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NATIONAL LABORATORY OF THE ROCKIES

EV Stock and Load Forecasting for HECO

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HECO IGP Stakeholder Working Group

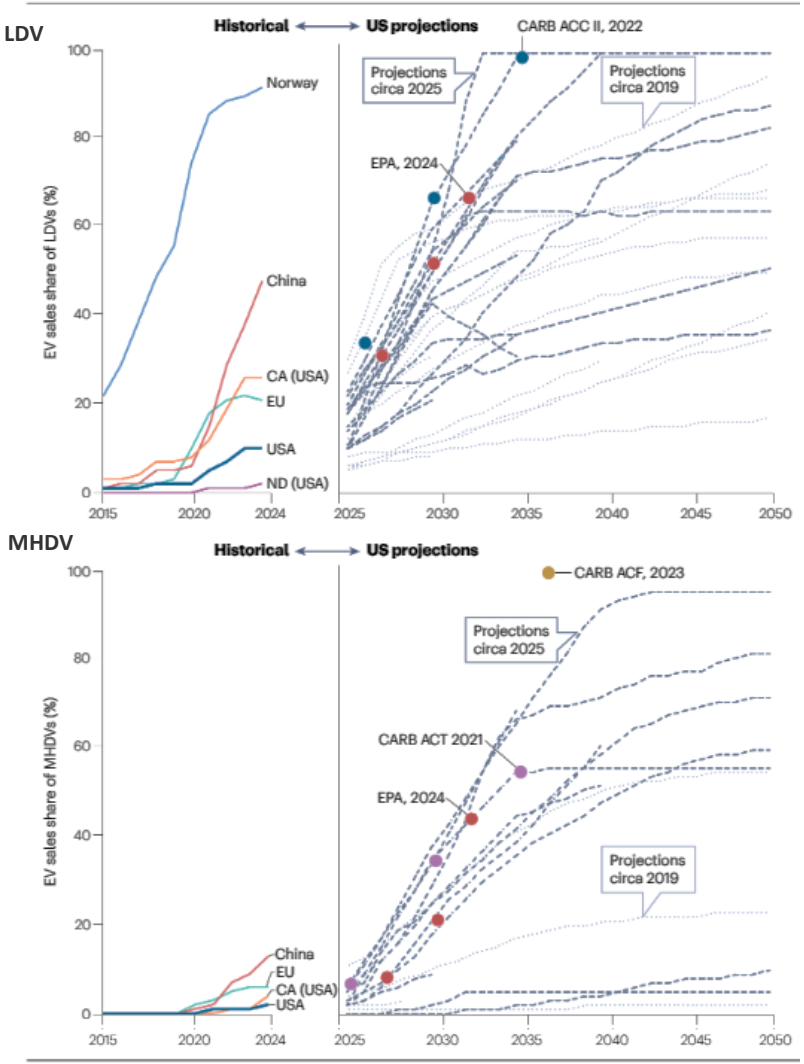
2025-10-23

Photo from Getty-181828180

Outline

- Overview of TEMPO
- Coverage and market segmentation
- Drivers of EV adoption
- Methodology and process
- Hawaii-specific factors
- Scenario design with key assumptions

As of 2025, projections and ambitions for EV adoption had increased substantially, relative to the previous 5 years

