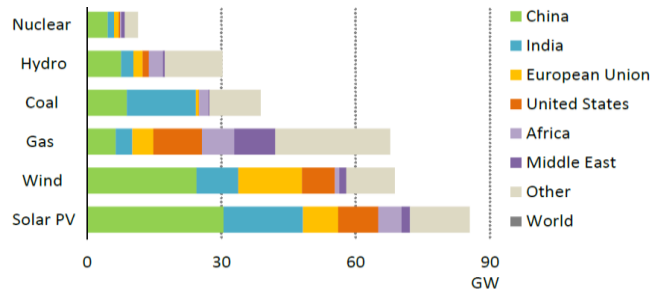
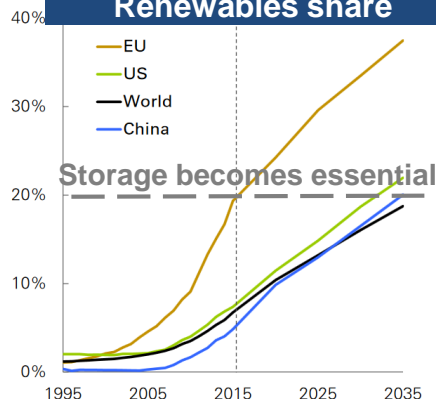
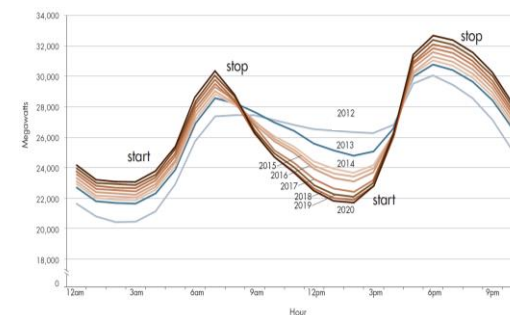




## **HYBRID POWER PLANTS & H2 SOLUTIONS**

**ANIMP, Milan 5th July 2018**

# Why market it is looking at new ways of energy production ... Key drivers

**Power installation until 2040**

**Renewables share**

**New operating conditions**


## Renewables

After a century of dominance, **fossil-fuelled power plants no longer lead**, as renewables account for more than **60% of total capacity additions to 2040**

Increased (intermittent) renewable power production will generate

- **Times of overproduction**
- **Times of power shortage**

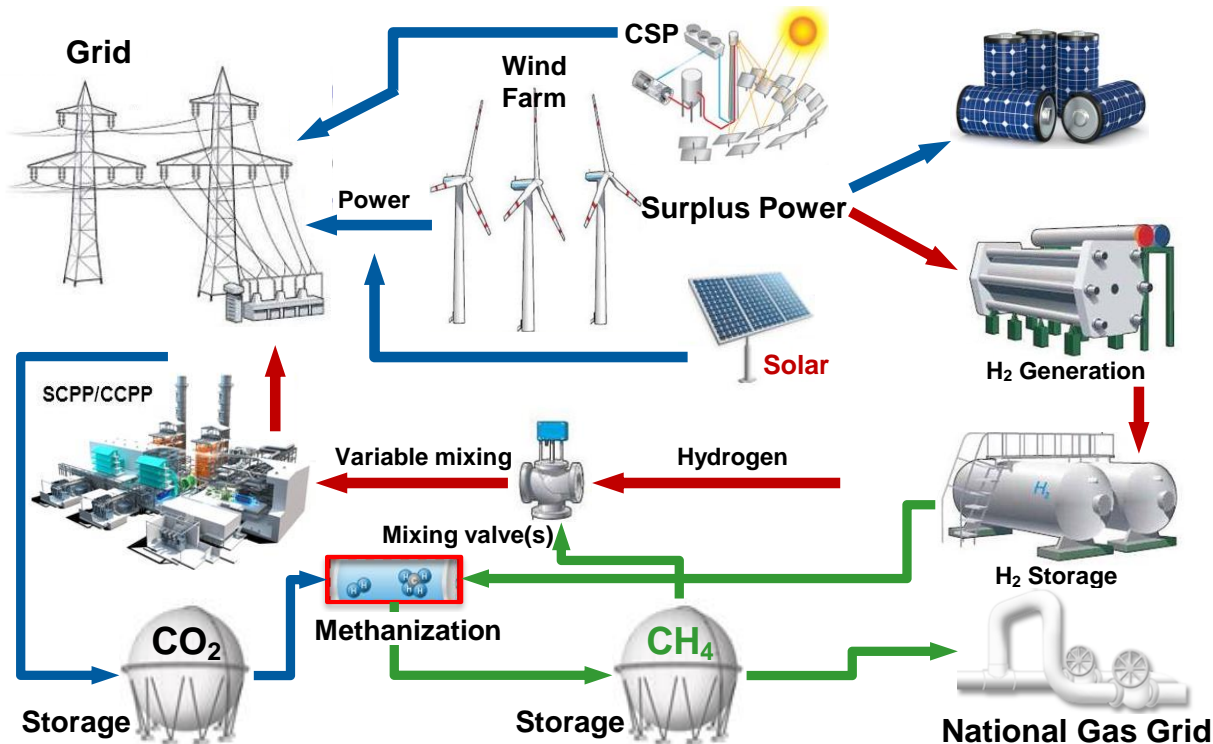
H2 is one of the ideal storage carriers for storing

