Decarbonizing Refineries & Chemical Plants with Electrification & Digitization

Shebin Jalal
Yasmine McColl

We continue to accelerate our commitment to Sustainability

Leading ESG by example
in our ecosystem

Be the digital partner for **Sustainability and Efficiency** for our customers

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Increasing Sustainability in Chemical Industries

Schneider Electric is on a mission to make industries of the future eco-efficient, agile and resilient through open, software-centric industrial automation.

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Chemical Manufacturing

Key Challenges & Opportunities

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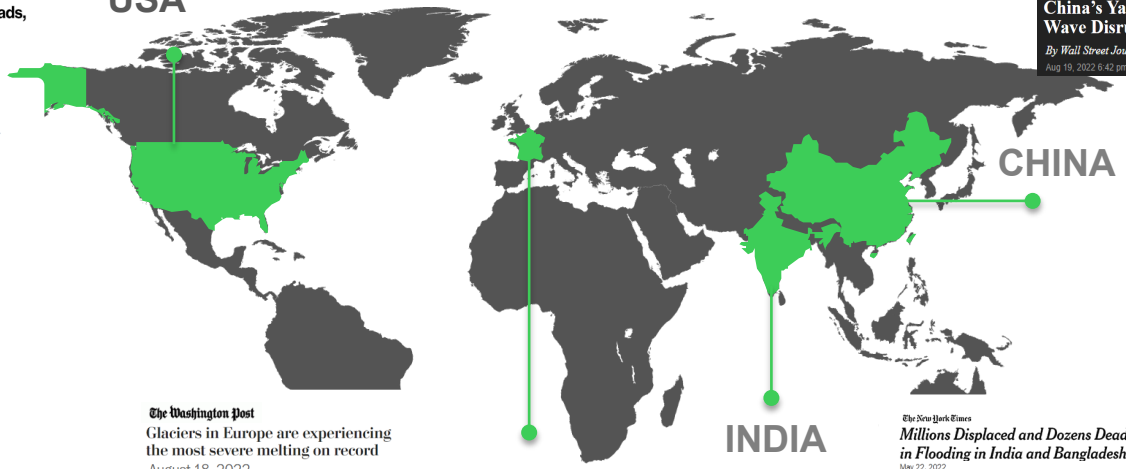
While our attention remains fixated on wars, energy shortages, social tensions & new variants, climate-related impacts continue to ravage our world



Bloomberg
Yellowstone Floods Wipe Out Roads, Bridges, Strand Visitors
June 14, 2022 at 3:35 AM GMT+8

The Washington Post
July 2022 featured hottest nights in U.S. history
August 18, 2022

Bloomberg
California Braces for 109-Degree Heat That Will Test Grid
August 15, 2022 at 10:40 PM GMT+8

China's Yangtze River Dries Up as Heat Wave Disrupts Factories
By Wall Street Journal
Aug 19, 2022 6:42 pm

The Washington Post
China's summer heat wave is breaking all records
August 24, 2022

The Washington Post
Glaciers in Europe are experiencing the most severe melting on record
August 18, 2022

The New York Times
Millions Displaced and Dozens Dead in Flooding in India and Bangladesh
May 22, 2022

BBC
Drought hits Germany's Rhine River: 'We have 30cm of water left'
12 August

REUTERS
France battles 'monster' wildfire as heatwaves scorch Europe
August 12, 2022

FINANCIAL TIMES
'A super-flood to beat all': monsoon disaster piles misery on Pakistan

REUTERS
Landslide kills 14 in eastern India, nearly 50 others feared dead
July 1, 2022

Impacts which will only get more frequent, severe, devastating and irreversible

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We are under pressure to decarbonize…but have a dilemma

- Stakeholders pressure
- Risks on access to finance
- Risks on access to talents

You have taken ambitious NetZero commitments…

Credibility challenges:
- Setting appropriate short-term targets
- Asset divestments must not justify continued investment in new fossil assets
- 3rd Party offsets may not actually lead to emissions reductions
- “nature-based solutions” will be challenged
- Ambitious (and costly) technologies such as CCUS, Blue or Green Hydrogen need in-depth scrutiny and stable regulatory framework

What are you going to do?

?

Scope 1 & 2

- **Energy & Process Efficiency** Conduct operations more efficiently
- **Electrify** with Renewables
- **Green Hydrogen**
- **CCUS** and Blue Hydrogen

Scope 3 Suppliers

- **Credit Offsets**
- **Value and Supply Chain** Suppliers, engineering & construction