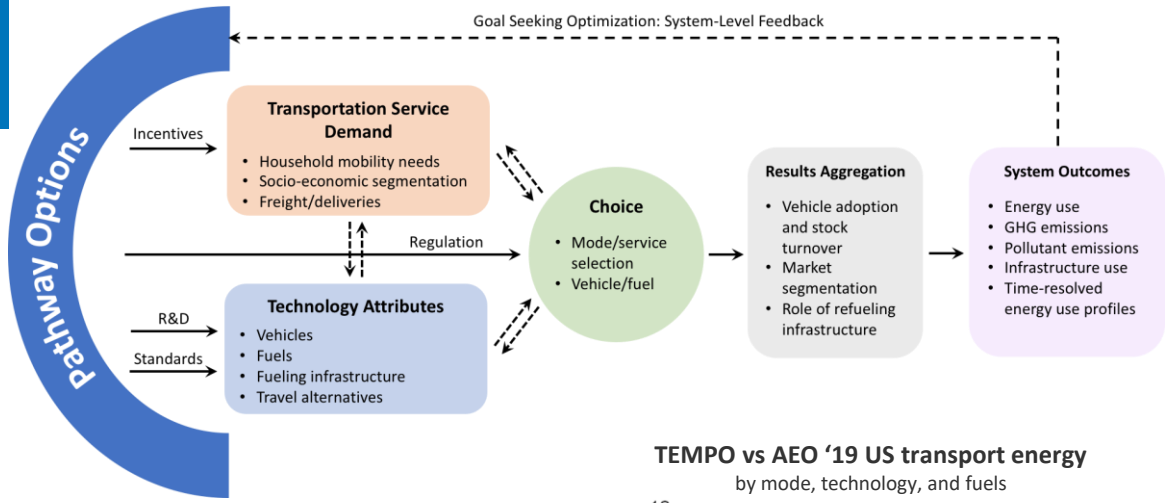


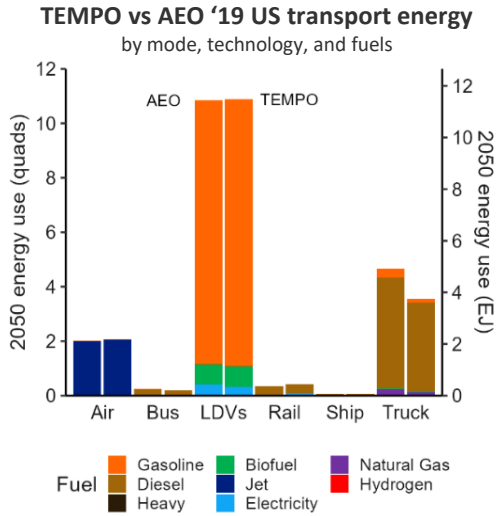
From

Muratori et al. (2025) Nature Reviews Clean Technology

What is TEMPO?

The Transportation Energy & Mobility Pathway Options (TEMPO™) model is a **comprehensive transportation demand macro model** for exploring long-term scenarios of energy use across all transportation.





Muratori et al., 2021

- TEMPO combines methodologies used in energy-economic models such as EIA's AEO and travel demand forecasting models used by DOTs and MPOs.
- TEMPO is national in scope and offers county-level resolution.
- TEMPO produces a range of scenarios by varying inputs on technology cost and performance, consumer behavior, system attributes.

Drivers of EV Adoption

In TEMPO, household technology choice depends on the monetized utility of available options. The components of this utility are:

- Upfront capital cost of the vehicle
- Operating costs (fuel/charging and maintenance)
- Trip feasibility
- Charging time/convenience
- Vehicle make-model availability
- Calibrated preference adjustments based on historical adoption

Additional factors affecting above are:

- Subsidies/incentives, affecting upfront cost
- Travel activity and patterns, affecting operating costs and trip feasibility
- Household demographics, including housing, affecting charging cost, time, and convenience, and also vehicle ownership and purchasing behavior

Coverage and Segmentation for HECO

Geographic coverage

HECO territory by county

- Honolulu County
- Hawaii County
- Maui County

Each county has unique characteristics considered in TEMPO

Vehicle type coverage and segmentation

All on-road transportation (excluding military)

- Household passenger LDVs
- Freight MHDVs
- Vocational/service MHDVs
- Fleet LDVs (government, rental)
- Buses

Each subsector contributes a different proportion to total EV load, have their own adoption and growth rates, and load shapes

Factor unique to Hawaii or counties	How it affects TEMPO	Data sources, benchmarking
Passenger travel	EV trip and charging feasibility Charging cost and convenience EV range selection	NHTS Oahu, BTS, DBEDT
Freight activity		VIUS, DBEDT
Charging availability		AFDC, RECS, Experian
Energy prices	TCO of EV vs. ICEV	HECO, NLR
Household demographics, including housing	Purchasing behavior Charging availability	ACS
Vehicle stocks and characteristics	Vehicle type mix Sales, survival, and turnover rates	ACS, NHTS, VIUS, Experian, DBEDT
Government EV policies	EV and EVSE subsidies and availability Scenario-specific projections	IRS, EPA/NHTSA, DOE, HSEO
Weather/temperature	EV performance and adoption	NOAA

Customizing TEMPO for Hawaii

Establish HI data inventory

Disaggregate and validate data (comparing between HI counties/islands, and HI vs. US)

