sweet swiss energy research for the energy transition

PATHFNDR

Alternative fuels

Flexibility provision in Switzerland's future sector-coupled energy system

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1 INTRODUCTION

Switzerland's energy transition hinges on balancing energy supply and demand across seasons. We investigate the potential flexibility of the national integrated energy system to balance temporal mismatches while complying with energy policies for sustainability and security.

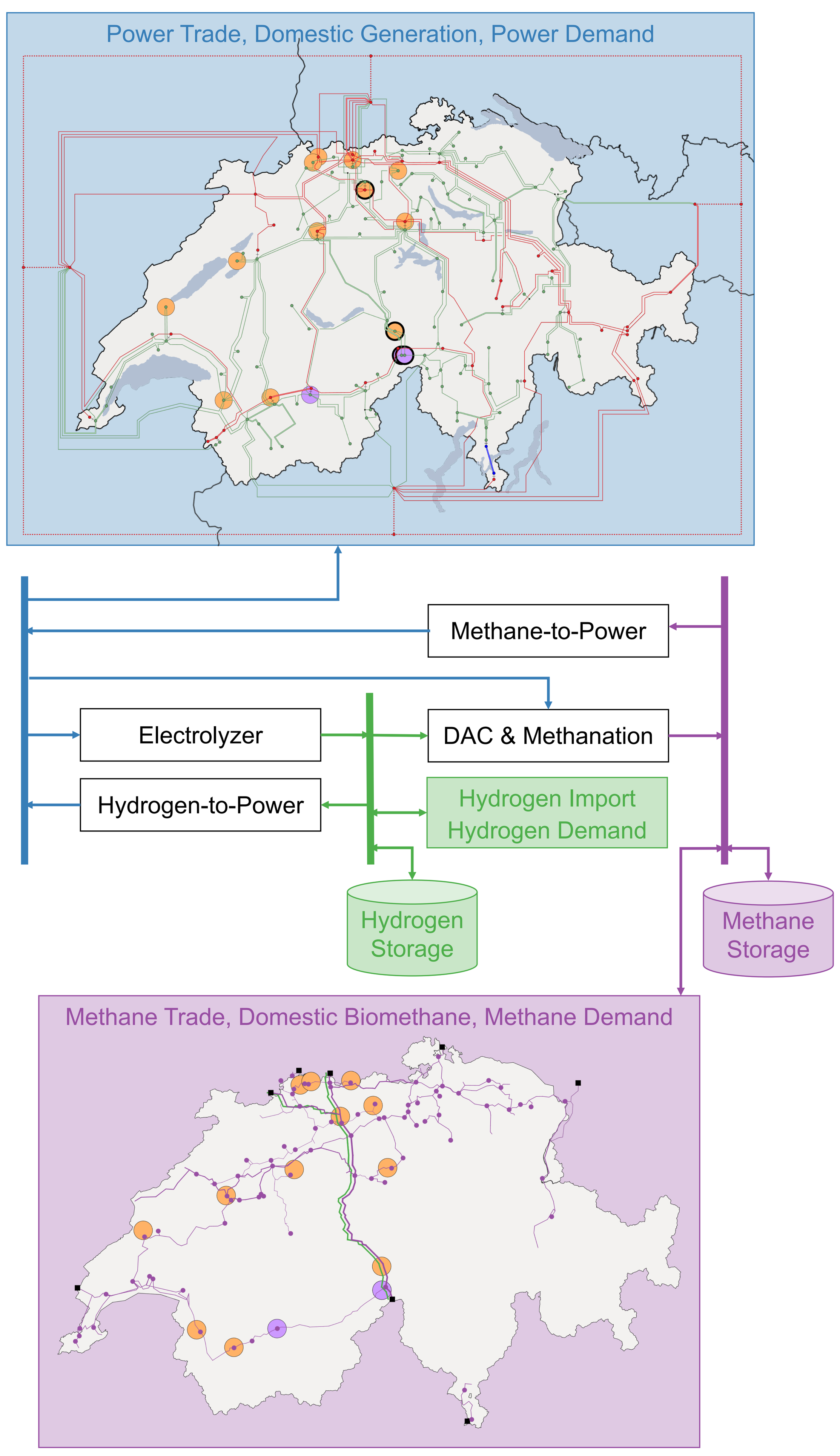
Contributions:

(1) detailed modeling of power and gas transmission networks

(2) modeling and quantification of flexibility from energy demand and energy storage

3 SYSTEM DESCRIPTION

We use Nexus-e [1] for power generation and transmission expansion planning and GasNet [2] for gas supply chain optimization. Annual demands for power, hydrogen, and methane are from EP2050+ [3].