Understanding the Heavy GHG Footprint

In Heavy Process Industries

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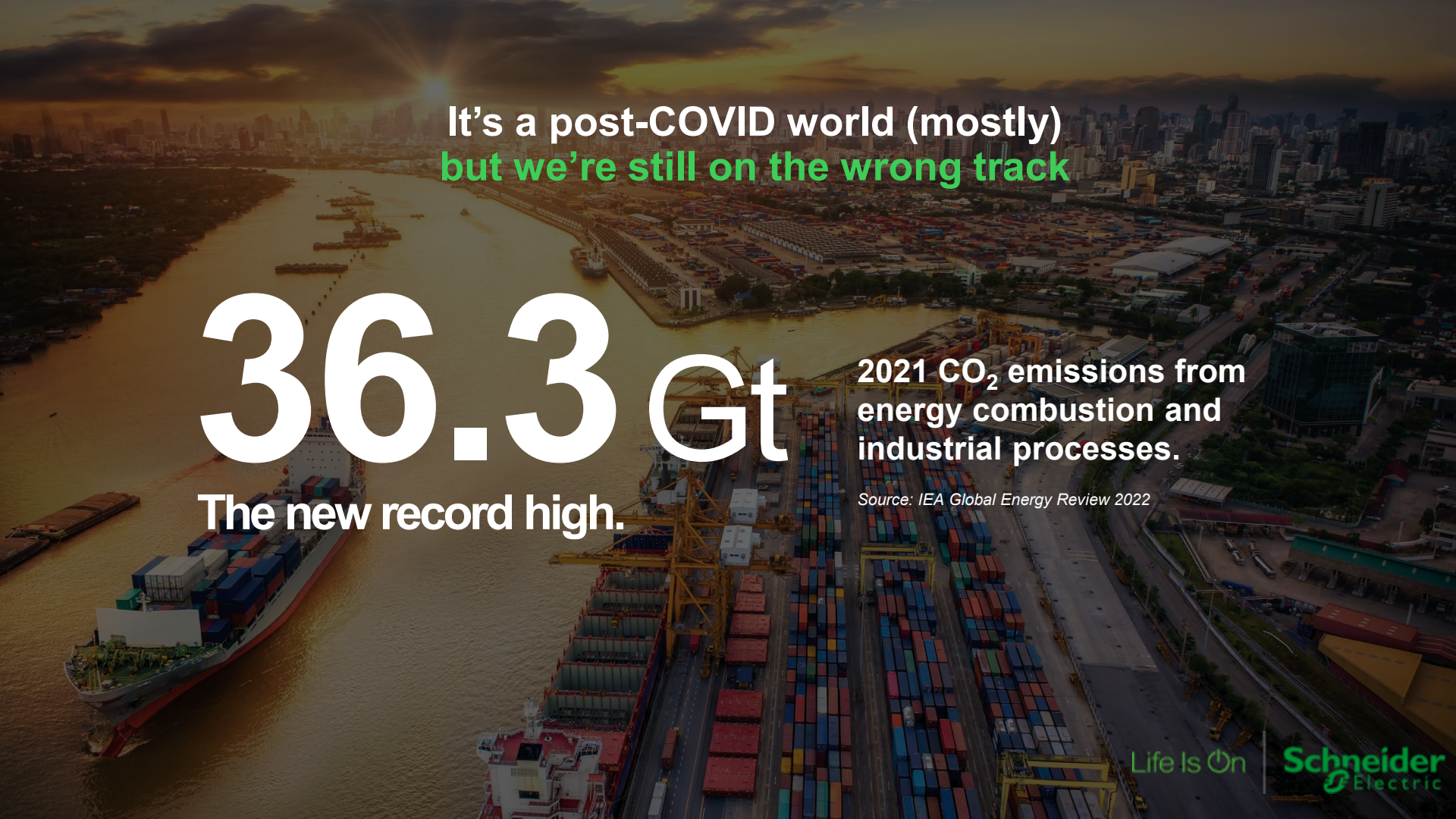
It’s a post-COVID world (mostly)
but we’re still on the wrong track
36.3 Gt
The new record high.
2021 CO_2 emissions from energy combustion and industrial processes.
Source: IEA Global Energy Review 2022
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The industries we all rely on contribute a substantial portion of global emissions

8.7 Gt

Power generation, industrial emissions are the largest contributor to total global emissions (26% in 2020).

Source: IEA, Tracking Industry 2021

"Industry is the largest end-use sector in terms of energy use and CO_2 emissions; its challenge is to meet the rising demand for materials while transitioning from unabated fossil fuels."

Industrial energy consumption increased an average 1% per year between 2010 and 2019

IEA World Energy Outlook 2021, page 134

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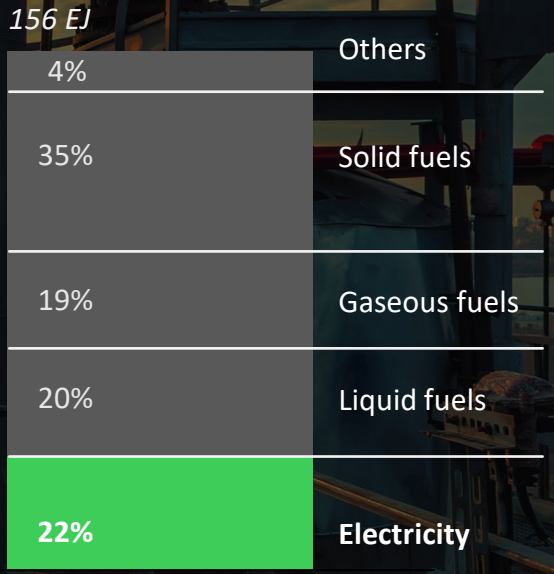
High industrial emissions come from the choice of fuels

78%

of energy used in industry is not electrified

Source: IEA, Tracking Industry 2021

2020 global final energy consumption in the industry sector



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Industries have different ways to decarbonize

Why does process electrification top the list?

