



Path_— to100%

Renewables for California

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Path to 100% Renewables for California

Cortney Piper
Piper Communications



What is Path to 100%?

Path to 100% is an objective community intended to bring together thought leaders and industry experts **to discover solutions, raise awareness, and create a dialogue** on how to achieve an operationally and financially realistic approach towards a 100% renewable energy future.

Path to 100% is made possible by **Wärtsilä**, a global leader in smart technologies and complete lifecycle solutions for energy and marine markets.

California Study and White Paper

California has set a target of **100% clean electricity by 2045**.

The study establishes a new path that enables California to meet its RPS target **5 years ahead of schedule (2040)**.

This new path provides **a reliable, affordable and most importantly, environmentally friendly way to decarbonize the electricity generation**.

Path to 100 % Renewables for California

Agenda

- **California Path to 100 % Study**
 - Recap of approach & main findings
 - New Hydrogen scenario
 - Policy recommendations to enter the *Optimal Path*
- **Panel discussion**
 - Progress, opportunities & challenges on California's path to 100 %
 - Policy recommendations to enter the *Optimal Path*
- **Q&A**



Panelists



Karl Meeusen

*Senior Advisor, Infrastructure &
Regulatory Policy*
California Independent System Operator



Jan Smutny-Jones

CEO
Independent Energy Producers Association



Joe Ferrari

*General Manager,
Utility Market Development, North America*
Wärtsilä

Cortney Piper
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Moderator



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Decarbonizing Electricity in California by 2045

Background....

- California's **Current Plan** for carbon neutrality by 2045 is reliant on renewables and battery storage
- Wärtsilä suggested an **Optimal Path** for California to reach its RPS goals earlier than targeted, leveraging power-to-gas (PtG), specifically Methane
- Frequent Webinar questions were:
 - What about Hydrogen?
 - What would be the first steps to enter the **Optimal Path**?



Updated Scenarios

			New Scenario
Current Plan	Current Plan w/o thermal	Optimal Path (PtM)	Optimal Path (PtH)
<ul style="list-style-type: none">• OTC retirement delayed to 2026+• Limited repowering with thermal• 100% of retail sales carbon-neutral by 2045• ~ 8% of generation can still be fossil-thermal (to cover grid losses)	<ul style="list-style-type: none">• OTC retirement delayed to 2026+• NO repowering with thermal• Only solar, wind & traditional storage allowed• Carbon-neutral by 2045	<ul style="list-style-type: none">• OTC retirement 2023• OTC's repowered with optimal capacity mix• RPS commitments met by 2040 (5 years early)• Carbon-neutral by 2045• Requires allowance of Power-to-Methane (PtM)	<ul style="list-style-type: none">• OTC retirement 2023• OTC's repowered with optimal capacity mix• RPS commitments met by 2040 (5 years early)• Carbon-neutral by 2045• Requires allowance of Power-to-Hydrogen (PtH)

Long term capacity optimization, technology & capacity choices, costs etc. determined by PLEXOS software

California power system expansion modeling through 2045

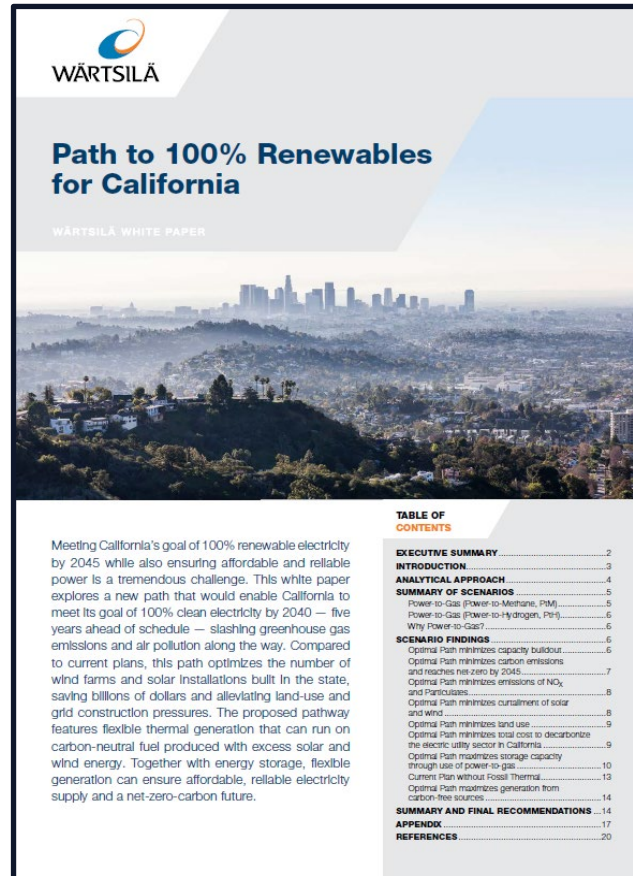
How?

Wärtsilä used high-performance energy system simulation software, and a model used by CAISO to support 2019 IRP as starting point.



