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How much do household habits shape the value of fully automatic smart EV charging at home?

A simulation study of Flemish households

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FULL REPORT

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GHENT UNIVERSITY

economie
FPS Economy, S.M.E.s, Self-employed and Energy

Why could behaviour still matter

if software already optimises at-home charging in a fully automatic way?

1 The car needs to be plugged in

2 The user needs to let the software decide how full to charge the battery

Hypothesis

Most of the potential value of smart charging remains unrealised without the right behaviours.

We simplify it
to “bad behaviour” vs “good behaviour”

Bad behaviour

PLUGGING IN

Only when the battery drops below 20%

± 25% of arrivals home

CHARGE TARGET

100% full by the next morning

Good behaviour

PLUGGING IN

80% of arrivals home — so most evenings

effective rate ≈ 83%

CHARGE TARGET

None — the software decides how full the battery must be

How do we research this?

we simulate each combination of charging and behaviour separately

	Bad behaviour	Good behaviour
Dumb charging (uncontrolled)	**dumb + bad** Plug in only when the battery is nearly empty, then charge at full power until it is full.	**dumb + good** Plug in most evenings — but charging still starts at full power. *Without software, there is nothing to give room to.*
Smart charging (managed)	**smart + bad** Software optimises, but only in the rare windows the car is plugged in, and must still reach 100%.	**smart + good** Software optimises, the car is plugged in most evenings, and it decides how full to charge.

Technology step ↓

Behaviour step →

Where do the financial savings come from?

Three value streams, exploited jointly in one optimisation

STREAM 1

Raise solar self-consumption

Steer charging into hours with surplus PV, so those kWh never leave as cheap injection.

STREAM 2

Lower the capacity tariff

Limit the increase in total household monthly peaks caused by EV charging.

STREAM 3

Buy remaining grid kWh cheaply

On a dynamic contract, concentrate grid draws into low-price quarter-hours.

These are **not separate modes**. The algorithm simply finds the charge plan that yields the lowest electricity bill, using whichever mix of the three works best.

Which households should we simulate?

Households differ on many fronts that change the value of smart charging and of behaviour:

- how big the EV battery is
- how fast their home charging station can charge
- how many kilometres they drive
- what the rest of the house's electricity use looks like
- whether they have solar panels — and how many
- which type of electricity contract they have
- …and more

OUR APPROACH

Simulate **thousands of possible households**, varying on all of these dimensions — and measure how much behaviour matters across different households.

A simplifying assumption:
all EV charging happens at home

What we are not modelling

People who do large parts of their EV charging (or even *all* of it) elsewhere — at public fast chargers, or at their employer.

How to read the numbers

If only half your charging is at home, cut the euro savings in this research roughly in half.

As home charging shrinks, so does everything smart charging can save.

Annual EV at-home charging bills (€/year)

Across >2,500 simulated households

	Bad behaviour	Good behaviour
Dumb charging (uncontrolled)	**dumb + bad** **€727** the baseline every other box is measured against	**dumb + good** **€763** +€36 (plugging in more often causes higher peaks)
Smart charging (managed)	**smart + bad** **€603** **–€125** below **baseline** (–17.1%)	**smart + good** **€368** **–€234** below **smart+bad** –€359 below **baseline** (–49.4%)

Technology step ↓

Behaviour step →

Which good behaviour makes the biggest difference?

Annual EV bill under smart charging.

Bad behaviour (reference)
Plug-in when <20%
and 100% morning target



Starting point after the technology step

Only plug-in discipline
80% plug-in,
but still a 100% morning target



save €93 (–15%)
vs bad behaviour

Only leaving battery target to algorithm
Plug-in when <20%,
but algorithm chooses SoC