Electric

makes energy green

Electricity is the most efficient energy and the best vector of decarbonization

&

Digital

makes energy smart

Digital makes the invisible visible, measurable, and actionable

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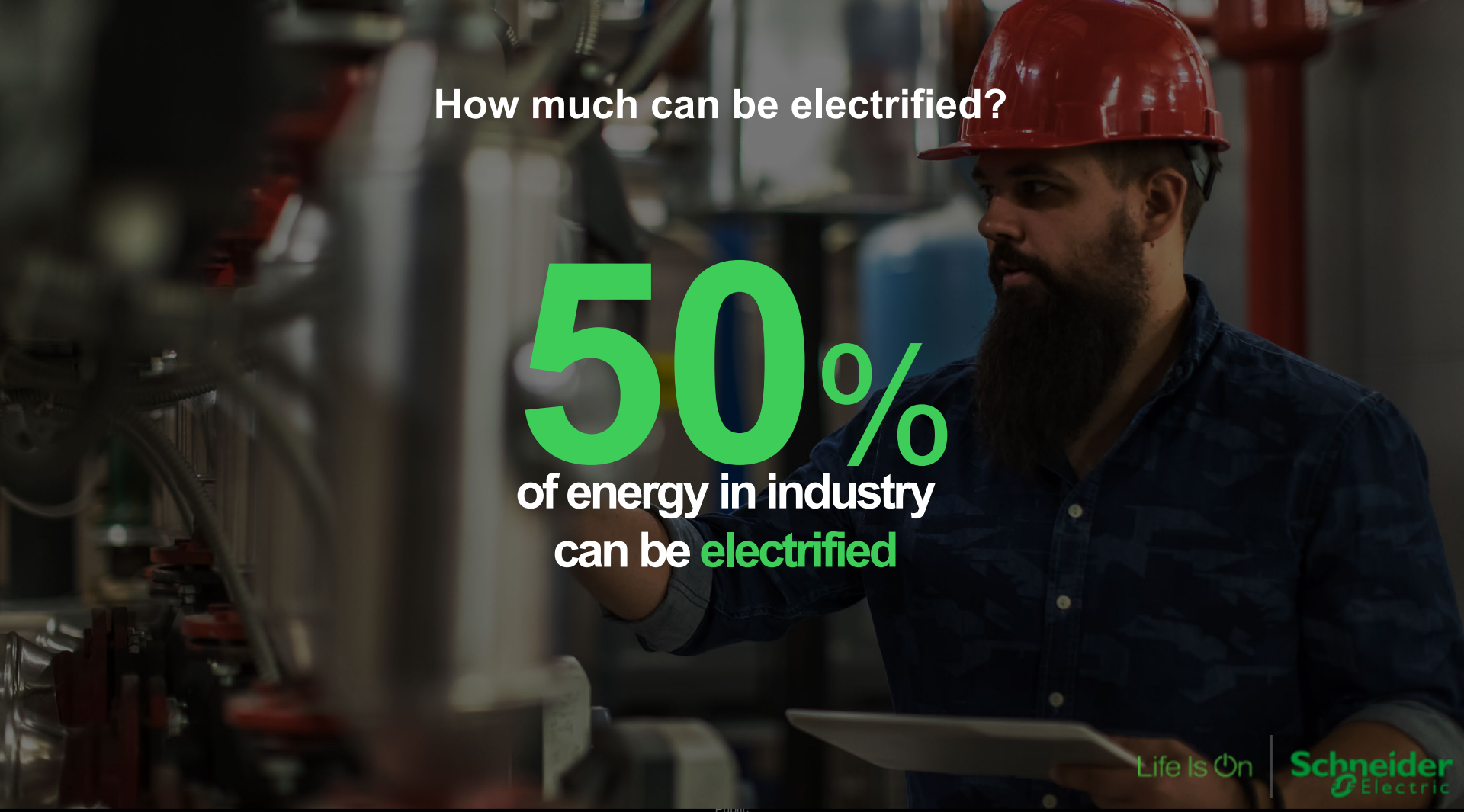
How much can be electrified?
50%
of energy in industry
can be electrified
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Decarbonization Strategies

For Refining & Petrochemicals

Decarbonization Journey Towards Net Zero Operations

Low Hanging Fruit 0-35% CO_{2e} Reductions

- Remote operations in onshore upstream
- VSD on various pumps, fans and compressors
- Intrusion Detection + Leak Detection
- Harmonic filtering and reactive power compensation
- Planning and Scheduling for energy efficiency
- Sustainability KPI's monitoring
- …and more….

Paradigm Change

- Power Purchasing Agreement
- Energy as a Service
- Control & Operate an Offshore /onshore Windfarm
- Power from Shore
- **Process Electrification**
- De-manned / Remote operations
- Operator Training Simulators
- …and more…

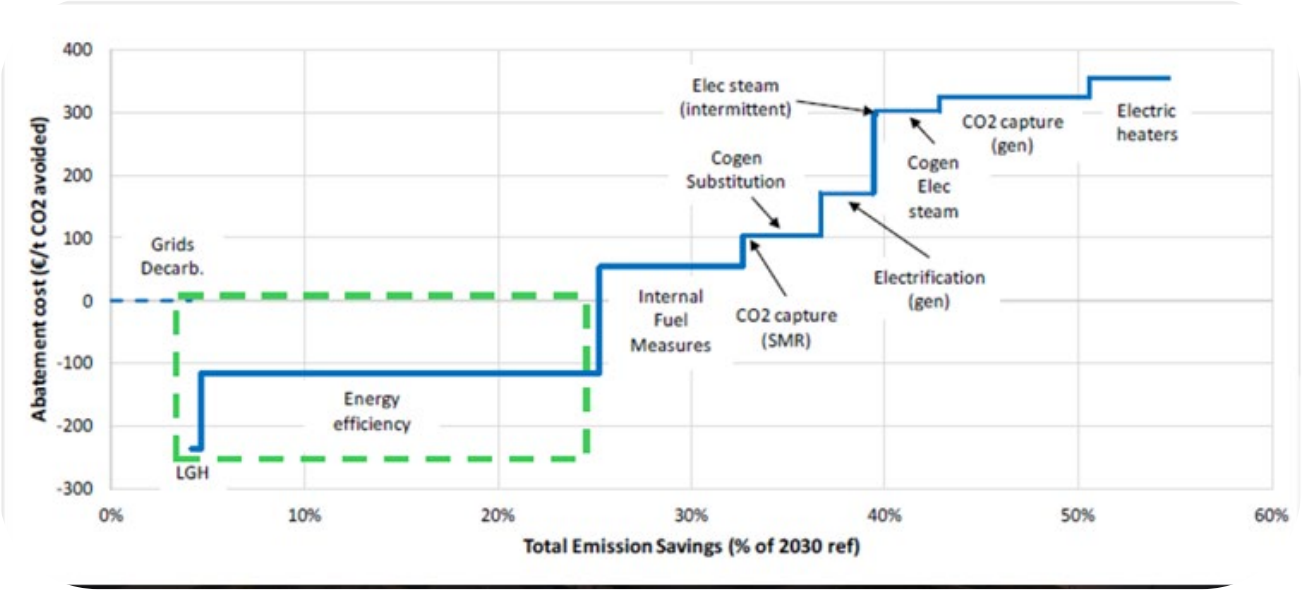
Breakthrough

- Carbon Capture
- Blue and Green Hydrogen
- Electro-chemical processes
- …and more…

CO_2 Cost Abatement For Different Options

CO_2 Abatement Cost Curve

(Energy prices and potential CO2 savings as defined in the 2050 median case)



- EE offers ROI even without any Carbon tax
- Electrification cost can be much lower by integrating flexibility
- CCUS requires major capital investment and proper ecosystem

Source: Concawe report on CO2 reduction technologies - https://www.concawe.eu/wp-content/uploads/Rpt_19-8.pdf

Electrification of Heavy Processes

Building a Roadmap

Asset Process Electrification Journey

Assess the Potential

- Select Pilot project
- Consulting / Pre-study
- Approximative saving quantification

+

Process Electrification

- Identify functions to be electrified:
- Small heater
- SMR electrification
- Catalytic reactive heaters
- Heat pumps
- Re-optimize heat exchangers
- VFD based flow regulation
- Large motors & compressors

+

Proposed Power Supply

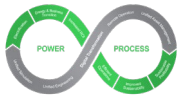
- Green Energy
- Utility contract
- Hybridation

+

Leverage Demand-Side Flexibility

- Hybrid heaters
- Storage (heat, electricity, intermediate feedstock)
- Process adjustments
- Monetization

GHG Reduction Ambition



GHG Reduction Target!