PLEXOS engineers the optimum
**Path to 100 % decarbonized power
system for California!**

Details



New Scenario

Optimal Path (PtH) (Power-to-Hydrogen)

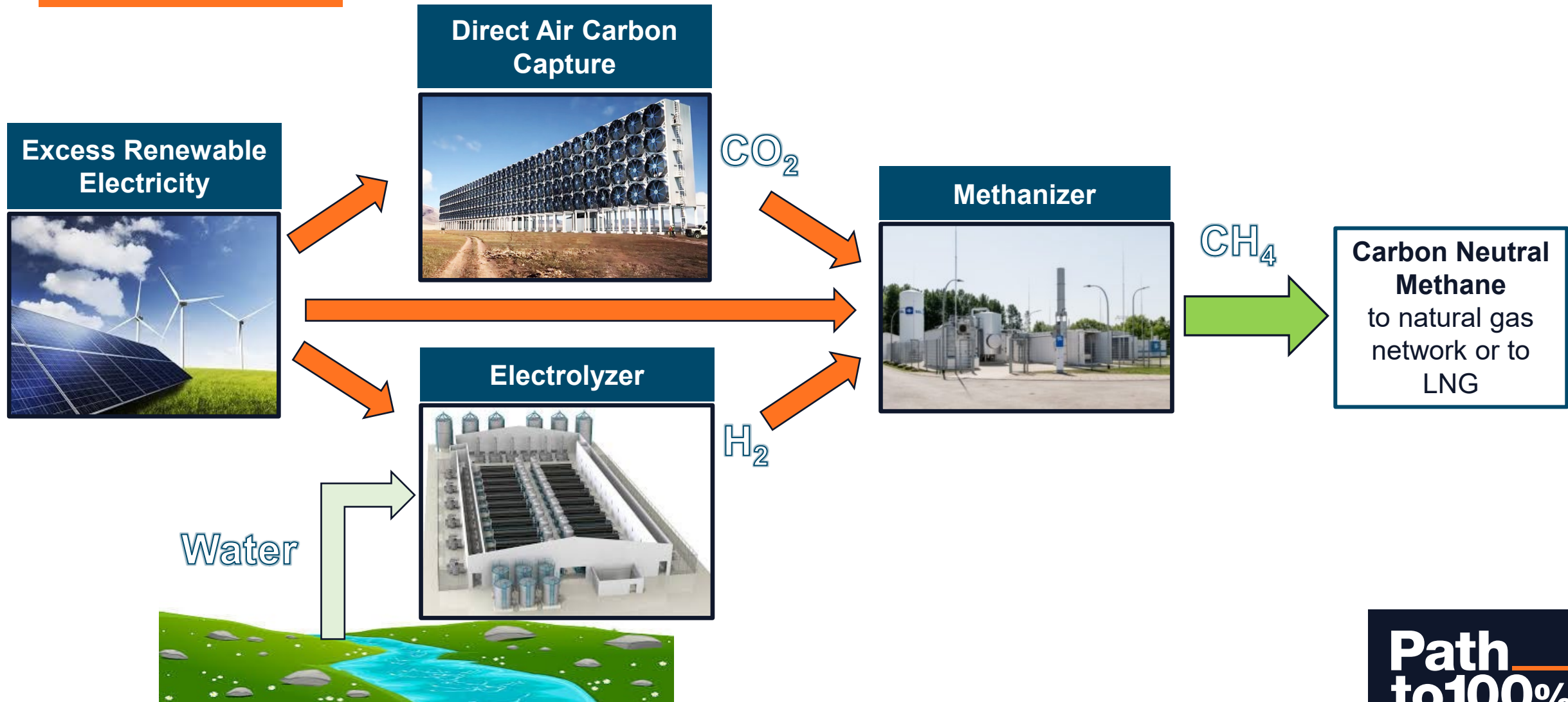
Hydrogen versions of thermal technologies **available by the time renewable fuels become economically viable**

Power plant price levels (\$/kW) & performance similar as natural gas (methane) versions

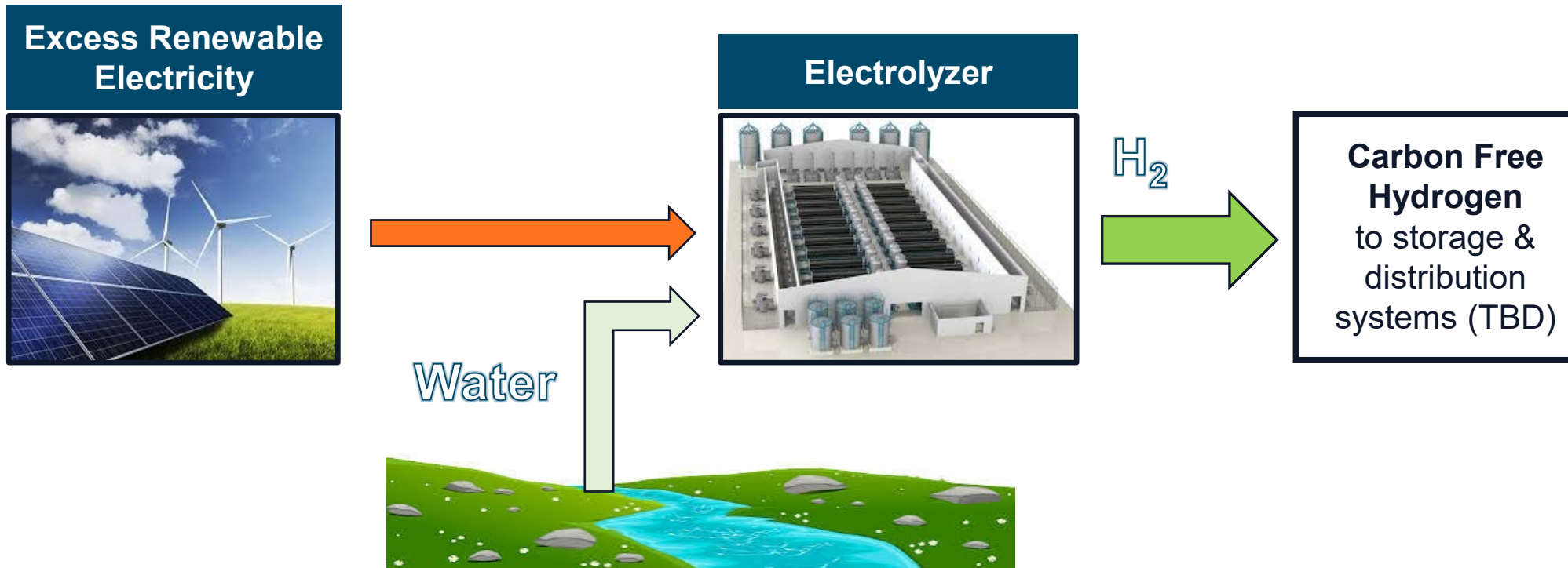
Hydrogen distribution & storage infrastructure costs not included