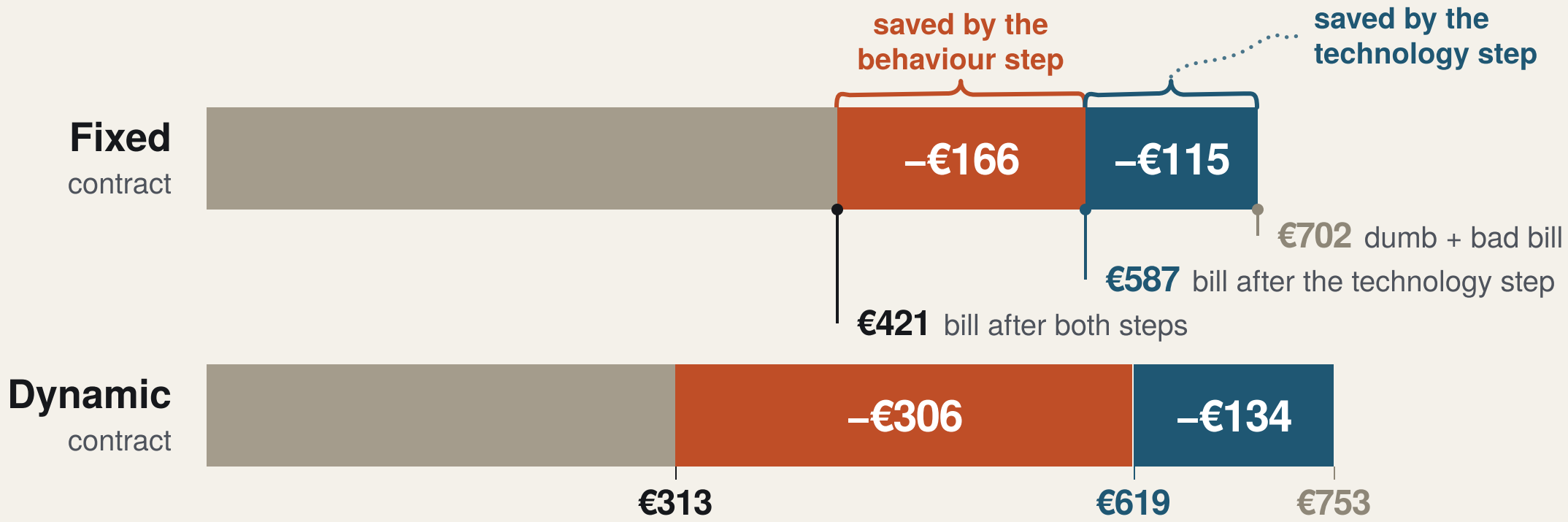
save €131 (–22%)
vs bad behaviour

Both together
80% plug-in
AND algorithm chooses SoC



save €234 (–39%)
vs bad behaviour

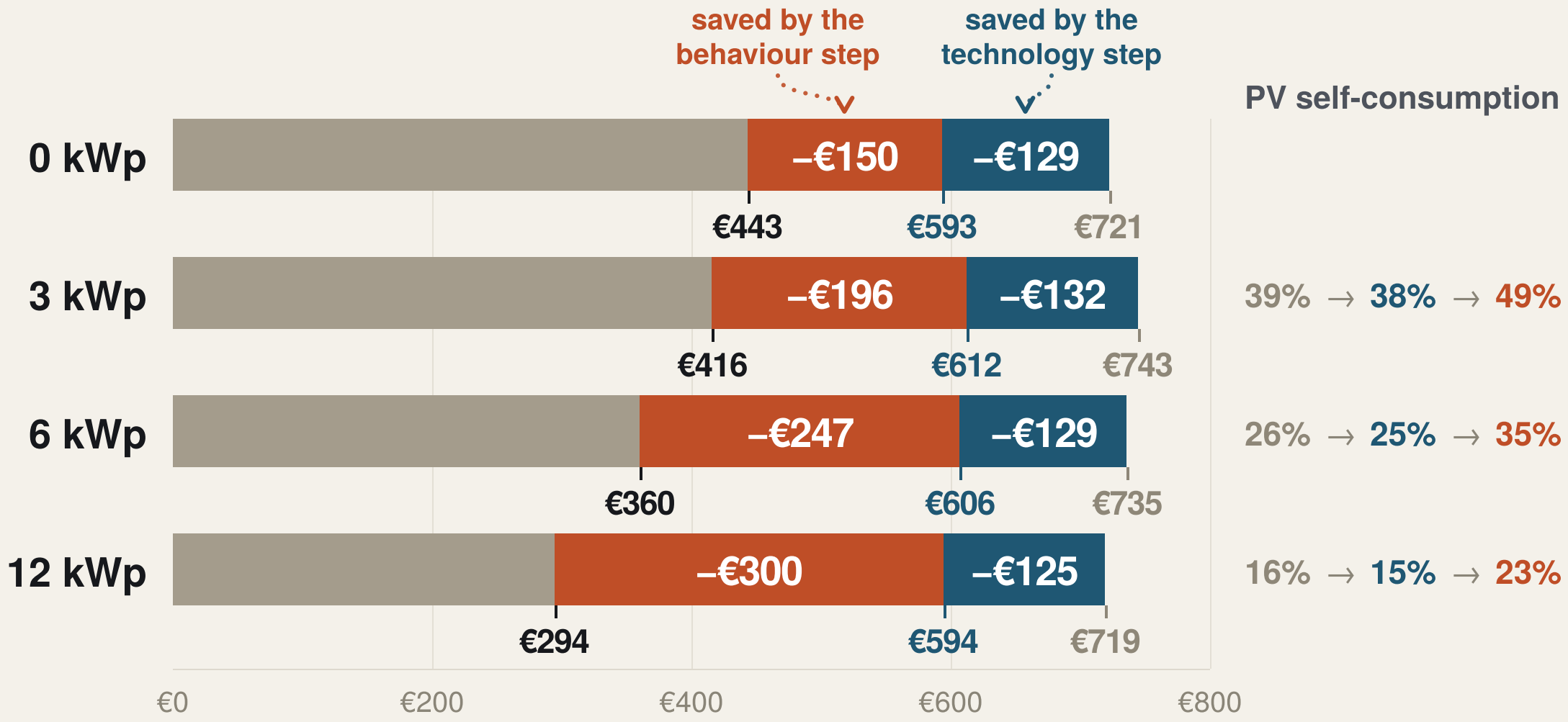
Good behaviour matters more if the household has a dynamic contract



