TRANSFORMERS MAGAZINE'S
INDUSTRY NAVIGATOR

INVESTMENTS, ARTIFICIAL INTELLIGENCE AND SUSTAINABILITY
CONFERENCE 2024

Sustainability and Industrial Processes Efficiency

- A Smart Legacy to the Future of Power Transformer -

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Presentation Overview

- **Essex Energy**, part of **Superior Essex**, is a leading European producer of winding wires for Power Transformers (PT), HVDC cables and for other market segments

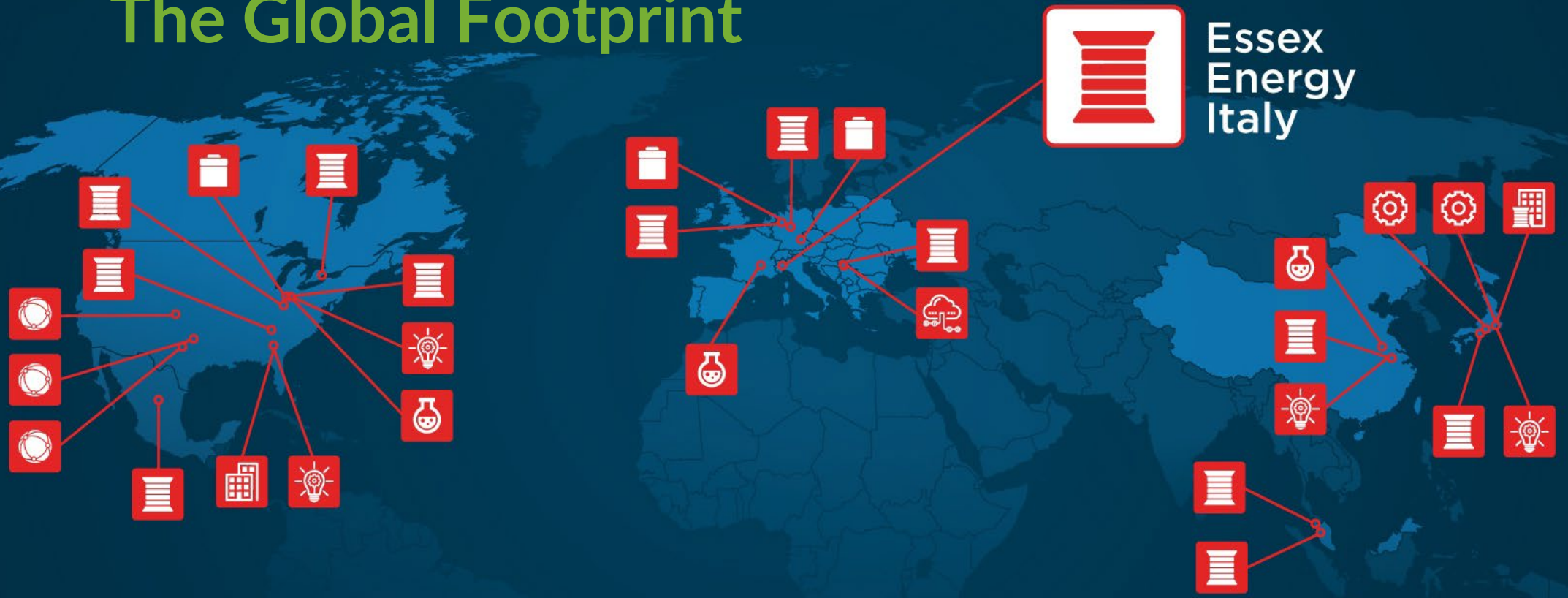
- The main application used by PT customers are the Continuously Transposed Conductors (CTC) and the Paper Wrapped Conductors (PWC)

- Superior Essex is a vertically integrated company specialized in the processing of copper rods with a wide and consolidated product range supporting Small, Medium, Large PT up to HVDC applications

Presentation Overview

- **Essex Energy** produces custom products exclusively upon the designs of our PT customers
- Only 100% customized products are manufactured
- Essex Italy is an Energy intensive production plant (>1 GWh/Month used)