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Power-to-Methane (PtM) fuel production process



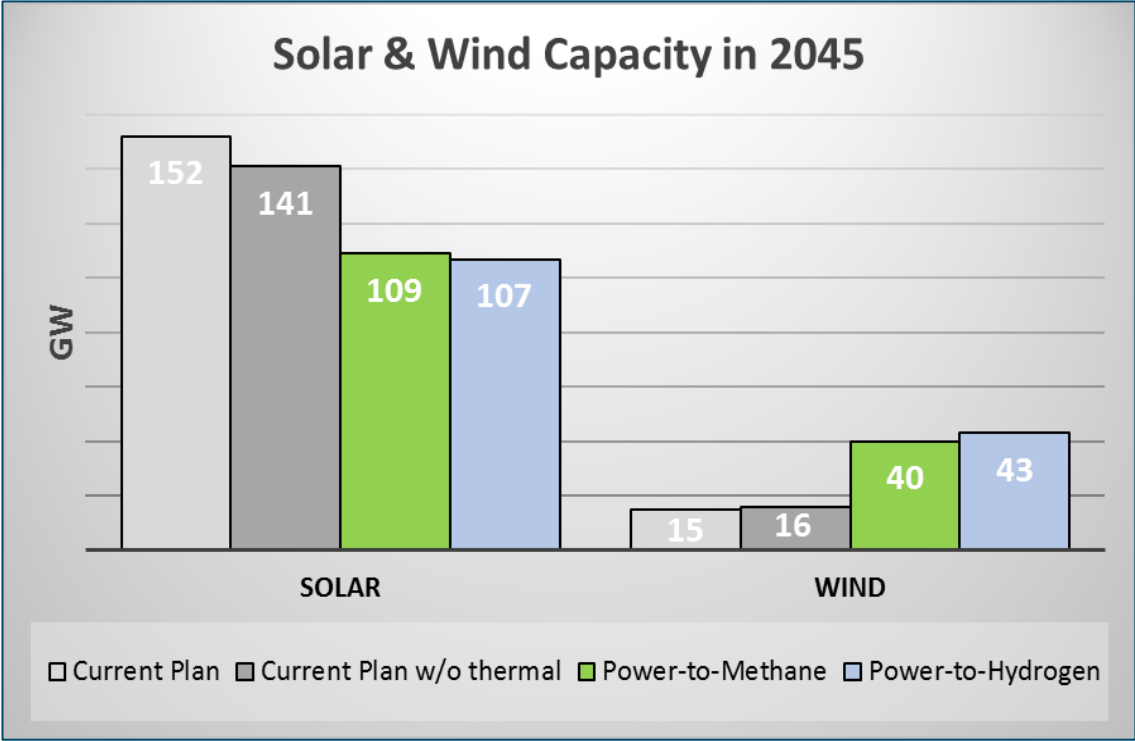
Power-to-Hydrogen (PtH) fuel production process