- **Large amounts of power** (10GWh to 10 TWh)
- **Over medium to long storage cycles** (1h to several months)

Technologies

## Electrolysis + Storage

Source: WEO 2017



- The hydrogen supply / production / availability will be fluctuating due to the **intermittent nature** of renewables
- The storage capabilities are **limited** (limited volume or limited swallowing capacity of pipelines due to upper H2 content limit in pipeline standards)
- The combination of multiple sources will require **coordination** to meet system operators' requirements

**Ansaldo Energia** is setting itself to play a **key role** in this new market ...

→ **Plant Optimizer** to drive smooth coordination of multiple resources

→ **GT H2 capability** to burn increasingly higher quantity

### Hybrid power plants

Various sources combination

Batteries or others  
(hydro pumped storage  
or compressed air or  
H2)

**Storage  
systems**

**Generation  
sources**

Simple or combined cycle, wind,  
● solar photovoltaic or hydro

**Plant  
optimizer**

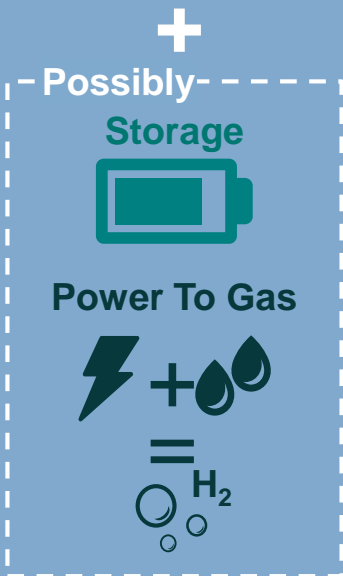
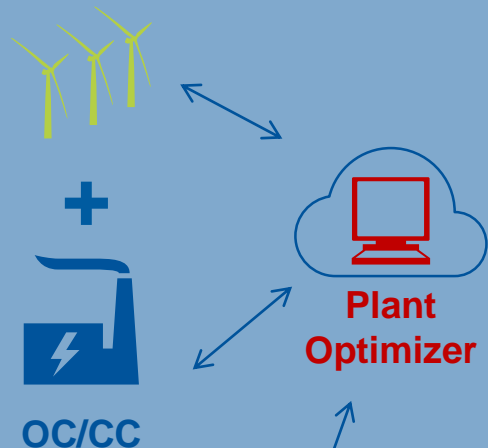
● Hardware and  
software optimizing  
sources and storage

to accentuate the positive aspects and address the challenges of a  
specific generation type in order to provide

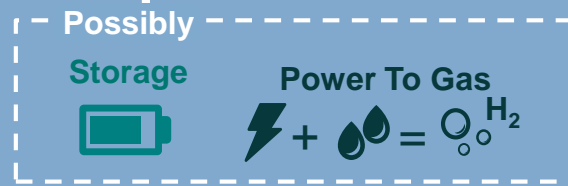
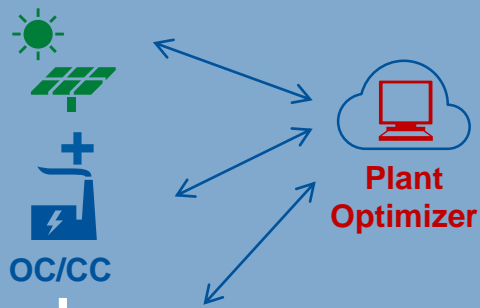
**Affordable, reliable and sustainable solutions**