The Global Footprint



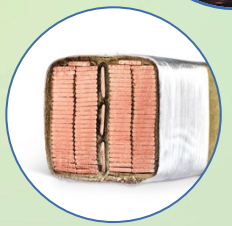
- MAGNET WIRE
- ROD & FOUNDRY, SPECIALTY WIRE
- CHEMICAL PROCESSING
- INNOVATION
- COMMUNICATIONS
- CORPORATE HEADQUARTERS
- MAGNET WIRE HEADQUARTERS JAPAN
- MAGNET WIRE SALES JAPAN
- GLOBAL IT SERVICE CENTRE
- 16 DISTRIBUTION CENTERS*
- 2 FABRICATION*

Solutions for the Energy Market: *PT and HVDC cables*

PRODUCTS

Continuously-Transposed Cable/Conductor
Available with B-Stage Epoxy

Specialty CTC
Netting CTC, Twin CTC, Cordex®



Wrapped Wire
Polyimide/Polyamide/Glass/Paper

Bare Copper

APPLICATIONS

Large Power Transformers

HVDC Power Transformers

HVDC Cables (CU & AL)

Distribution Transformers

Company Key Figures

CAPACITY

- ~20.000 T/y (365 days a year)

PRODUCTS

- **CTC**: ~12.000 MT/y (actual mix)
- **Bare**: ~6.300 MT/y
- **Paper**: ~1.200 MT/y
- **Glass/Tapes**: 800 MT/y

EQUIPMENT

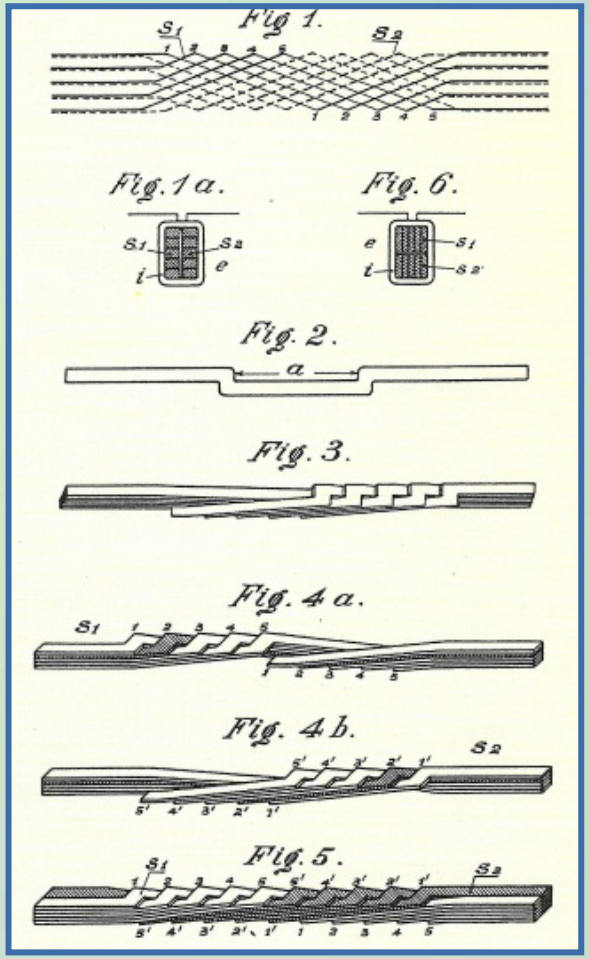
- Drawing, Rolling Mills and Konform machines
- Annealing Oven
- Vertical Enameling Ovens
- CTC & TWIN CTC lines
- Paper and Glass Wrapping lines

PEOPLE

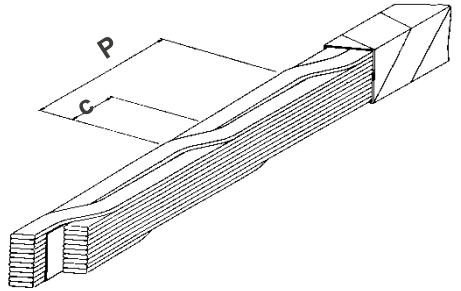
- 160 people
- Production running 24/7

History of Continuously Transposed Cable

- Ludwig Roebel faced big losses due to the skin effect when designing generators above 10 MW
- In 1912 he had a great idea: single insulated and transposed strands to replace the large cross-section conductors that were currently in use within generator designs
- Since 1940, transformer designs have used the ideas of Ludwig Roebel. CTC is now the best winding wire solution for the active part of the PT