Enablers

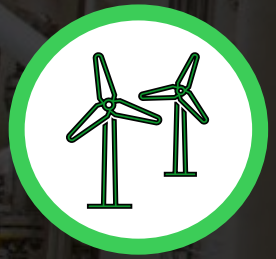
Parallel activities of Short-term and Long-term Roadmap

- Optimize Electrical Design & Architecture / Re-assess
- Electrical Network Study
- Integrate Electrical system with Process Control

A Comprehensive approach to Electrification

From design to operations

Decarbonization



- Carbon Reduction Strategy
- Alternate Technology Assessments
- Power Purchase Agreement
- Onsite Renewable Generation
- Energy Procurement Risk Management

Grid Connection

- Capacity Assessment
- Energy Management System

Power System

- Process Electrification Consulting
- Optimized Electrical Distribution
- High Availability of Power Supply
- Power quality and control
- Heating loads Power Control

Process System

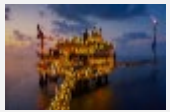
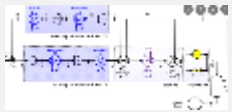
- Model-based Predictive Control
- Process Control
- Consistency with energy balance

- Integrated Power & Process Control
- Asset Performance Management
- Operator Training Simulation
- Safety and Cybersecurity

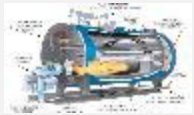
Refineries and Chemicals Electrification

2 Key Areas of Process Electrification

1 Electrification of Machine Drive
(compressors, pumps, etc.)

Light Processes (1-10MW) Eg: Final Product Compression	Heavy processes 10-100MW Eg complete offshore topside electrification	Heavy processes 100+MW Eg complete LNG train electrification
Pumps, Compressors 	Motors, pumps, compressors 	Motors, pumps, compressors 
Diesel + Pump ⬇ VSD + Motor + Pump	Replacing direct drive of compressors by gas turbines by a centralised power gen and electric motors ; eventually connection to mainland grid or offshore renewables	Replacing gas-turbine driven compressors by a centralised power gen and electric motors. Potentially connection to grid or renewables

2 Electrification of Heat
(Furnaces, Steam boiler, Gas fired heaters)

Small heaters <10MW Eg refinery & petrochemicals hot oil heaters, steam boilers, heat-tracing…	Large heaters Large green H2 100+MW Eg refinery & petrochemicals CDU, crackers, …
Heaters 	Heaters, boilers, crackers 
Replacing gas heaters by electric or hybrid heaters	Each refinery (600+WW) and Petrochem plant (2000+ WW) represents 1+GW potential Major players start to investigate, create consortiums

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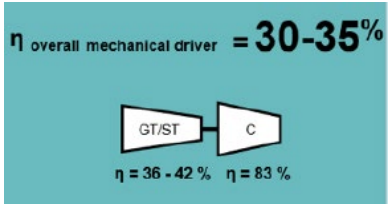
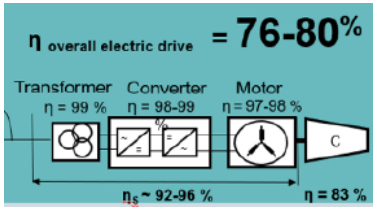
Electrification is delivering value beyond GHG

- Better control, driving higher **Efficiency: ~**95% for electric motors and 99% for thermal energy conversion vs 25 - 40% for fuel powered systems.





Reference 1

- Lower maintenance costs with **Longer MTBF** (x10 vs Gas Turbine) **and Shorter MTTR** (<10% vs Gas Turbine)[2]. Simplifying the system components, eliminating flue gases and soot buildup for heating
- Enablement of **Remote Operations,** better visibility, faster response times with SCR controllers and VFDs.
- Monetization of **Flexibility**

1. Replacement of Steam and Gas Turbines with Electrical high-speed drive systems for CO2 reduction, Siemens AG, PCIC 2022
2. When should an Electric Adjustable Speed Drive be used instead of a Gas or Steam Turbine? – TMEIC 2013

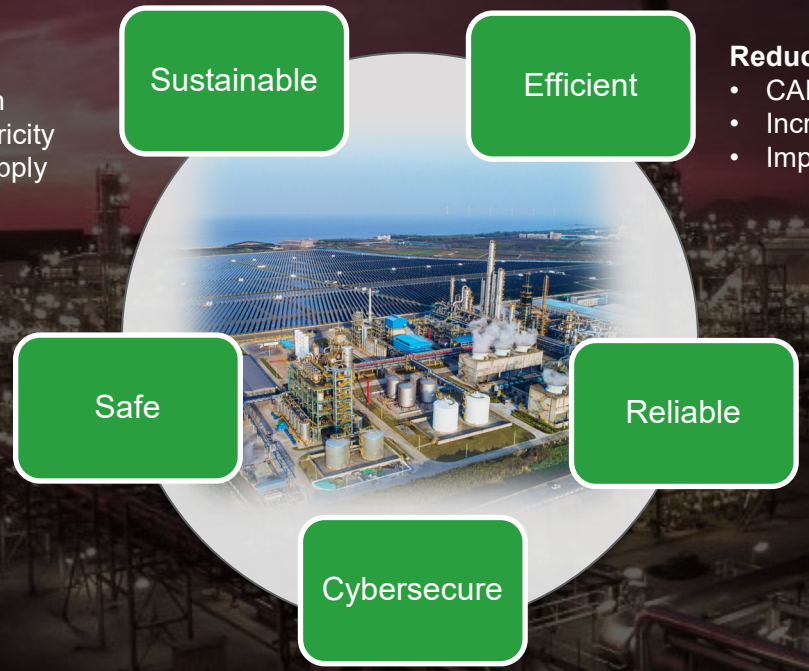
Process Electrification Key Challenges

- Major Electrical Infrastructure upgrades are required behind and in-front of the meter
- High Temperature electrical heating controllability requires Technology breakthroughs.
- How to secure green electricity for large scale electrification ?
- Electrification of Furnaces and Boilers adds a new set of challenges w.r.t Electrical safety!
- Scale of Heating Electrification – large & complex projects