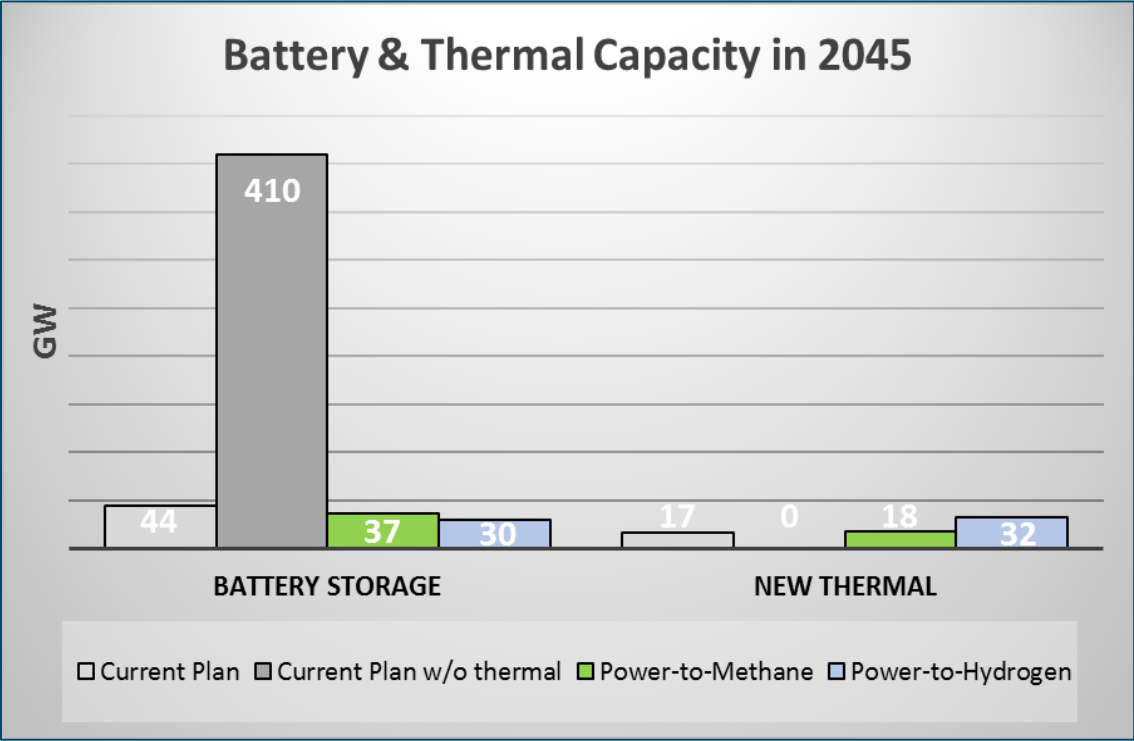
Study results - capacity additions by 2045



Optimal Path (PtM) contains 10 GW of PtM capacity
Optimal Path (PtH) contains 20 GW of PtH capacity

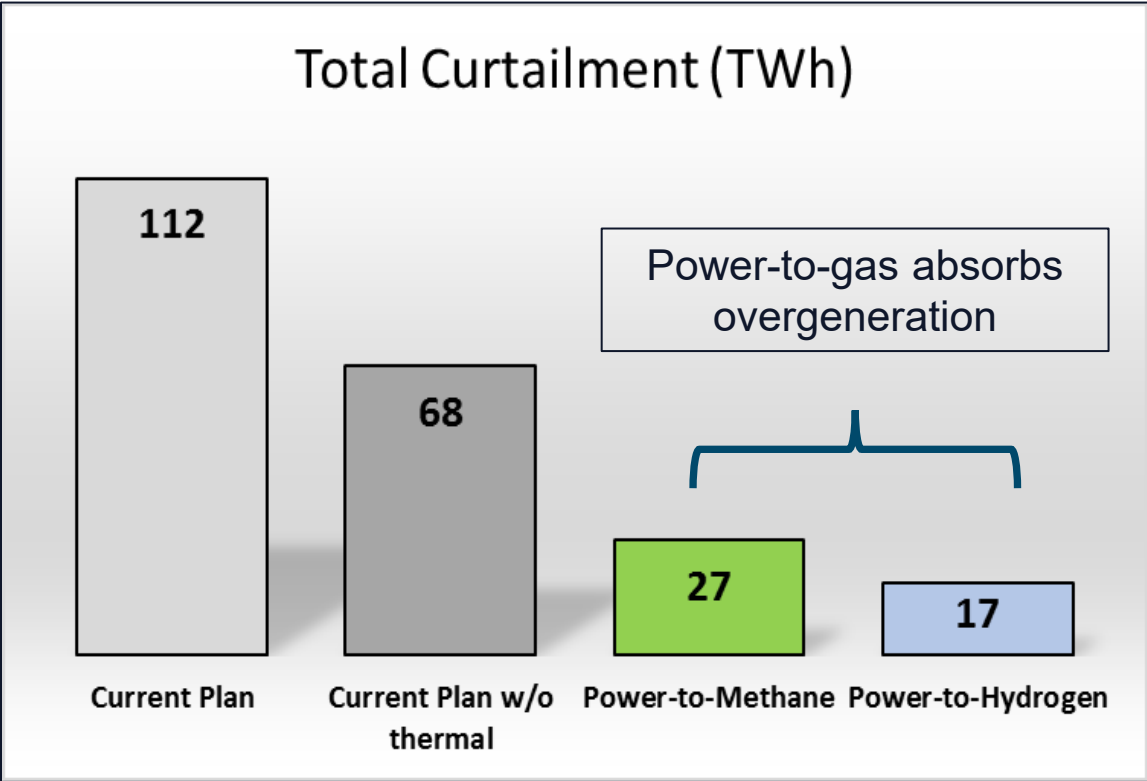
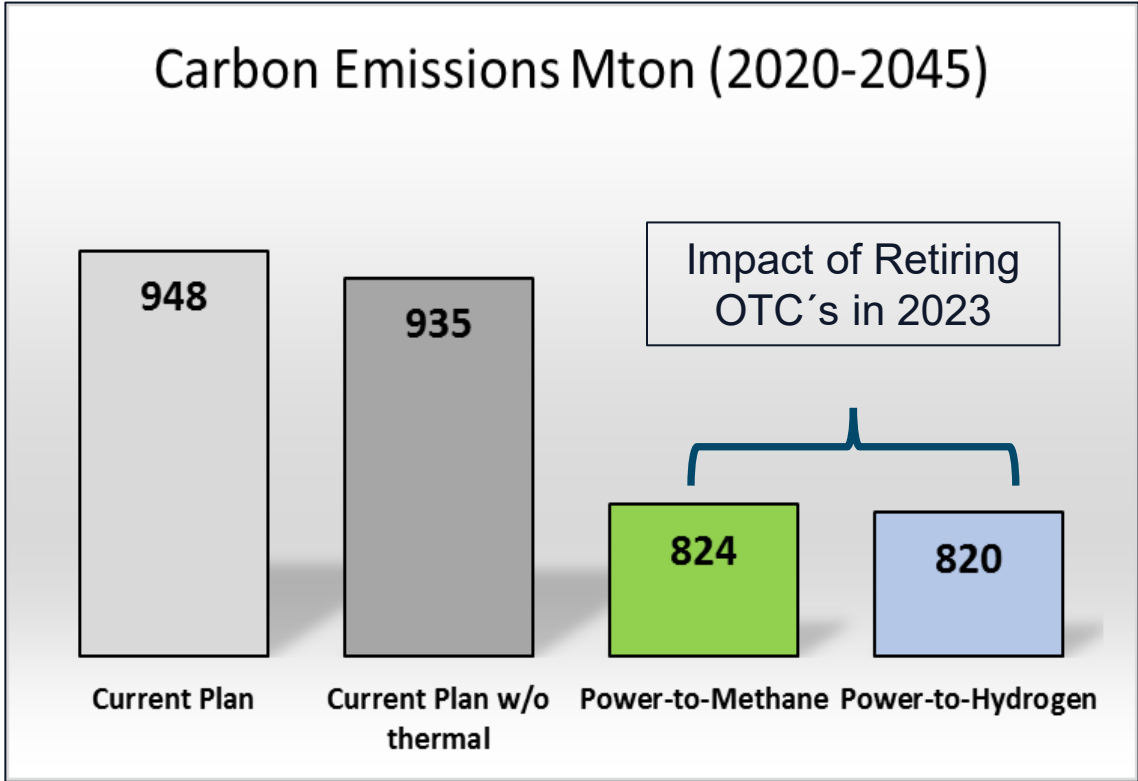


