics in the vehicle and avoids an expensive DC unit at every parking space.
Retrofitting the installed base	Adapter and control layer for continued use of existing AC charging environments.
Metering and verification	MID-compliant metering, continuous recording, logging and allocation to each user or vehicle.
Building and grid limits	Real-time load management, phase monitoring, prioritisation, reserve and safe fallback.
Interoperability	ISO 15118-20, PLC, Modbus/EMS and OCPP-/OCPI-related backend processes.
Aggregator connectivity	Transmission of controllable, metered power to energy trading and flexibility markets.
Open ecosystem	A manufacturer-independent implementation layer instead of closed vehicle-charging-point combinations.

Positioning
Not: "abacus builds another wallbox." Instead: "abacus opens private and existing AC charging infrastructure as an interoperable European flexibility store."

10. Business and system value for abacus

Source of value	Monetisation and the role of abacus
Day-ahead and intraday arbitrage	Direct market revenue from time-shifting energy; abacus supplies control, metering and billing.
FCR, aFRR and mFRR	Capacity and energy remuneration after prequalification; marketed through an aggregator and only for reliably available pooled power.
Peak shaving and atypical grid use	Customer-side savings from limiting power and connection peaks; dependent on site and tariff.
PV self-consumption and dynamic tariffs	Avoiding expensive grid intake and using low-price or renewable hours.
Balancing-group and portfolio optimisation	Reduction in balancing energy and forecasting costs for the electricity supplier or aggregator; remunerated bilaterally.
Local flexibility and redispatch	Site-specific relief of grid congestion; currently mostly dependent on projects, pilots or regulation.
Avoided curtailment, grid losses and grid expansion	High system value, but currently usually no payment stream directly attributable to the individual EV.
Capacity, reactive power and resilience	Future or bilateral revenue areas; technical preparation is useful, but general revenue cannot currently be promised.
Metering, aggregation and billing	A prerequisite for any remuneration: verifiable power, energy, availability, user release and site allocation.
Platform and service	Recurring revenue from eControl, operation, monitoring, billing and interfaces to aggregators and energy partners.
Avoided fossil power-plant starts, fuel and CO2	Portfolio and system value from lower peak and reserve generation; monetisable only where the electricity supplier actually bears these costs or receives contractual remuneration. No double counting with electricity price, redispatch or balancing-group value.

Long-term value arises from hardware, eControl, metering and aggregation. At the average prices used, the 25/5/20 energy-trading profile shown generates a calculated gross arbitrage margin of EUR 526.94 per active EV and year - already after 5.00 kWh of daily driving electricity and the assumed conversion losses. With an abacus share of 20.00-35.00%, this would correspond to EUR 105.39-184.43 per EV and year for abacus; before its own costs, the electricity supplier or aggregator would retain EUR 342.51-421.55. Additional sources of revenue can increase the value, but may be added only where power and energy are not already committed elsewhere at the same time.

11. Strategic priorities and limitations

1. Perform an end-to-end test with a real ISO 15118-20-capable AC-bidirectional vehicle.
2. Demonstrate 11-kW charging and feed-in within defined building, phase and connection limits.
3. Document MID metering, logging and the billing path in an auditable manner.
4. Integrate user reserve, departure time, minimum range and cycle budget as binding control parameters.
5. Test price, generation and local grid signals separately and then in combination.
6. Demonstrate the retrofit of an existing AC charging point.
7. Validate interoperability with multiple vehicle or backend configurations.
8. Define the revenue and role model between vehicle owner, site, aggregator, electricity supplier and abacus.

Implement the Bidi4free daily balance with a 25.00-kWh usable battery swing, 5.00 kWh of driving electricity and 20.00 kWh of battery-side V2G flexibility as a separate product profile.

Measure round-trip efficiency and auxiliary consumption on the real vehicle across several power levels; use 80.00%, 85.00% and 90.00% as sensitivities.

Quantify provider benefits from avoided power-plant starts, fuel, CO_2 and balancing-group deviations only on a portfolio-specific basis and without double counting.

The 2025 tables and the value-source matrix provide a persuasive strategic rationale, but not a complete investment or revenue calculation. Before making any external commitment, all 8,760 hours, local grid constraints, connection probabilities, prequalification requirements, market saturation, end-customer charges, aggregation costs and battery limits must be taken into account.

Priority 2026/2027
Do not demonstrate the maximum theoretical arbitrage; demonstrate a robust end-to-end system: compatible vehicle, AC-BPT, safe parking-space control, MID metering, user reserve, interoperability, billing path and scalable retrofit.

12. Overall summary

For the first time, the EU Electrification Action Plan establishes a credible political and regulatory timetable for broad V2G deployment. Interoperable V2G requirements are to be defined by the end of 2027 for new electric vehicles placed on the EU internal market from 2030. In parallel, the technical specifications for public and private charging points are to ensure bidirectional capability and interoperability. Sandboxes, living labs, demonstration projects and European financing instruments are intended to accelerate the transition from pilots to industrial application.

For abacus, this is a direct market-opening opportunity. The central gap is not only in the vehicle, but at the regularly used private parking space: only there does the battery become measurable, controllable, integrable into building and grid limits and marketable by an aggregator. With 11-kW AC-BPT, a retrofit adapter, MID metering, eControl, the simulator and aggregator connectivity, abacus addresses precisely this implementation layer for multi-family buildings, underground garages, neighbourhoods and company parking spaces.

The 2025 electricity data demonstrates the power-system need. Solar reduces residual load primarily around midday, while grid load and prices often rise in the morning and evening. Price-optimised charging and feed-in windows are therefore generally system-friendly. The model calculations demonstrate technical and economic potential, but must not be understood as guaranteed revenue. The single-cycle model is an illustrative upper bound; the multi-cycle model operates with perfect foresight and shows theoretical flexibility density rather than normal real-world operation of a private vehicle. There were also 573 negative-price hours, 74.17% of which occurred between 11:00 and 15:00. In the more practical 25/5/20 daily backtest, EUR 265.25, or 52.43% of modelled annual arbitrage, arose on days with at least one strictly negative-price hour.

The viable business model is created by a value stack: hardware and retrofit margin, recurring eControl, metering and operating fees, participation in realised flexibility and system-service revenue, and site-specific savings. Day-ahead arbitrage is only one component. Balancing energy, peak shaving, balancing-group optimisation, local flexibility, avoided curtailment and partial avoidance of fossil peak generation can create additional value, but must be assessed on a portfolio-specific basis and without double counting.

The calculation does not work without the users. The required storage fleet emerges only when people switch to electric vehicles and connect them regularly. Bidi4free translates abstract system value into a customer benefit that is immediately understandable: an energy credit or substantially reduced-cost driving electricity in return for controllable availability. The bonus-malus system rewards long connection times while protecting range and user comfort, thereby creating the predictable fleet availability from which the enterprise value of abacus arises.

The next strategic stage is no longer a small isolated trial, but a European end-to-end and scaling project: a real AC-BPT vehicle test, an interoperable PKI and authorisation chain, ElaadNL conformity testing, CE and grid-connection validation, a multi-family-building or fleet pilot, a pilot series, cybersecurity and a robust role and revenue model. This will allow abacus to demonstrate that the V2G capability sought by the EU is not merely present in the vehicle, but can be used practically and economically in existing private charging infrastructure.

Overall positioning
abacus does not merely build another wallbox. abacus opens private and existing AC charging infrastructure as an interoperable, controllable European flexibility store - linking the regulatory V2G ramp-up to tangible benefits for users, electricity suppliers, buildings and the power system.