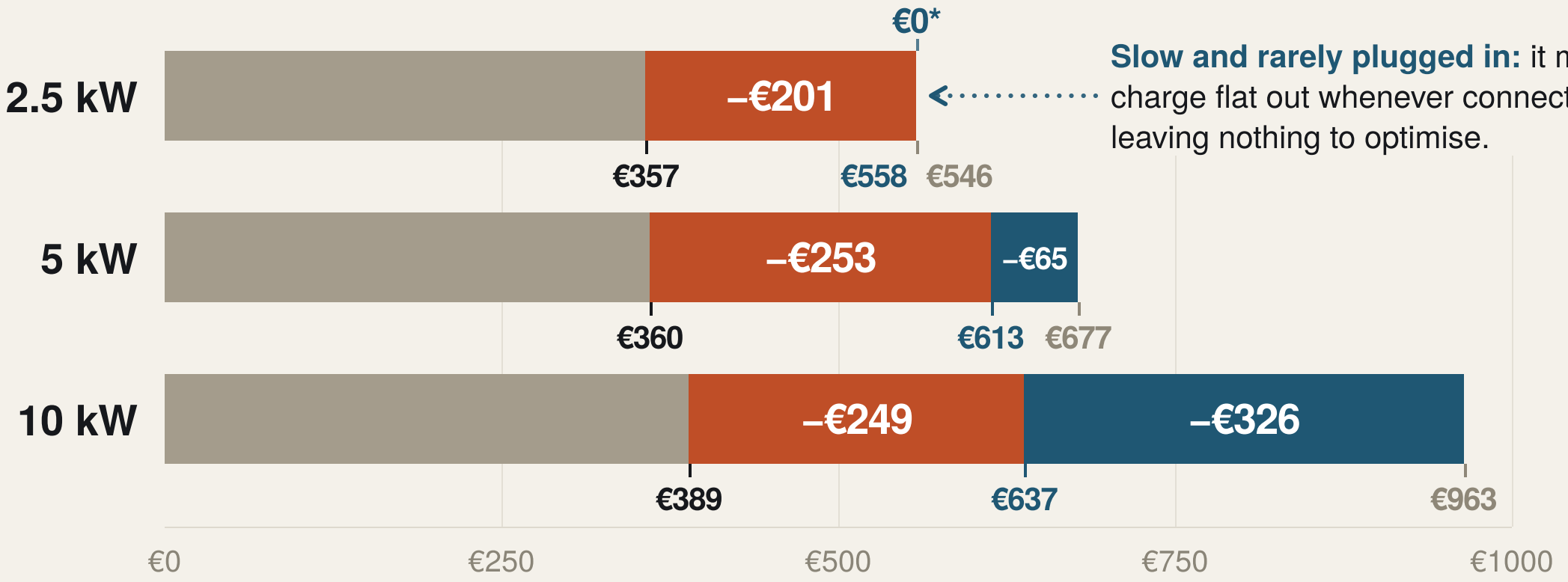
- The **technology step** saves almost the same on both contracts.
- The **behaviour step** roughly **doubles** on a dynamic contract.