## Hybrid power plants - Configurations

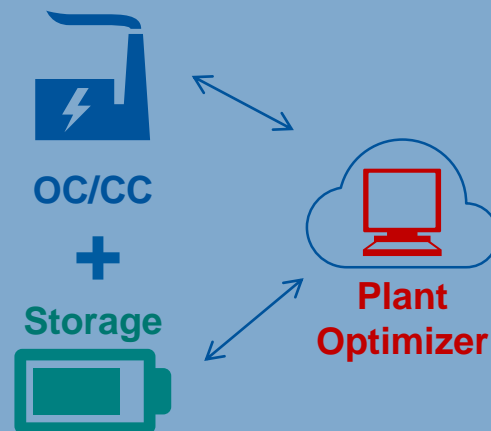
### Wind solutions



### Solar PV solutions



### Storage solutions



### Solar CSP solutions

CSP



+

Steam  
Turbine

ISCC



+



### Engine solutions



OC/CC

+

Reciprocating  
engine

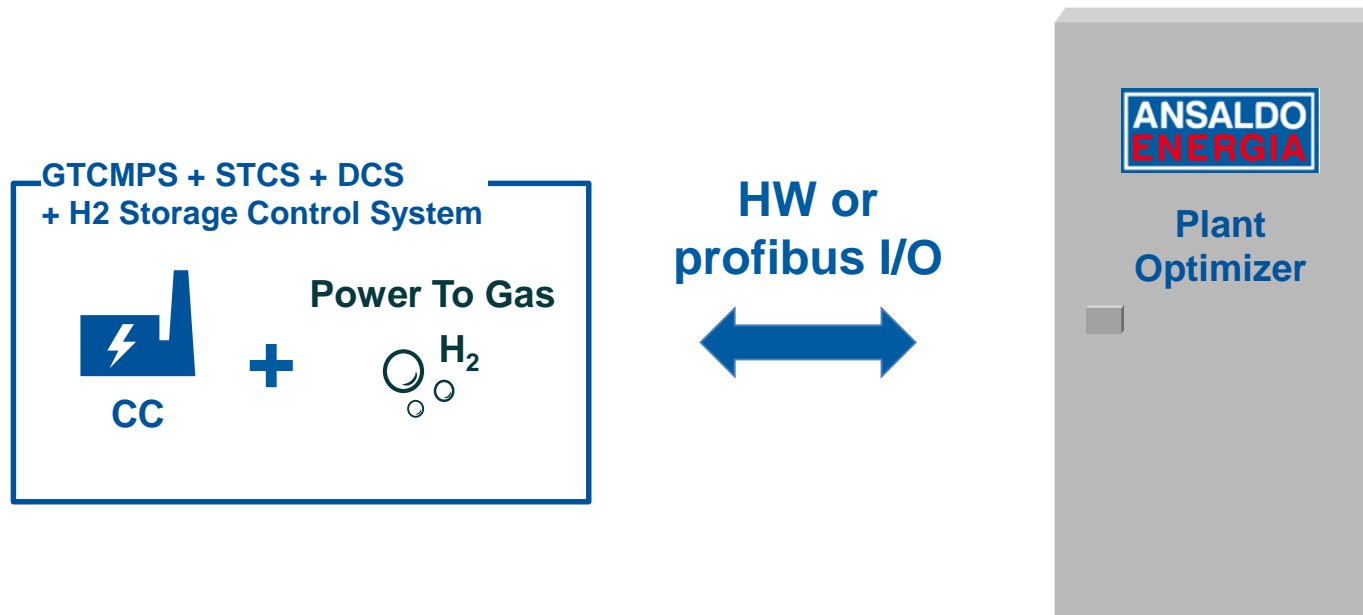


Plant  
Optimizer

### Plant Optimizer - Ansaldo Energia System Integrator

Concept & appearance: “**plug&play**” branded electronic cabinet provided with the **necessary HW** and the **relevant control system**

Example of application: **CC + H2 storage**





It provides a **higher automation level** for OC / CC plants interfaced with the existing plant automation system

It manages **CC in different configurations**  
Single or Multi Shaft «1+1», «2+1», «4+1», «mGT+ nST»

It is derived from about **30 installations over 20 years of Ansaldo Energia experience** in CC management

It applies to **Virtual Power Plants** (individual OC / CC plants with common load profile and dispatcher interface)