Decide on data and forecast resolution

Define scenarios

Run TEMPO to produce Annual Stock and Energy Scenarios

Run TEMPO and EVI-Pro to produce EV Charging Profiles

Data types
- household/vehicle stocks
- travel demand & options
- energy prices, charging costs
- policies & regulations
- turnover/survival
- temperature conditions
- charging infrastructure access

Other: assumed U.S./exogenous
- vehicle technology and prices
- no hydrogen/biofuels
- decision-making /preferences

Scenarios distinguished by primarily EV adoption drivers

Charging assumed to be unmanaged (charge on arrival when available)

Process

Establish HI data inventory

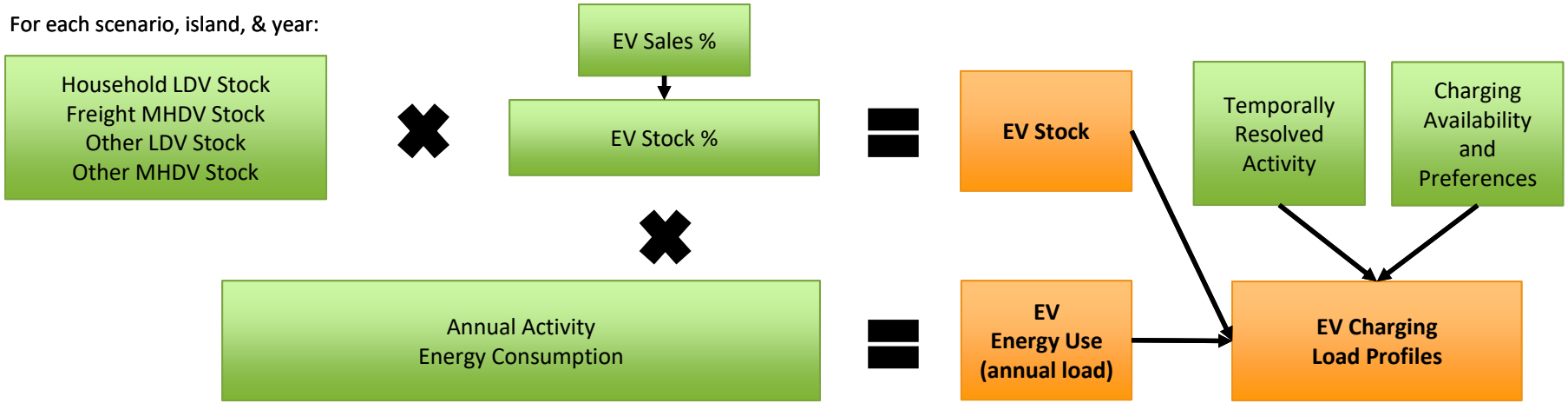
Disaggregate and validate data (comparing between HI counties/islands, and HI vs. US)

Decide on data and forecast resolution

Define scenarios

Run TEMPO to produce Annual Stock and Energy Scenarios

Run TEMPO BEV module to produce EV Charging Profiles



<table>
<tr><th rowspan="2">Scenario Name and Definition</th><th>Technology</th><th colspan="3">Policies</th><th colspan="2">Additional Factors</th></tr>
<tr><th>Technology progress
(EV cost and efficiency)</th><th>Subsidies for EVs</th><th>National CAFE/GHG regulations on automakers</th><th>State regulations/goals</th><th>Residential parking & public charging access</th><th>Make-model availability</th></tr>
<tr><td>Base
(Low tech progress, repealed policies)</td><td>ATB-Conservative</td><td>None</td><td>None</td><td>None</td><td>Low</td><td rowspan="2">Endogenous (roughly calibrated to historical and latest trend)</td></tr>
<tr><td>Base Alt
(Mid technology progress, policies on the books as of 2024)</td><td>ATB-Mid</td><td>IRA tax credits, expiring in 2032</td><td colspan="2">Consistent with EPA (2024) national regulations up to MY 2032
- HI LD EV adoption above requirements in national regs, despite Hawaii not eligible to join CA ZEV under Section 177 of Clean Air Act
- HI MHD EV adoption in line with national regs</td><td>Mid</td></tr>
<tr><td>High
(Adoption meeting CA policies as of 2024, and HI stated goals)</td><td>ATB-Advanced</td><td colspan="2">Assumed consistent with high levels of EV adoption, surpassing EPA (2024) national regulations up to MY 2032</td><td>Consistent with California/US-leading state policies and Hawaii goals
- LDV: CA Advanced Clean Cars (ACC2)
- MHDV: Hawaii MHD MOU (30% by 2030, 100% by 2050), CA Advanced Clean Trucks (ACT)</td><td>High</td><td rowspan="2">Assumed consistent with high levels of EV adoption</td></tr>
<tr><td>NZ45
(Hypothetical scenario requested by HECO, 100% stock 2045)</td><td>ATB-Advanced</td><td colspan="3">Implied EV sales: 100% ASAP, + modified survival</td><td>High</td></tr>
</table>