Energy transmission networks including power-to-gas-power technologies with pressurized tanks (●) and lined rock caverns (LRCs) (●)

Key constraints:

non-hydro renewable generation ≥ 45 TWh/a

rooftop PV generation ≥ 33.6 TWh/a

net winter half-year electricity import 5 TWh

carbon emission ≤ 0 Gt-eq/a

4 RESULTS (2050)

Fig. 1:

- Contrasting seasonality between energy demand and generation from PV and run-of-river
- Seasonal flexibility from energy trade, pumped and reservoir hydro, alpine PV, and electrolyzers
- Cheap gas imports (<70 €/MWh) support winter power supply, with no power generation from domestic e-gases

Fig. 2:

- Hydrogen storage providing multiday to seasonal flexibility driven by variable renewable generation
- Methane storage providing seasonal flexibility driven by methane demand

Table 1, Fig. 3:

- Limited trades (lone, lone\LRC) increase costs by 35-39%, including:
  - 11-13 TWh wind generation
  - 10.8 TWh_e for power-to-gas
  - 1.7 TWh cavern storage
  - <0.3 TWh tank storage
  - 4-10% gas demand reduction

Table 1. Scenario definitions

Scenario	NTC*	Fuel import	Gas storage
2020	99%	Fossil, uranium	Only existing
base	100%	Fossil, renewable	Tank, cavern
lone	30%	Not allowed	Tank, cavern
lone\LRC	30%	Not allowed	Tank