More solar means bigger savings from good behaviour

While savings from technology stay about the same



Charger power decides how much you save

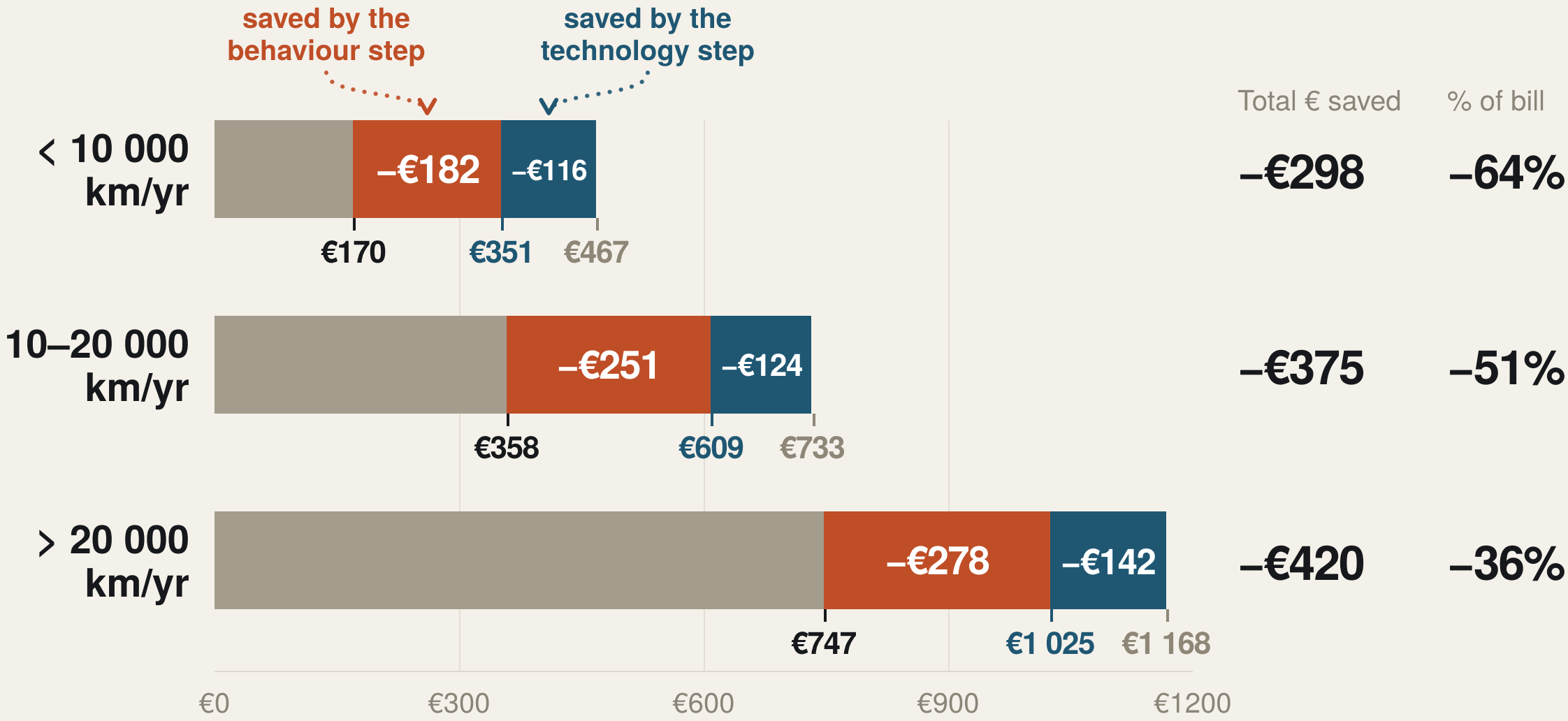


Slow and rarely plugged in: it must charge flat out whenever connected, leaving nothing to optimise.

* Even slight bill increases are possible due to simulation artifacts; shown as €0 in this case.