Meeting your sustainability objectives with process electrification solutions

Net Zero Operations
- process electrification with low-carbon electricity
- renewable energy supply

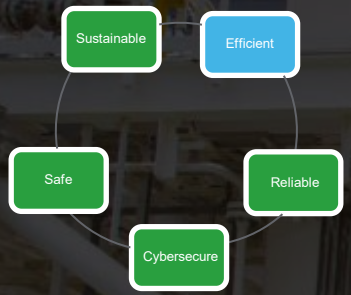
Reduce electrical risks / fires
- thermal monitoring
- arc flash protection



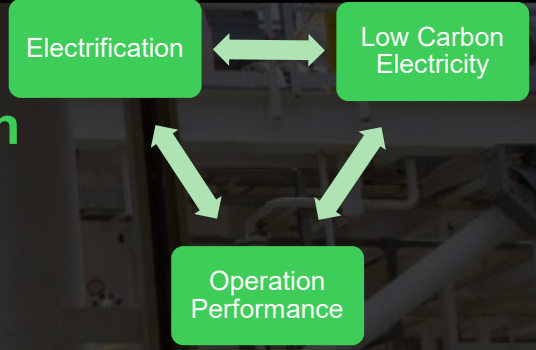
Reduced TCO
- CAPEX Optimization
- Increased equipment efficiency
- Improved process control

Reliability
- power control
- equipment reliability
- power quality

Cyber resilient
- protection, monitoring and control

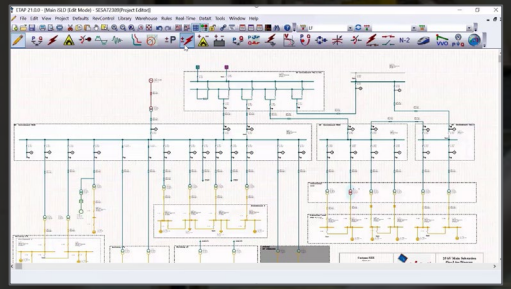


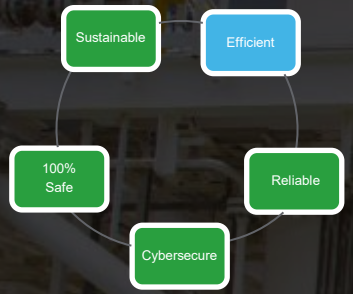
Optimal electrical distribution design



Ensure an optimized electrical distribution design as you migrate over time

- Design and supply electrical and control system to power newly electrified process
- Design optimization based on electricity availability, CapEx, OpEx and CO2 footprint
- Maximize the use of installed equipment
- Leverage ETAP Electrical Digital Twin design capabilities and models
- Streamline the engineering process: ETAP integrated with AVEVA Unified Engineering



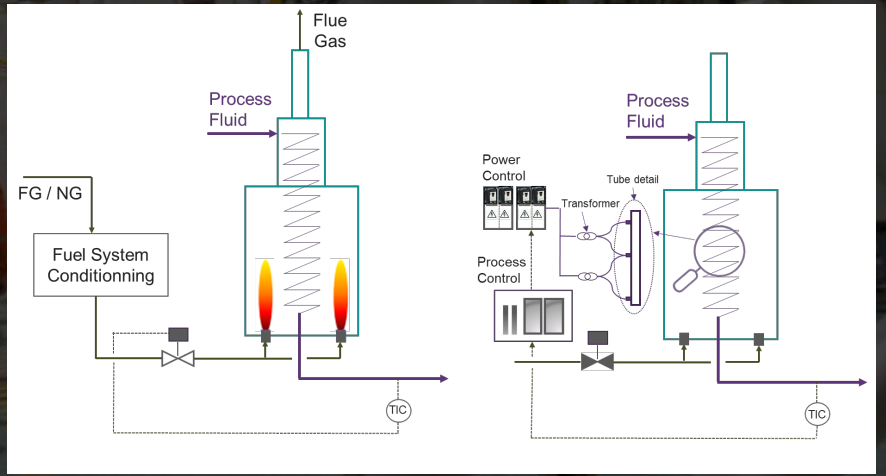


Process Control

Automation system for continuous operations

Ensuring continuous process quality and control 24/7

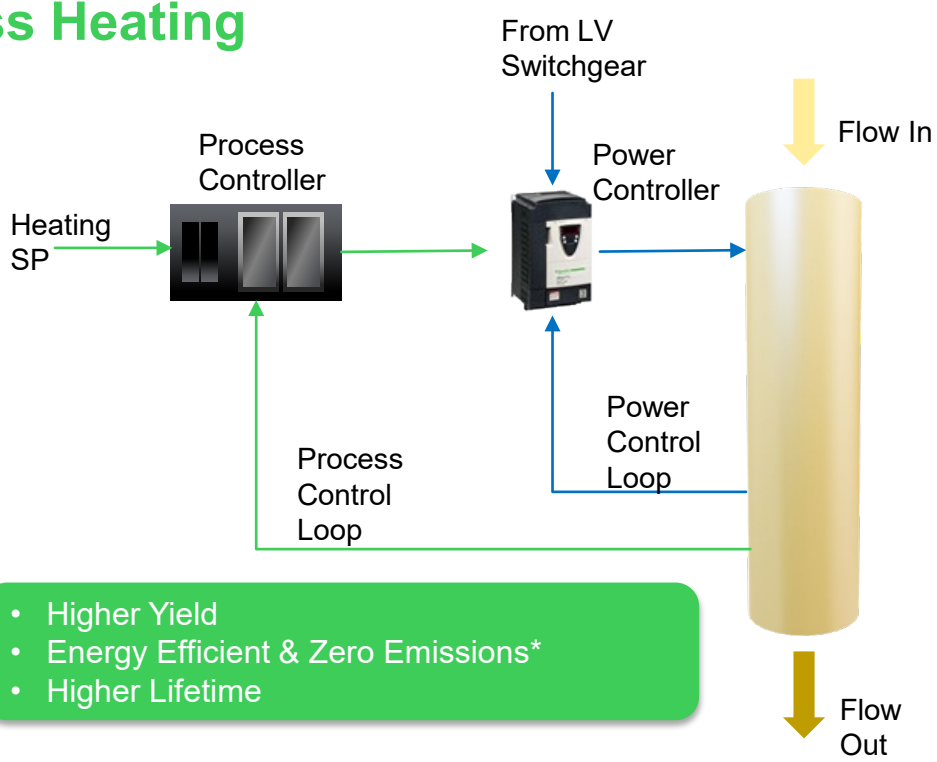
- Uniform temperature distribution and reduced hot spots
- Improved stability and faster response
- Improved turndown ratios for a wider operation range
- For specific technologies such as direct tube heating
  - direct and instantaneous control per pass or per tube
  - tube or pass can be divided into up to 3 zones for improved control to mitigate any potential coke deposit
  - monitoring of coke deposit thanks to the impedance measurement