**Certified by several patents**

### Main applications



#### **Distribution of the daily load profile**

among gas turbine, steam turbine and battery in accordance to their min/max limits and max load gradients, to minimize the load unbalances

#### **Ancillary services for grid support**

primary and secondary frequency control

#### **Steam turbine, by-pass and HRSG vent valves automatic coordinated management**

during all start-up, steady state and shut-down phases

#### **Storage & fuel management**

for plant efficiency optimization

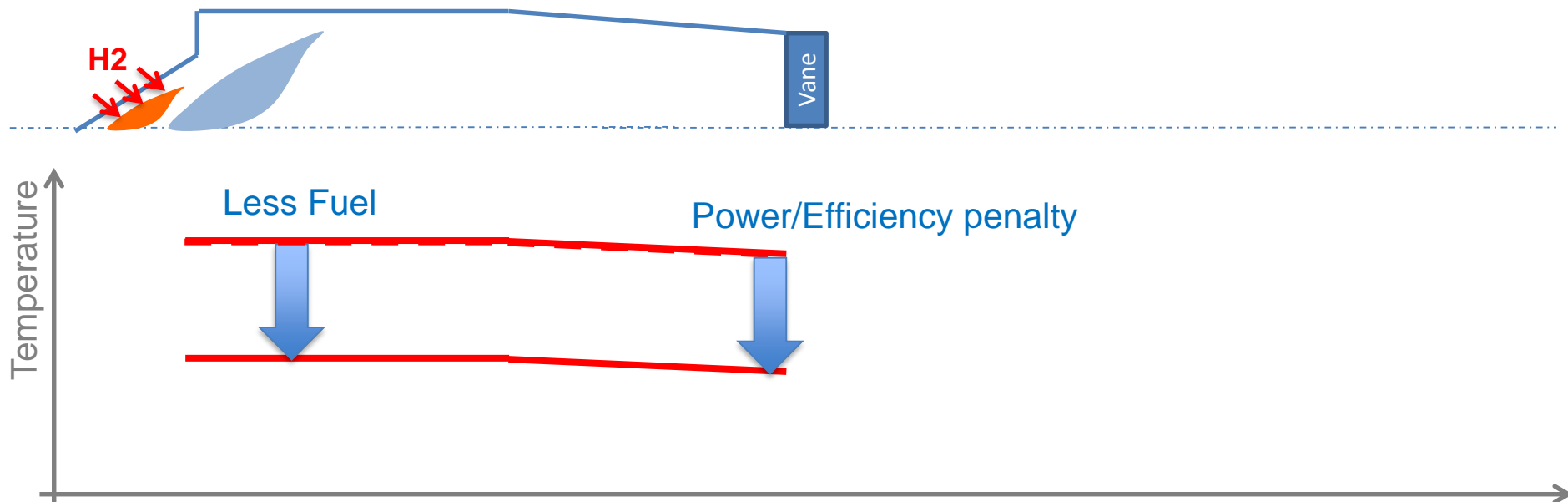


Ansaldo Energia has been at the forefront of **H2 combustion development** for many years, joining prominent European and international projects including:

- EncapCO2 [Developing **premix combustors** for H2 rich combustion]
- BigH2 [**Fuel injector** fundamentals co-/cross-flow]
- DECARBIT [Developing **reheat combustors for 100% H2** by power - 70% (vol.) H2 / 30% (vol.) N2]

During their development both **the GT26 and the new GT36 gas turbine** combustors underwent detailed validation under full engine pressure at the DLR (German Aerospace Institute) in Cologne.