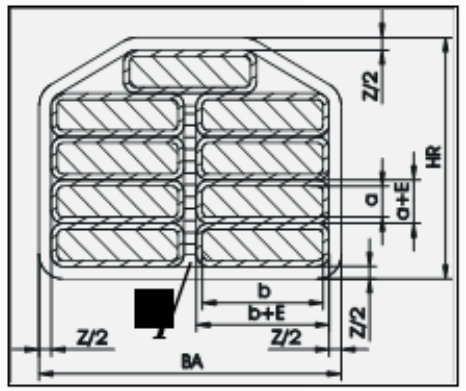
CTC Calculation Rules



Pitch $P = \frac{D \times \pi}{n}$

Transposing Factor $F_T = \frac{D \times \pi}{b \times n}$

d = *Winding diameter*
n = *number of strands*
b = *width of conductor*
c = *crank length*



Radial Size HR $= \frac{(n+1)}{2}(a+E)+Z$
(odd numbers)

Radial Size HR $= \frac{(n+2)}{2}(a+E)+Z$
(even numbers)

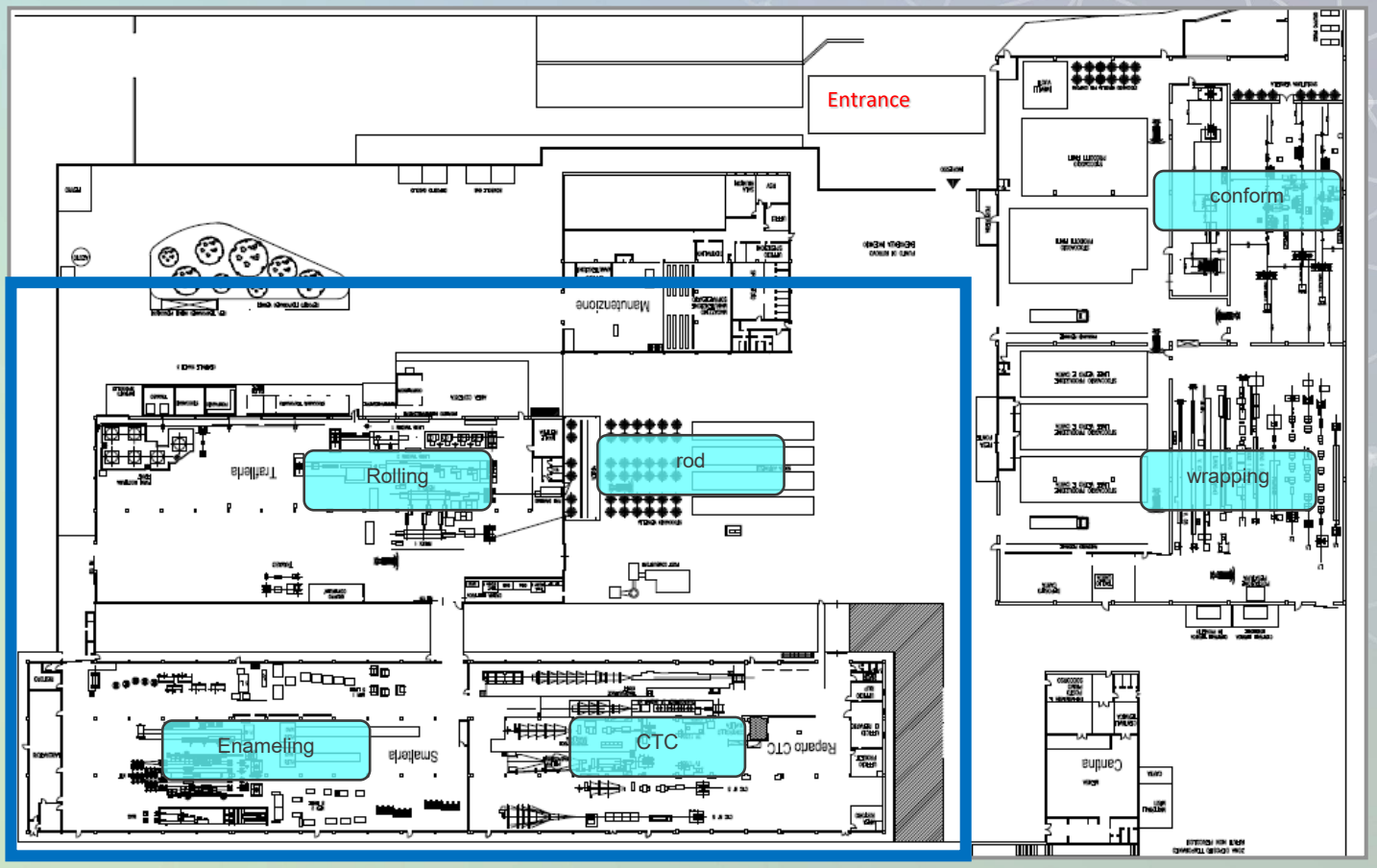
Axial Size BA $= 2(b+E)+I+Z$

Intercolumn Paper I $= \frac{(n-1)}{2}(b+E)$
(min. 8 mm)