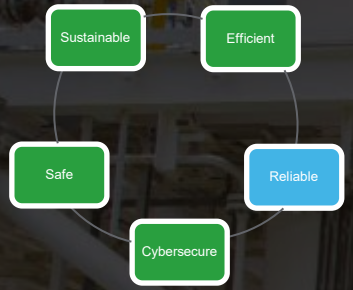
Technology Spotlight - Direct Electric Heating to Replace Fired Process Heating

- Suitable to retrofit high temperature applications in Chemicals (450-1200 Deg C)
- Operates at Safety Voltage (<50V AC)

- Wide Ranging Applications
  - Cracking Furnaces
  - Steam Methane Reformers
  - Ammonia
  - Fuel gas conditioning
  - Amine acid gas removal reboilers
  - Glycol dehydration reboilers
  - Liquid-gas vaporization
  - Condensate Stabilizers
  - Transfer Line Exchanger
  - Plastic Recycling



- Higher Yield
- Energy Efficient & Zero Emissions*
- Higher Lifetime



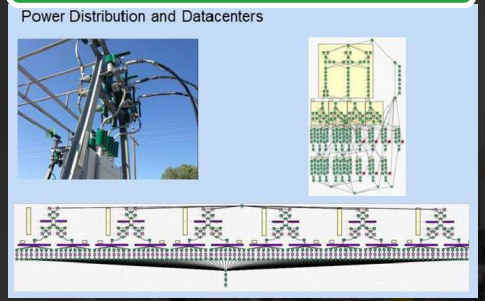
Improved Equipment Reliability

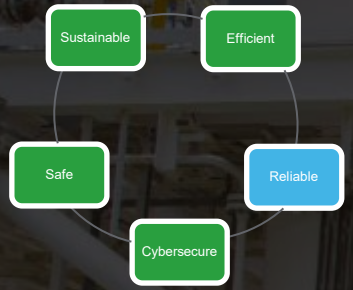
Increased availability

Ensuring continuous monitoring of equipment & systems reliability

- Real-time equipment monitoring and reliability modeling
- Predicts remaining useful life; can anticipate repairs or interventions
- Reduced fouling of heaters due to even energy distribution
- Increased equipment life due to reduced thermal shocks or cycling

Reliability Digital Twin – RAM Model



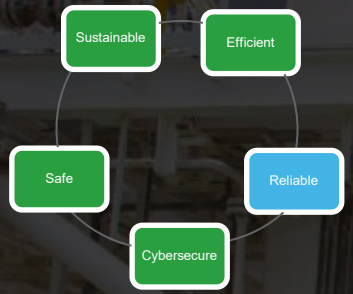


Power Management and Control

Electrical system operation for maximum uptime

Ensuring continuous power supply 24/7

- Intelligent Fast Load Shedding based on IEC61850 strengths to meet best in class response time (<27ms)
- Fault-Tolerant Control Power Architecture, with no data loss (IEC61850)
- Predictive analysis (Simulate before Operate) to secure power operations with ETAP Electrical Digital Twin