## Generic non-reheat combustor

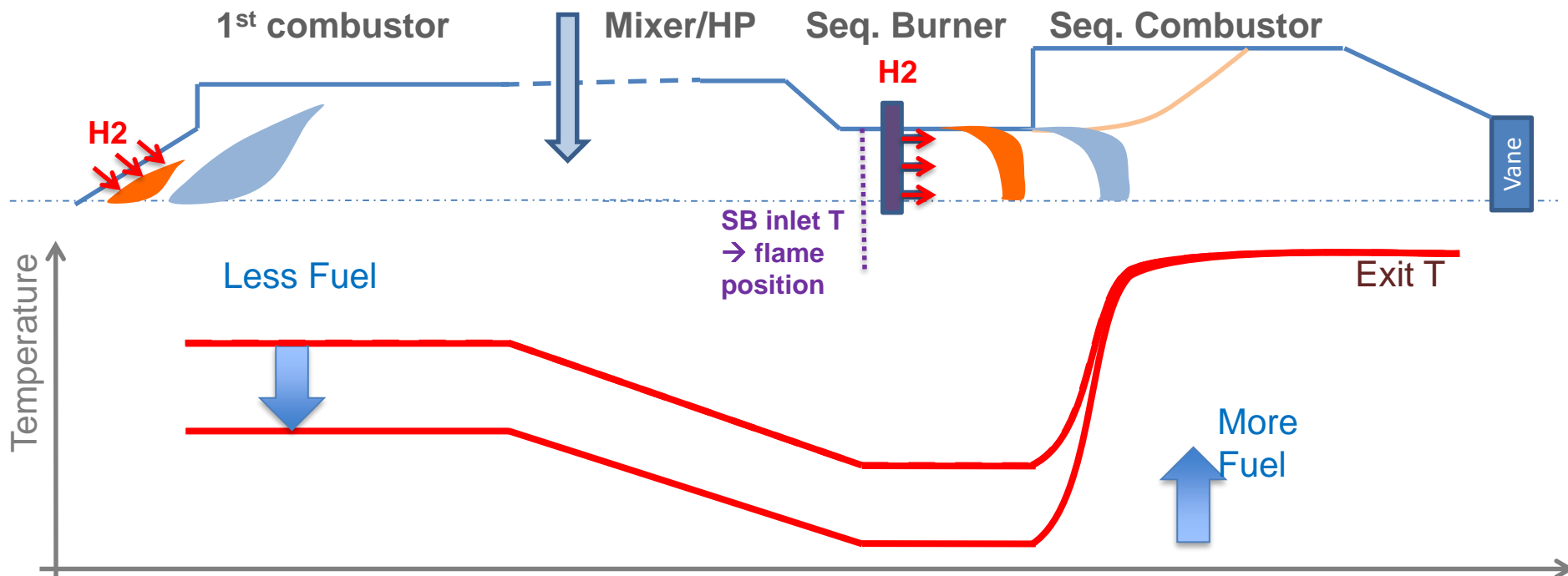


- **Non-reheat systems:**

- → flame propagation speed increases
- → flame temperature must be decreased to avoid flashback
- → turbine inlet temperature is decreased
- → power and efficiency loss

A generic premix combustor needs de-rating to prevent flashback

# Reheat combustion advantage for highly reactive fuels



## • Reheat systems

- → 2<sup>nd</sup> stage is mainly autoignition stabilized
- → 2<sup>nd</sup> stage inlet temperature needs to be decreased and not 2<sup>nd</sup> stage flame temp.
- → turbine inlet temperature less affected
- → 1<sup>st</sup> stage de-rating is compensated by shifting fuel to 2<sup>nd</sup> stage
- → significantly less power & efficiency debit

**Much less penalty on power and efficiency**

Technology	Engine model	year	H2 vol. %	Net Efficiency	Emissions	Load range
<b>Sequential combustion</b>	GT36 New	2018	50	~ 61.5%	NOx @ 15ppm	20-100%
<b>Sequential combustion</b>	GT26 New and service	2018	30	~ 60%	NOx @ 15ppm	20-100%
<b>FlameSheet</b>	Service for: GE 6F, 7F, 9E, 9F S/W, MHPS 501F/G, 701F/G Sie 501B/D	2018	40	~ -1% from original engine level	NOx @ 9ppm	30-100%
<b>Annular Combustion</b>	AE 94.3A	2008	15 (with derating ~ -2% load)	58.5%	NOx @ 25ppm	40-100%
<b>Silo Diffusion</b>	AE 94.2K	1998	35	50% (syngas)	NOx @ 25ppm (steam dilution)	50-100%

**Unlocking the full H2 potential, Ansaldo Energia is your ideal partner**



A close-up photograph of three hands placing wooden letter tiles onto a technical architectural drawing. The tiles are arranged to spell out 'PEOPLE INNOVATION WORLDWIDE EFFICIENCY TOGETHER'. The drawing features various circular and rectangular outlines with dimension lines and numbers, typical of engineering plans. The hands are positioned at the top, bottom left, and middle right, actively placing or adjusting the tiles.

# Power together

Manufacturing and technological capabilities, design expertise, innovative spirit and ability to deliver results, to offer tailor made solutions based on Customers' needs.

**ANSALDO  
ENERGIA**

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