Essex Italy Production Plant

CTC production starts from the copper rod:

- Cu-ETP1, Cu-OF1, CuAg0.1



Quattordio Plant Layout

3 MAIN PRODUCTION STEPS:

- Copper drawing ➔ A single copper strip
- Copper enameling ➔ Applied to this copper strip
- CTC Assembly ➔ Create the finished conductor

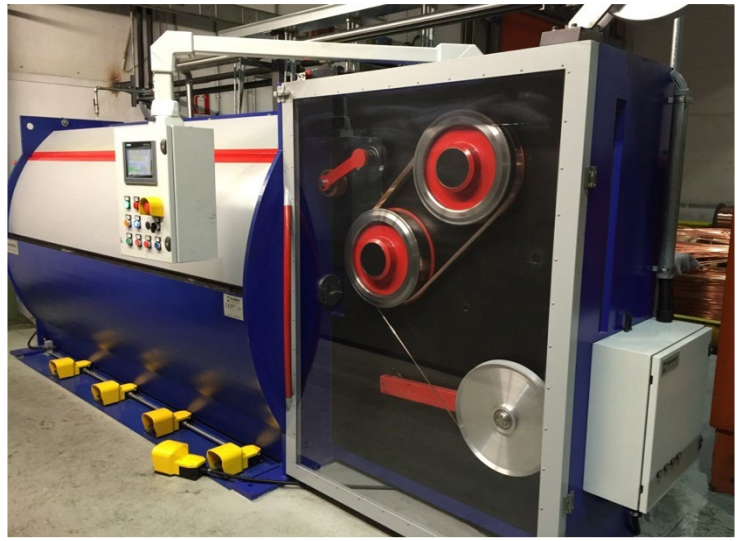
Drawing Department

BASE MATERIAL:

- Cu-ETP1, Cu-OF1, CuAg0.1

EQUIPMENT:

- 3 Five-stands rolling lines
- 2 Break down lines
- Production range: 4 – 150 mm²
- Inline process control:
  - Dimensions with visualization and print
  - Surface and inclusions of print material by inductive sensor