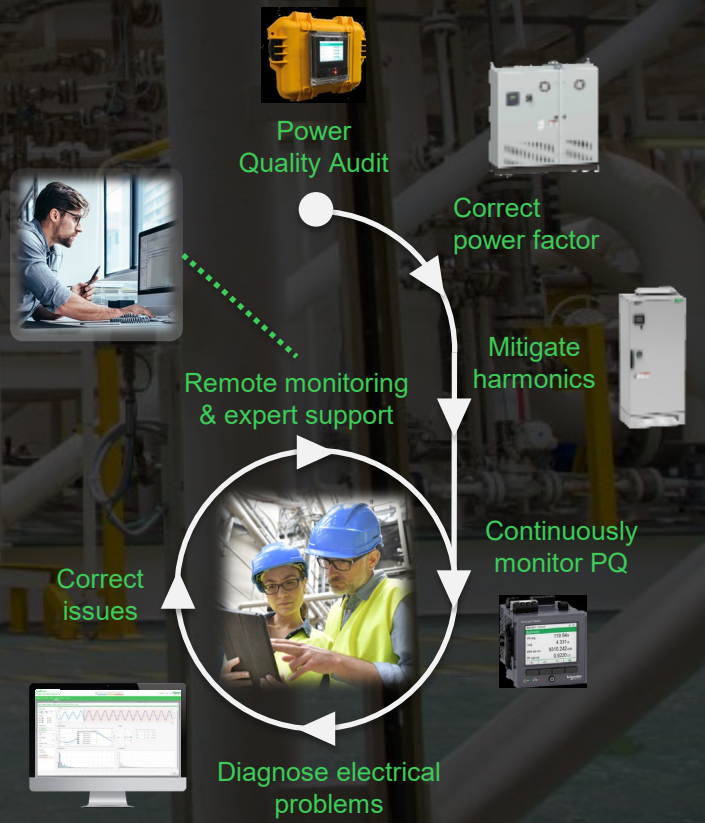


Power Quality Management

Avoid unplanned downtime and maximize equipment performance

Addressing the hidden risks of poor power quality

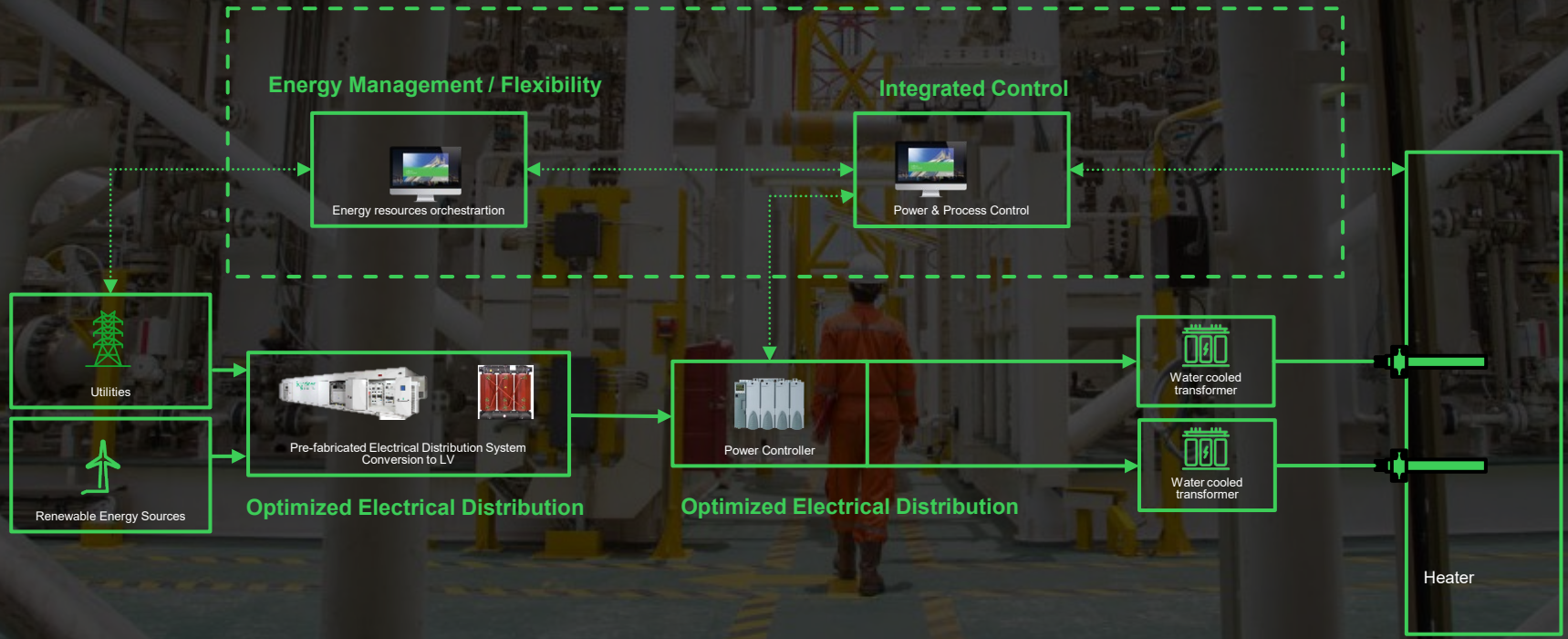
- Commission a Power Quality Audit to find hidden issues that pose a threat to equipment performance and uptime
- Correct poor power factor and mitigate harmonics
- Continuously monitor for power quality disturbances and quickly determine their direction and origin
- Diagnose electrical problems and correct issues efficiently to minimize impact on equipment and production
- Let experts monitor the system remotely and provide the decision support operators need to maximize power performance and lower OpEx



Technology Spotlight -An integrated power and process approach

Complete Power-to-Heat integration

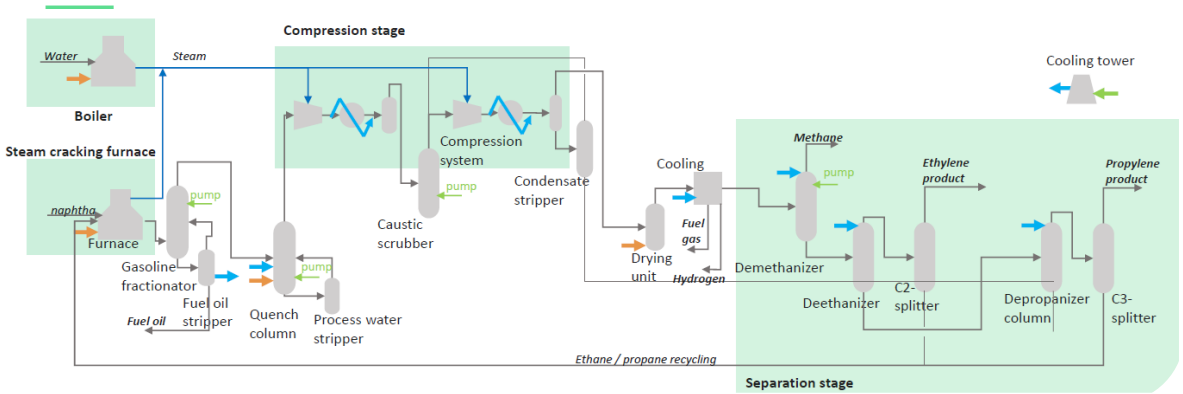
Power + Process



Petrochem – Partial vs Full Electrification

Ethylene Value Chain

Feedstocks	Process Energy and Inputs	Transportation	Use and End of Life
Scope 3	Scope 1 & 2	Scope 3	
• Oil & Gas Extraction • Refining	• Steam Cracking • Additional Processing	• Transporting intermediates and end products • Incineration, landfill	