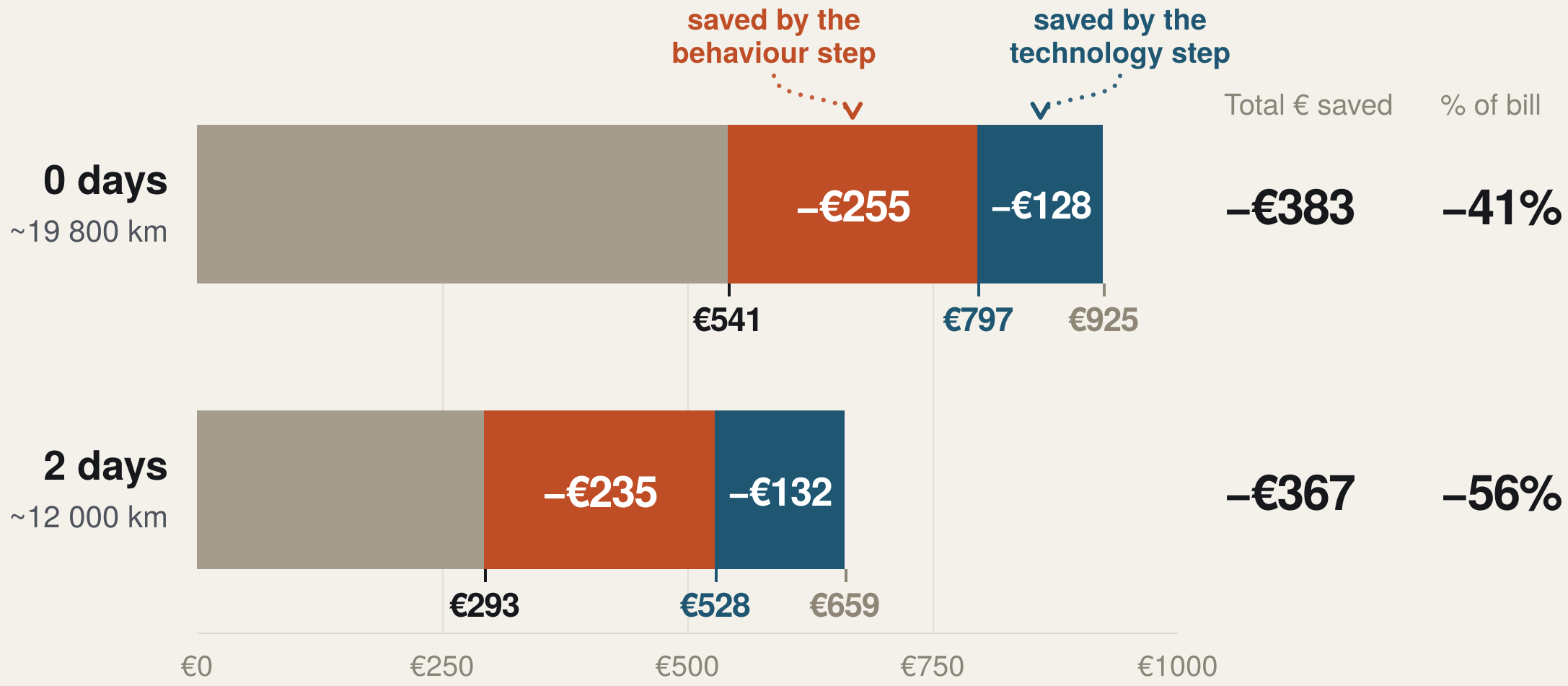
The grid gains too. Dumb charging with bad habits raises the household's average monthly peak from **4.5 kW** to **8.8 kW**; smart charging with good habits adds only **0.15 kW**.

Biggest % saving ≠ biggest € saving



Working from home helps

— mostly because you drive less



Limitations

1. Savings are averages across the swept parameters,
not across the real-world population of home-charging EV owners

   That would need empirical data on how common each setup is — 3 kWp PV, 10 kW charger, 70 kWh battery, …

2. The optimiser has perfect foresight;
real systems have to forecast

3. Simplified driving: commute trips only on weekdays,
and no driving at all on days worked from home

4. Solar output taken from the national aggregate profile —
smoother and more generous than a single rooftop

5. One historical year (2024) for household demand, solar and prices

What to remember:
Automation is only half the prize

Dumb charging
Bad behaviour

€727

baseline

Technology step

Smart charging
Bad behaviour

€603

–€125 vs baseline

Behaviour step

Smart charging
+ good behaviour

€368

–€234 vs smart charging

–€359 vs baseline

- Plug in whenever you get home
- Let the algorithm choose how full to charge

FULL REPORT

Scan to read the full simulation study online

Implications

Households

Adopting smart charging, but rarely plugging in and forcing a full battery every morning, leaves most of the savings on the table.

- Make plugging in the norm, and let the software decide how full to charge.

Industry

Hardware and algorithms are necessary but not sufficient: products have to build the habit of plugging in, and earn the trust to choose the target.

- Make “charge what I need” the default instead of a fixed morning target, and earn the trust that makes users accept it — for example with a guaranteed minimum range and a visible charging plan.
- Where users can set a minimum charge level, default it low and show what a higher level costs.

Policy

Only pushing the adoption of smart charging technology itself leaves half of the potential benefits on the table — not only for the households themselves, but also for society more broadly.

- Support for smart charging should also target habits around plugging in and battery target-setting.
- Policies are best judged by the flexibility they actually make available, not purely by how much they increase the adoption of smart charging technology itself.