Optimal Path = less solar, more wind than current plan(s)

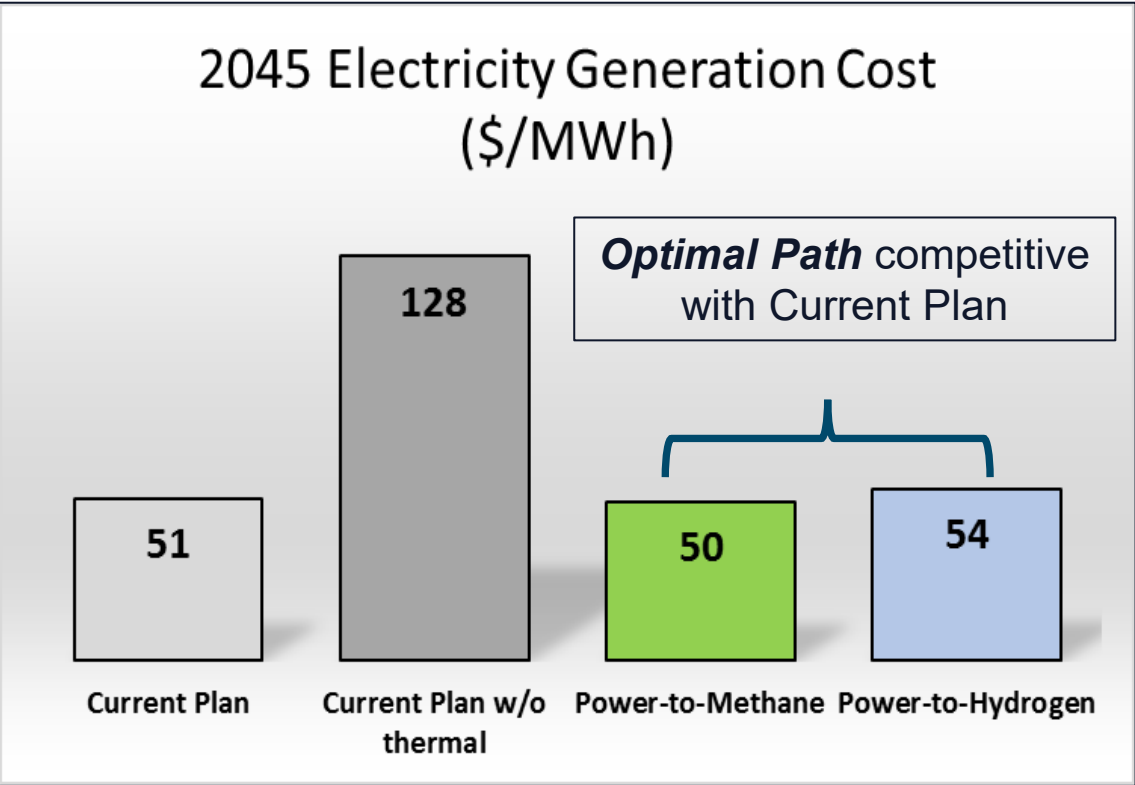


Current plan w/o thermal requires 10-fold larger Battery Storage capacity for system reliability (reserve margin)