Clean Power

For Process Electrification

Electrical Energy Demand is Expected to Grow 10-20x with Process Electrification

Conventional Petrochem Facility

20 – 50 MW Electrical System

All Electric Petrochem Facility

300MW – 1GW Electrical System

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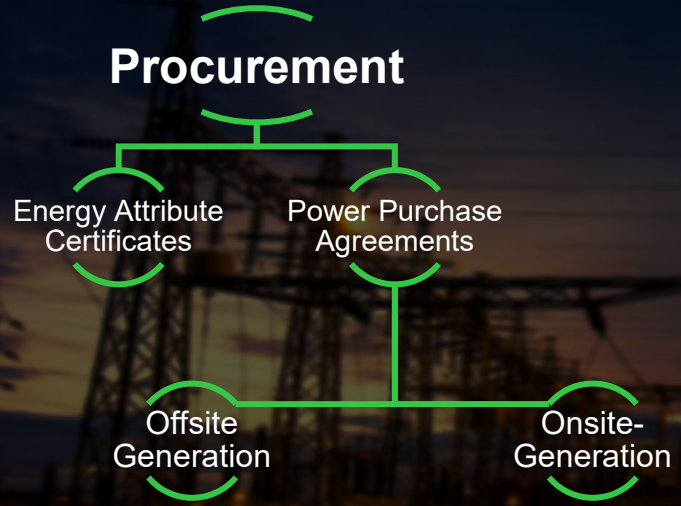
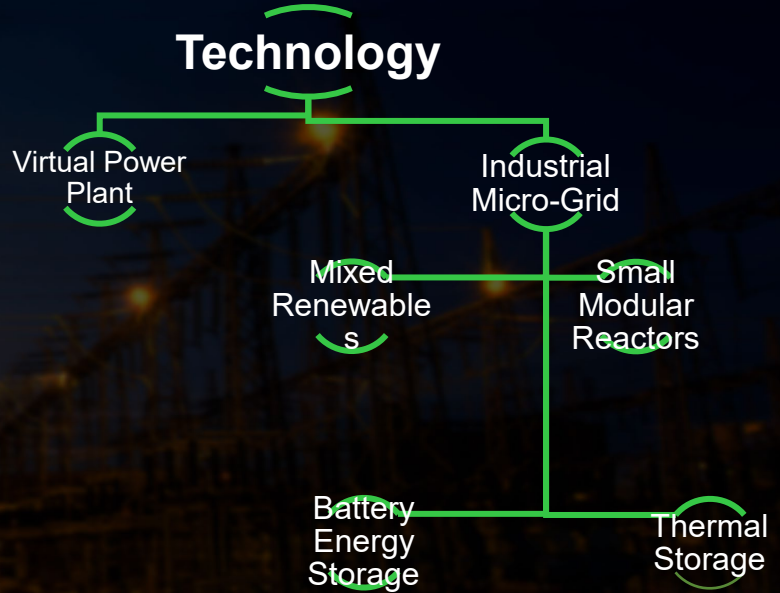
Pathways to Clean Power for Process Electrification





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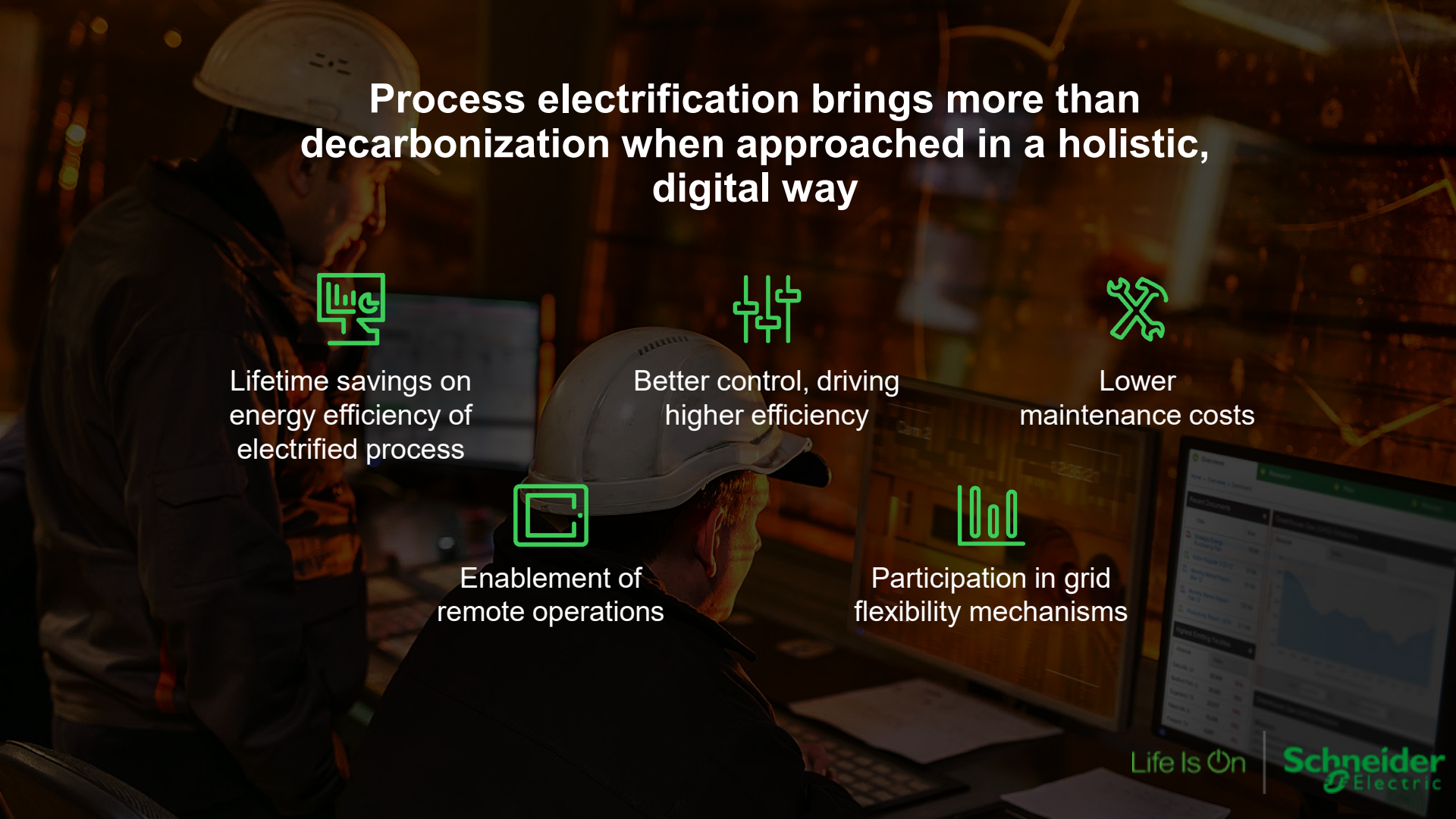
Process electrification brings more than decarbonization when approached in a holistic, digital way



Lifetime savings on energy efficiency of electrified process

Better control, driving higher efficiency

Lower maintenance costs

Enablement of remote operations

Participation in grid flexibility mechanisms

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