LDV Technology Adoption Formulation

$$u_t = \alpha_t + K_1\left(C_t^{total} + T^{charge}V^{time}\right) + K_2 F_t^{com} W^{com} + K_3 F_t^{cor} W^{cor} + K_4 \log M_t$$

- α_t: Importance of additional factors
- C_t^{total}: Vehicle and fuel cost
- $T^{charge}V^{time}$: Charging cost (time * value of time)
- F_t^{com}: Community trip feasibility
- W^{com}: Community trip weight
- F_t^{cor}: Corridor trip feasibility
- W^{cor}: Corridor trip weight
- $\log M_t$: Make/model availability

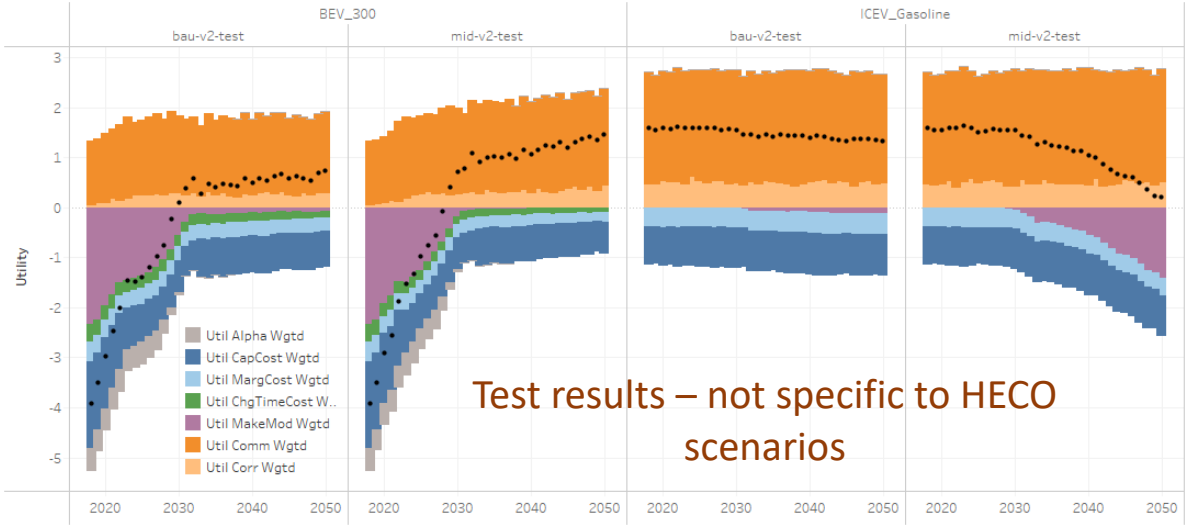
Logit parameters (highlighted in **green**) calibration based on regionally resolved data:

- **County-level:** sales, make/model availability (Experian); fuel prices (AEO); trip feasibility (AFDC and travel data)
- **State-level:** EV tax credits (AFDC)
- **National:** vehicles cost/performance (ATB/Autonomie); EV tax credit ($7,500); charging power/type share

Note: logit is applied at household bin level, but parameters not calibrated by bin, since we currently do not have bin-level sales data

Adoption Logit Disaggregation Functionality

- New functionality in TEMPO to disaggregate LDV adoption factors
  - Shows relative utility across powertrains and scenarios



Note sales share (s_t) is calculated as:

$$w_t = e^{util_t}$$

$$S_t = \frac{w_t}{\sum_{t=1}^{T} w_t}$$

More about NLR's TEMPO model

https://www.nlr.gov/transportation/tempo-model

Overview: The Transportation Energy and Mobility Pathway Options (TEMPO) Model – Overview and Validation of Version 1.0, NLR Presentation (2021)

Methodology: Exploring the Future Energy-Mobility Nexus: The Transportation Energy & Mobility Pathway Options (TEMPO) Model, *Transportation Research Part D* (2021)