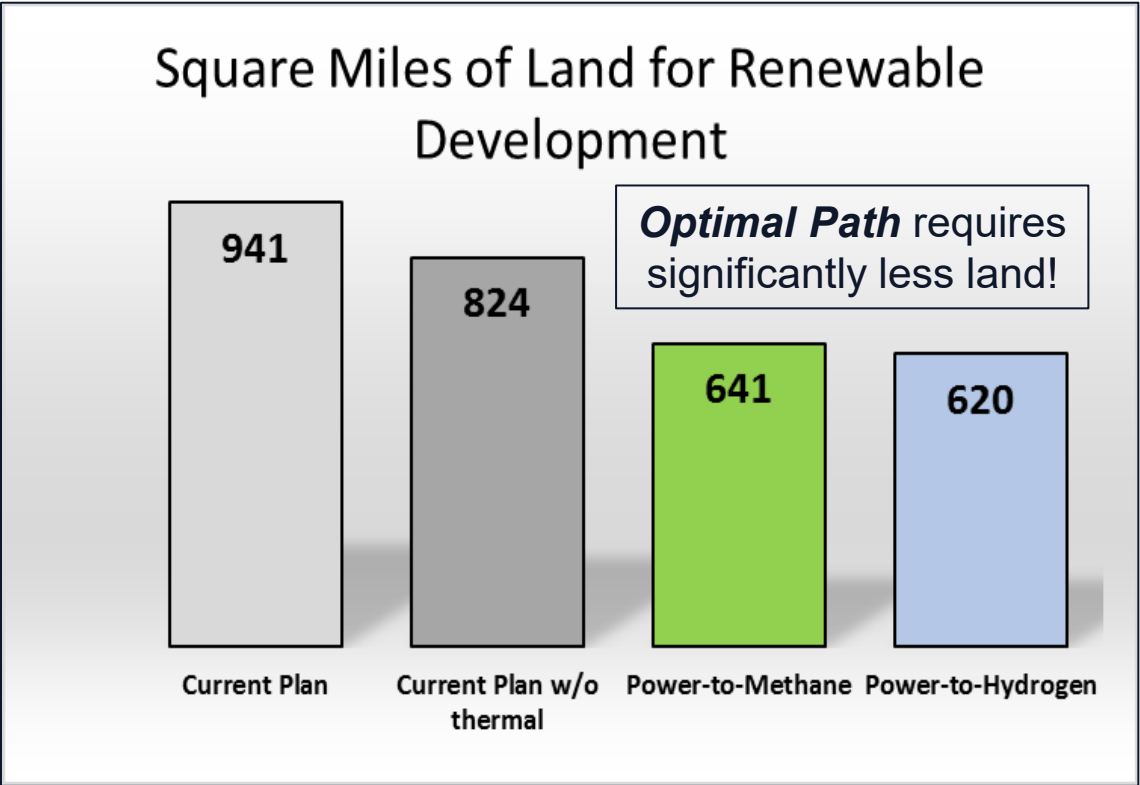
Cumulative carbon emissions and Solar & Wind curtailment (2045)