*Net transfer capacity

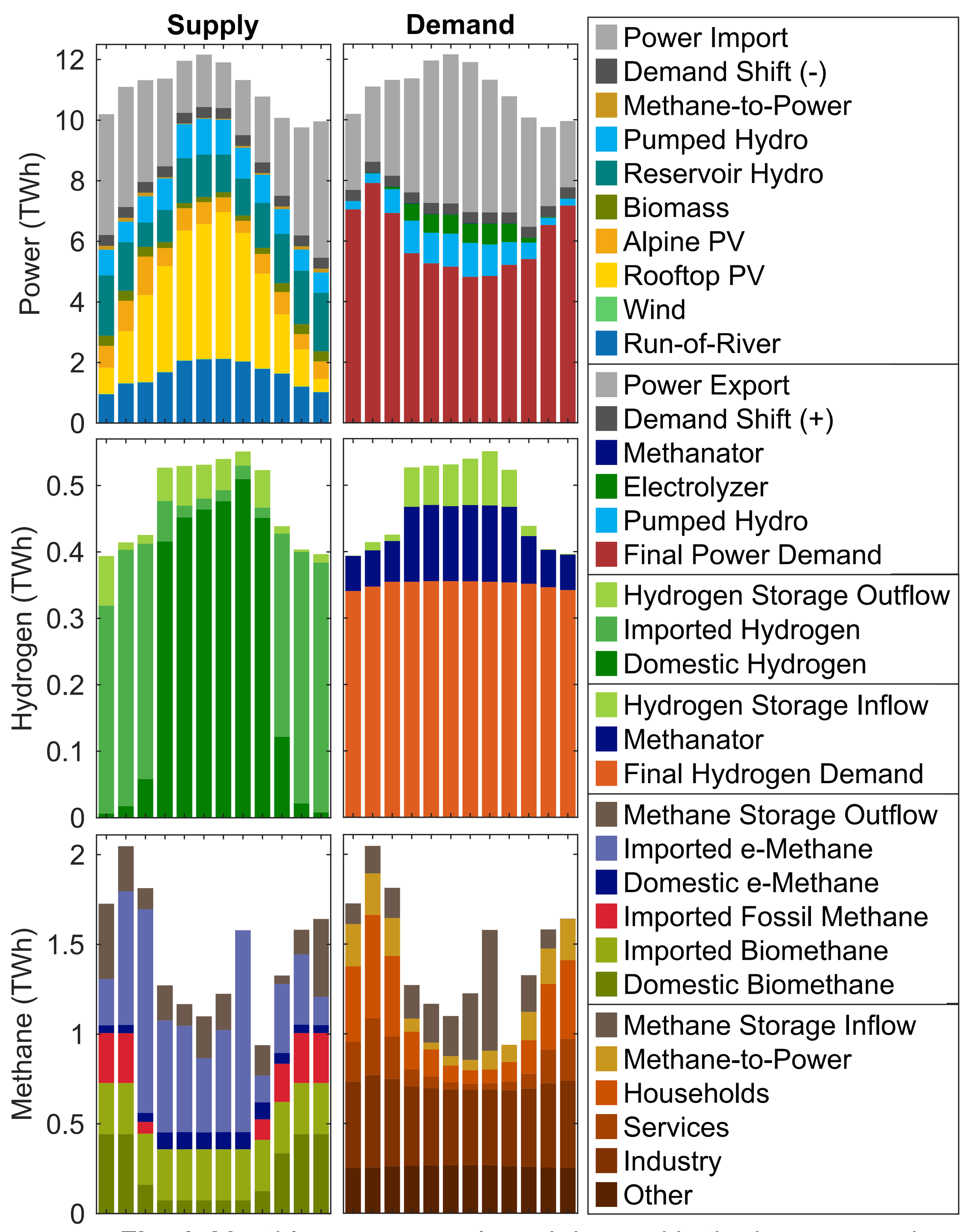


Fig. 1. Monthly energy supply and demand in the base scenario

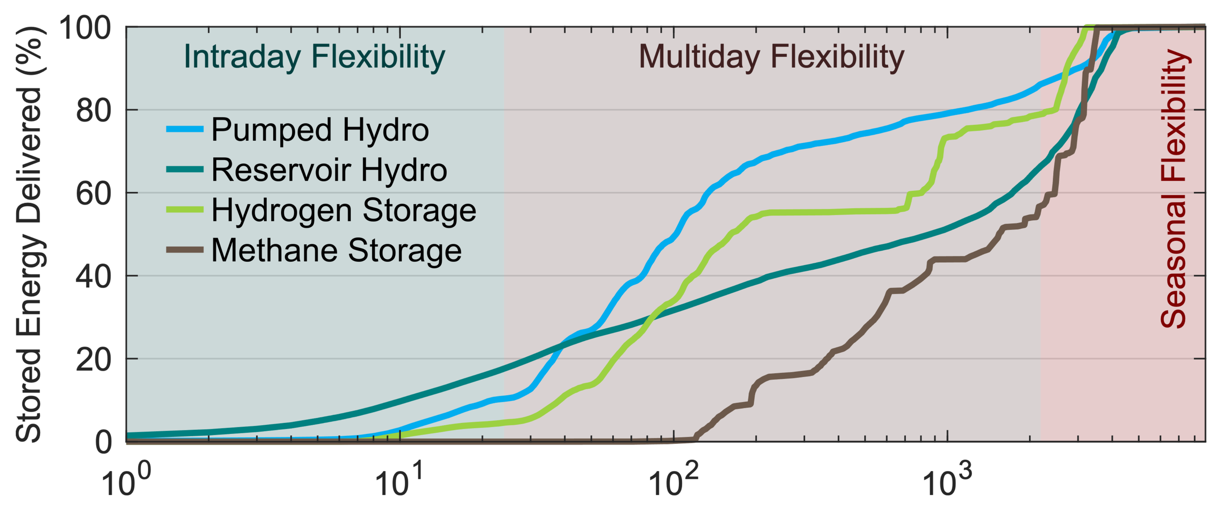


Fig. 2. Cumulative storage duration (h) distribution in the base scenario

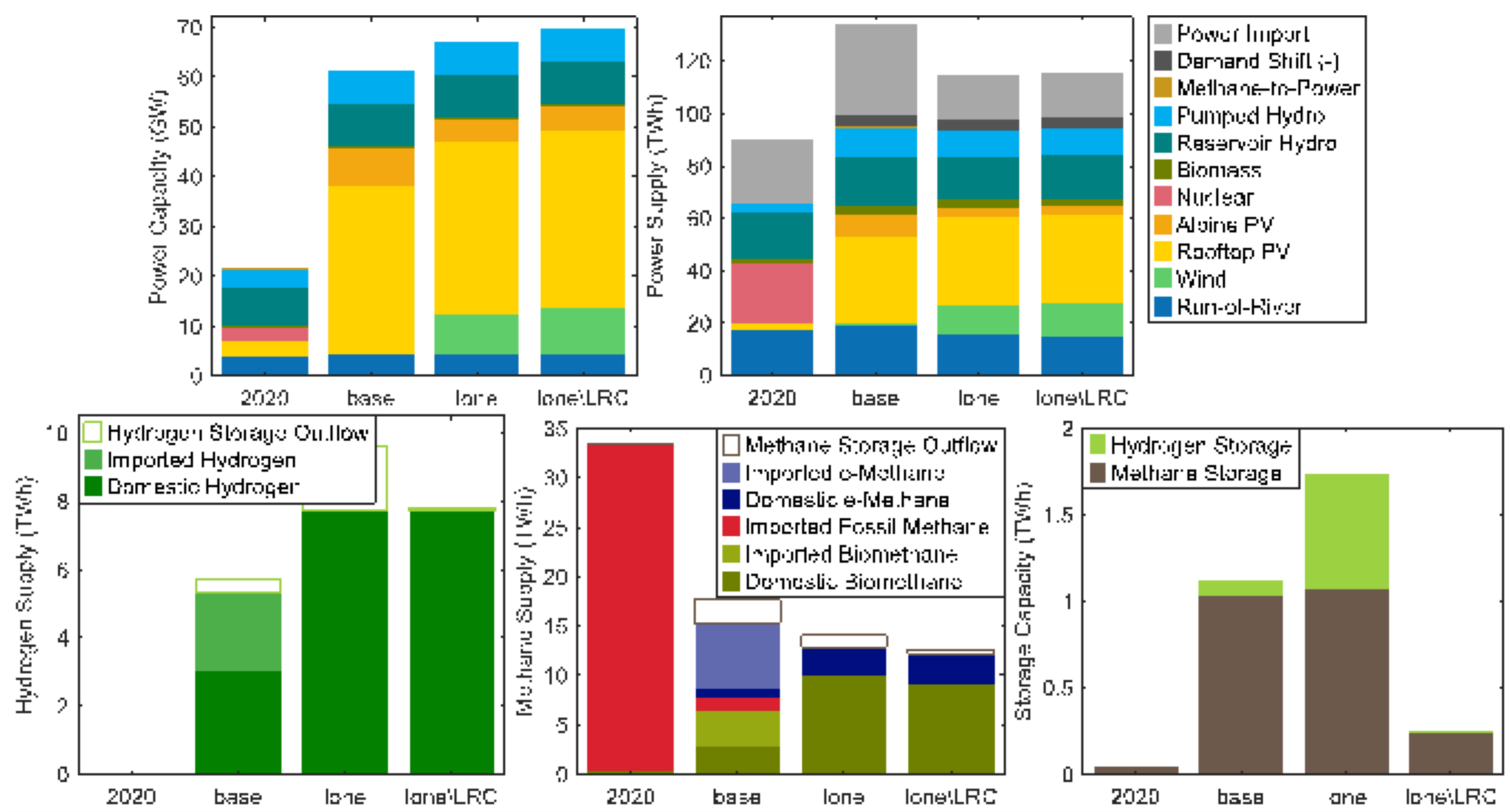


Fig. 3. Annual energy supply and installed capacities in various scenarios

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