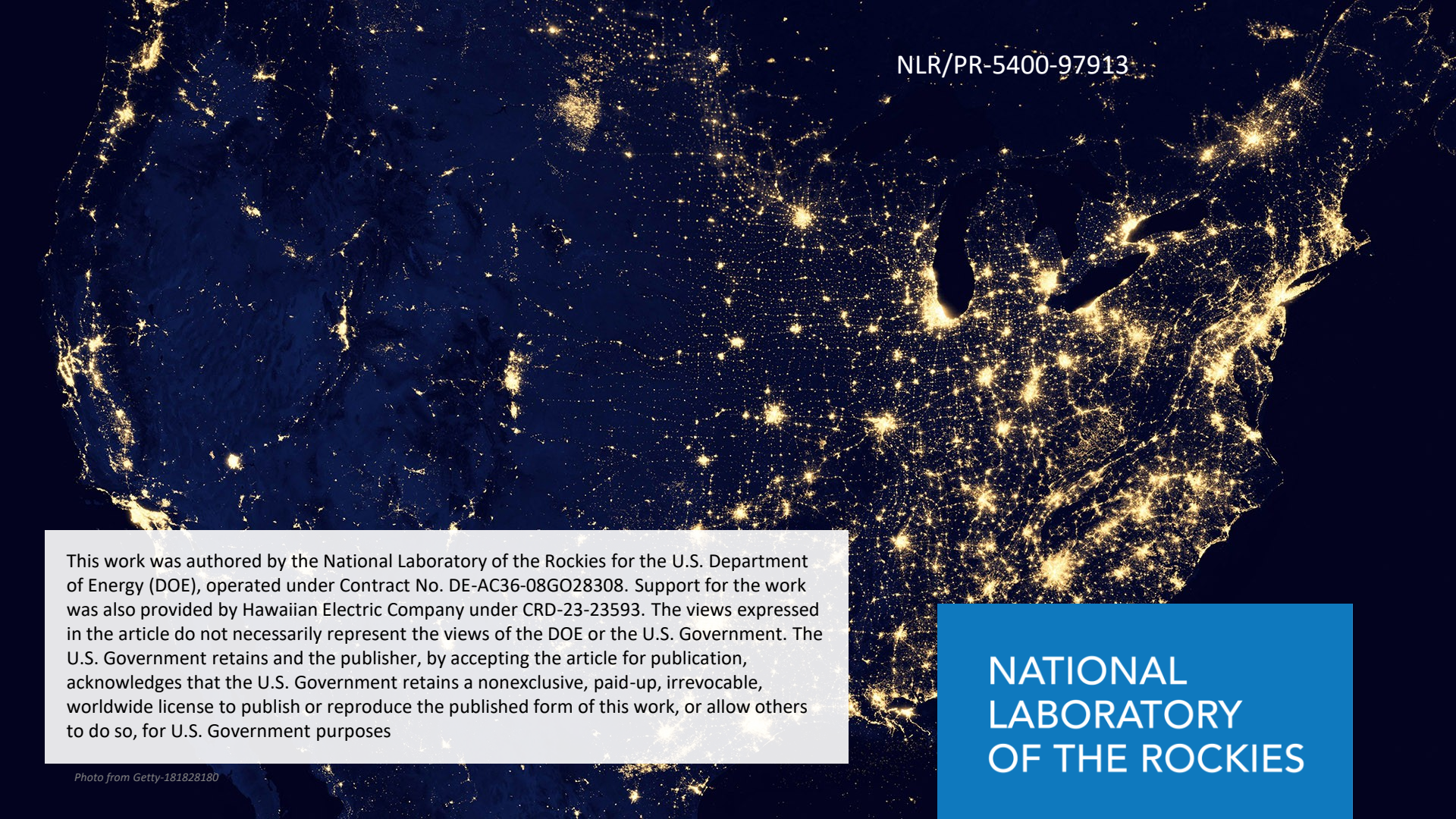
Highly Resolved Projections of Passenger Electric Vehicle Charging Loads for the Contiguous United States, NLR Technical Report (2023)

Applications:

Assessing Total Cost of Driving Competitiveness of Zero-Emission Trucks, *iScience* (2024)

Exploring Decarbonization Pathways for USA Passenger and Freight Mobility, *Nature Communications* (2023)

Electric Vehicle Managed Charging: Forward-Looking Estimates of Bulk Power System Value, NLR Technical Report (2022)



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