Electricity generation cost and land use



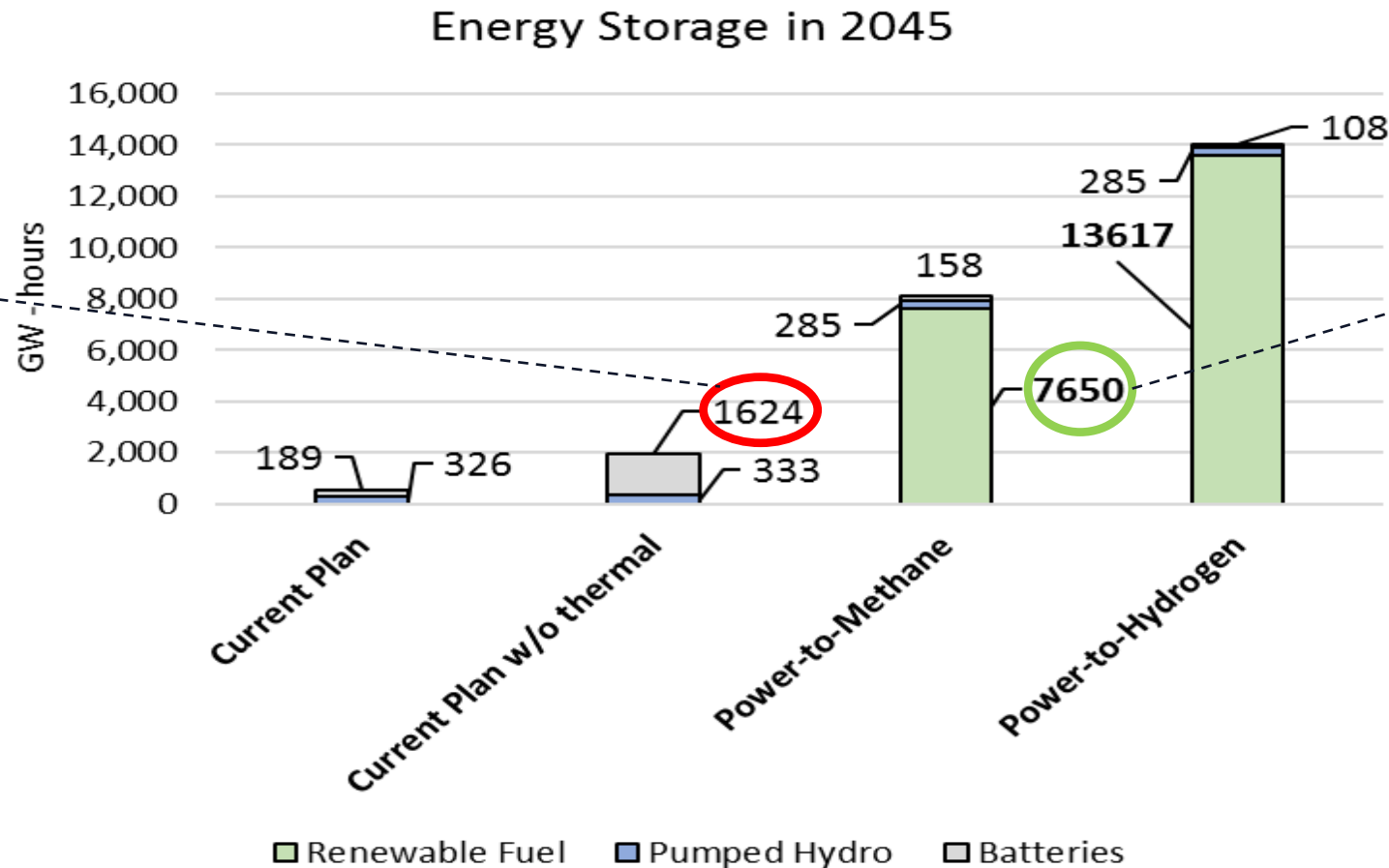
Current Path does not provide carbon-free electricity in 2045
Current Path w/o thermal provides highly expensive power



Land costs are excluded in this study

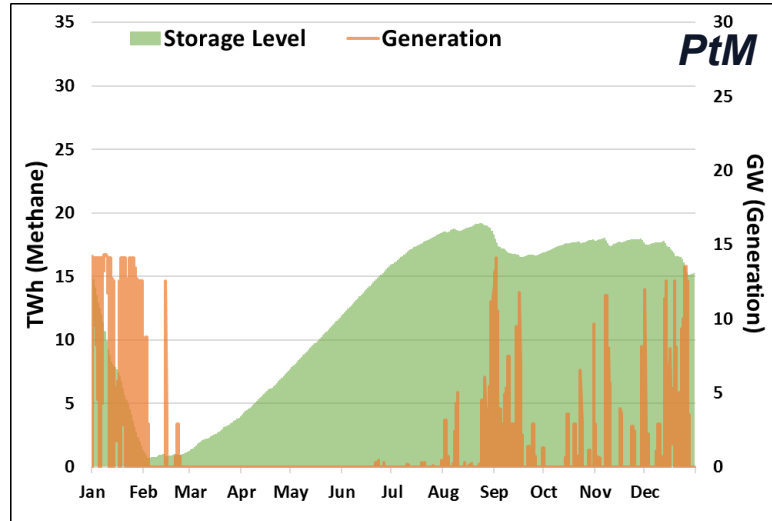
Energy Storage by scenario

As of 2018, the USA had 1.24 GWh of battery storage (EIA)



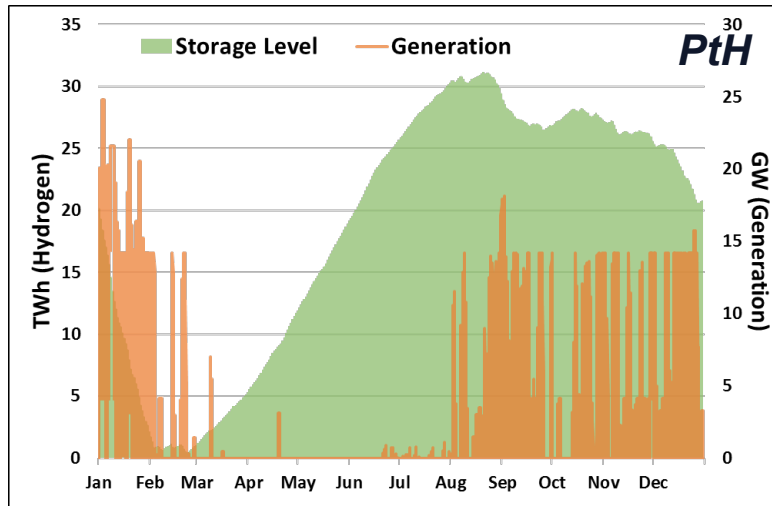
Optimal Path (PtM) utilizes ~ 15% of existing underground gas storage in California

Renewable Fuels as large Long Term Storage (2045)



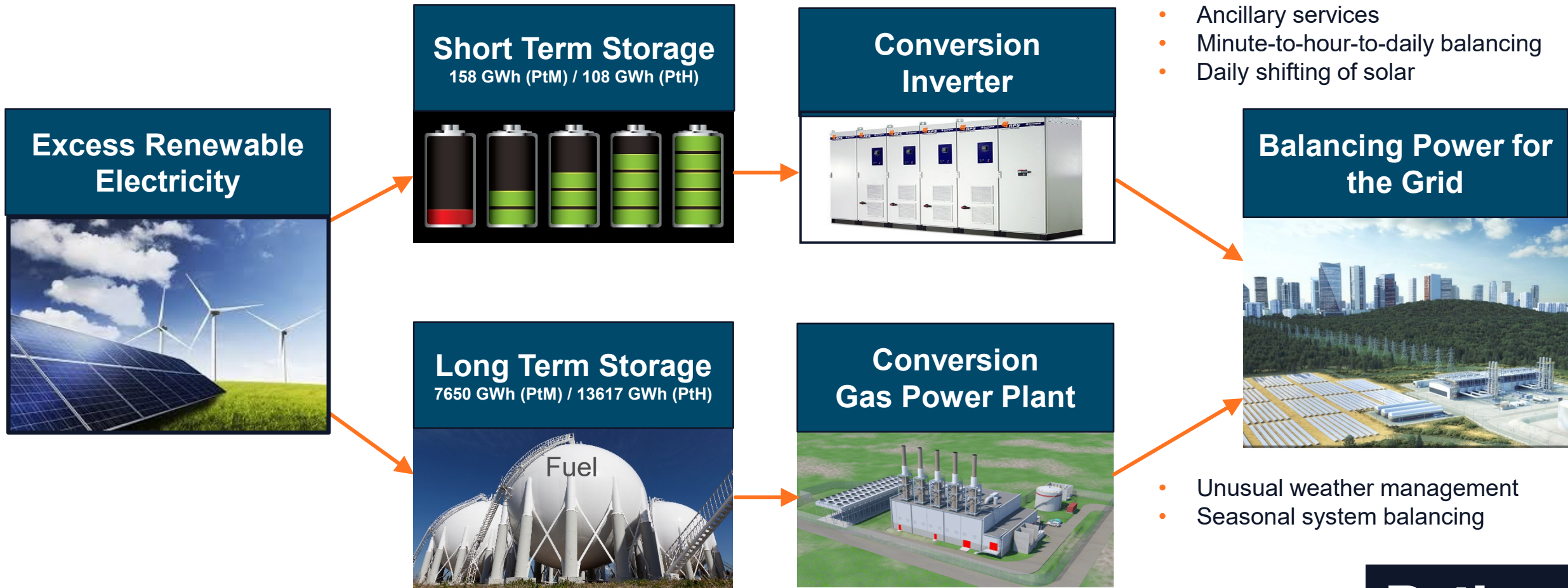
- Renewables oversupply banks 18 TWh of C-neutral methane (fuel) in underground storage
- Storage filled in spring/summer
- Can operate 32 GW_e power plant fleet for 240 hours (10 days) @ full power

**All necessary
renewable fuel
is produced
locally in California
using surplus
renewable energy!**



- Same concepts apply, 30 TWh of Hydrogen
- 32 GW_e for 427h (17 days) @ full power

P2G - New approach to electricity storage



Key takeaways



1. **Optimal path** outlined in the study is the best path to 100 % for California

- Faster, complete decarbonization
- More efficient use of solar, wind and battery storage
- Less land required for development
- Lower cost for ratepayers
- Maximized security of supply with dispatchable thermal fleet

2. **Power to Gas** (Methane or Hydrogen) **is a key ingredient of the optimal, clean power system**

- Enables construction of highly efficient, 100 % Carbon Neutral power system
- Optimal Path can be entered now as first year's actions are the same for PtM and PtH – renewable fuel choice can be made later!

3. **Policy recommendations for California**, to enter the *Optimal Path* to 100 %:

- Recognition of Renewable Fuels (including renewably sourced Methane and Hydrogen) as "renewable" for RPS compliance purposes
- Maintain OTC 2023 retirement dates; add necessary flexible gas generation to the power system to enable those retirements
- Add optimal proportions of Renewables, Traditional Storage and Flexible Thermal, to enable the transition to 100% clean energy

Full White Paper – PATHTO100.ORG

– Please download the full study at www.wartsila.com/energy/optimising-power-systems



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Path to 100% Renewables for California

WÄRTSILÄ WHITE PAPER

Meeting California's goal of 100% renewable electricity by 2045 while also ensuring affordable and reliable power is a tremendous challenge. This white paper explores a new path that would enable California to meet its goal of 100% clean electricity by 2040 — five years ahead of schedule — slashing greenhouse gas emissions and air pollution along the way. Compared to current plans, this path optimizes the number of wind farms and solar installations built in the state, saving billions of dollars and alleviating land-use and grid construction pressures. The proposed pathway features flexible thermal generation that can run on carbon-neutral fuel produced from excess solar and wind energy. Together with energy storage, flexible generation can ensure affordable, reliable electricity and a net-zero-carbon future.

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