Enamelling Department

NUMBER OF LINES: 31

OVEN HEIGHT: 22 – 25 meters

PRODUCTION RANGE: 4 – 80 mm²

INLINE PROCESS CONTROL: Surface Control

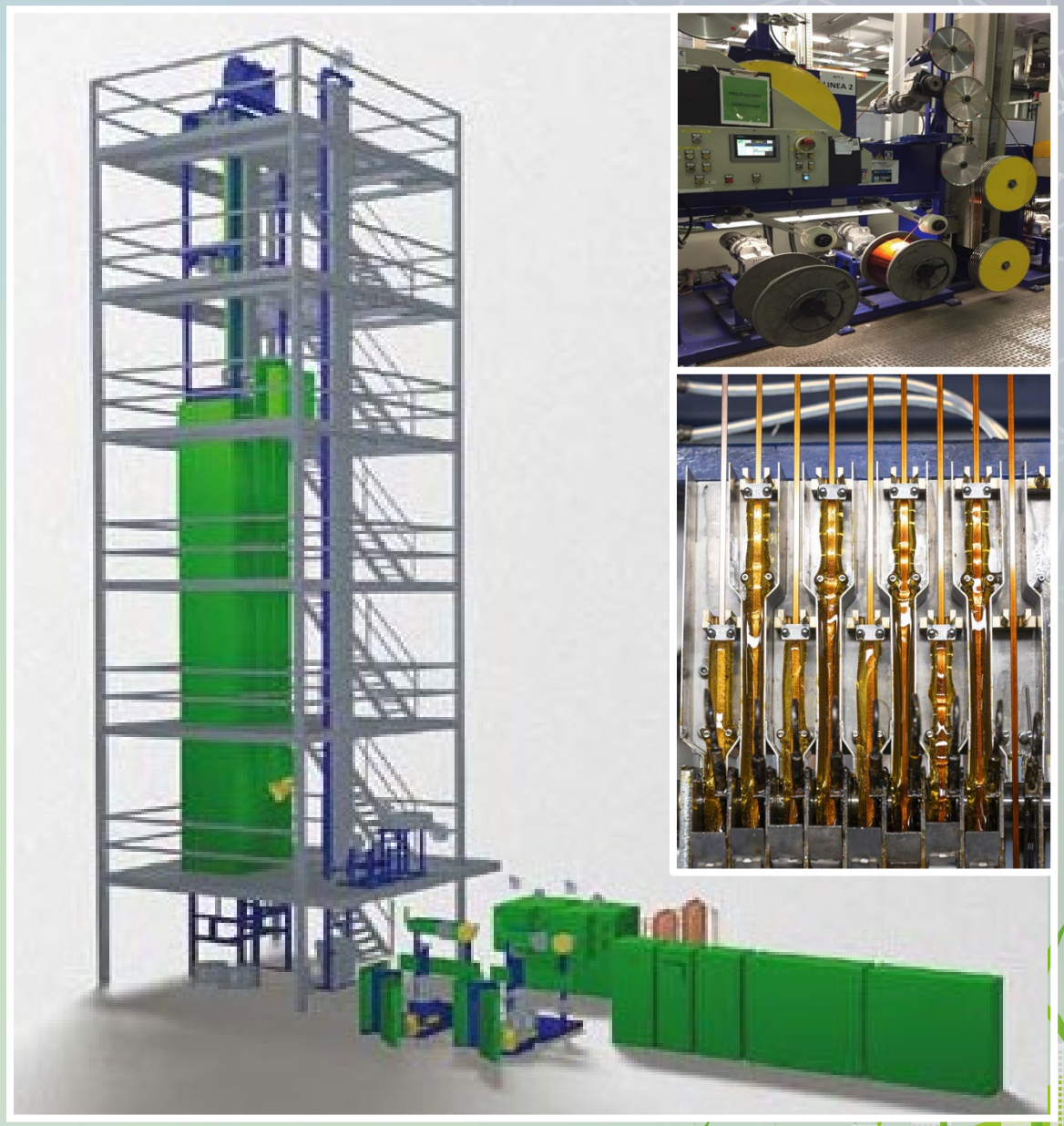
INSULATION COATINGS:

- PolyVinylFormal (PVF) - Class 120°C
- PolyEsterImide (PEI)+ Polyamideimide - Class 200° C
- PolyAmideImide (PAI) – Class 220°C

BONDING EPOXY RESINS:

- Bi-Stage - Thermosetting Epoxy
- Thermoplastic Epoxy

ENAMEL THICKNESS: 0.06 mm (ETE) – 0.18 mm



Source MAG

CTC Department

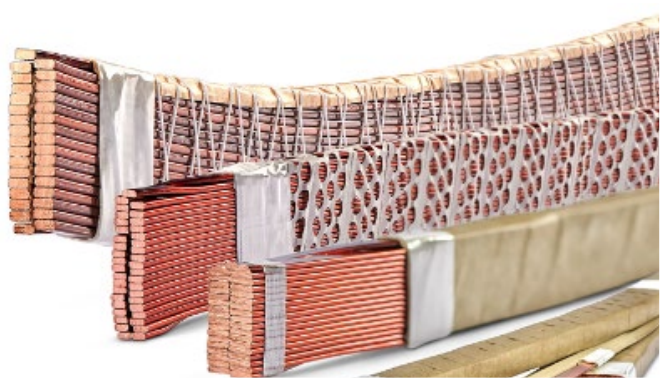
NUMBER OF LINES: 6

CHARACTERIZATION:

- Number Strands: 5 – 79
- Cross Section Strand: 4 – 36 mm²
- Bundle Size: 5,6 – 26,0/4,5 – 82,0 mm

INLINE PROCESS CONTROL:

- Short Circuit Inline Test
- Final HV Test Up to 500 V
- Transposition Failure Test
- Inline Dimensional Controls



Strategy

CHALLENGE:

Reducing the environmental impact—in terms of consumption, pollution, and emissions—is particularly challenging for CTC producing in energy-intensive companies such as Essex Energy

OUR GOAL:

Using less energy, fewer solvents and generating less emissions, Essex Energy believes we can provide our customers with greener products

Our aim is to reduce the energy required to produce 1 kilogram of finished product through a continuous improvement of the process and systems

ACTION PLAN:

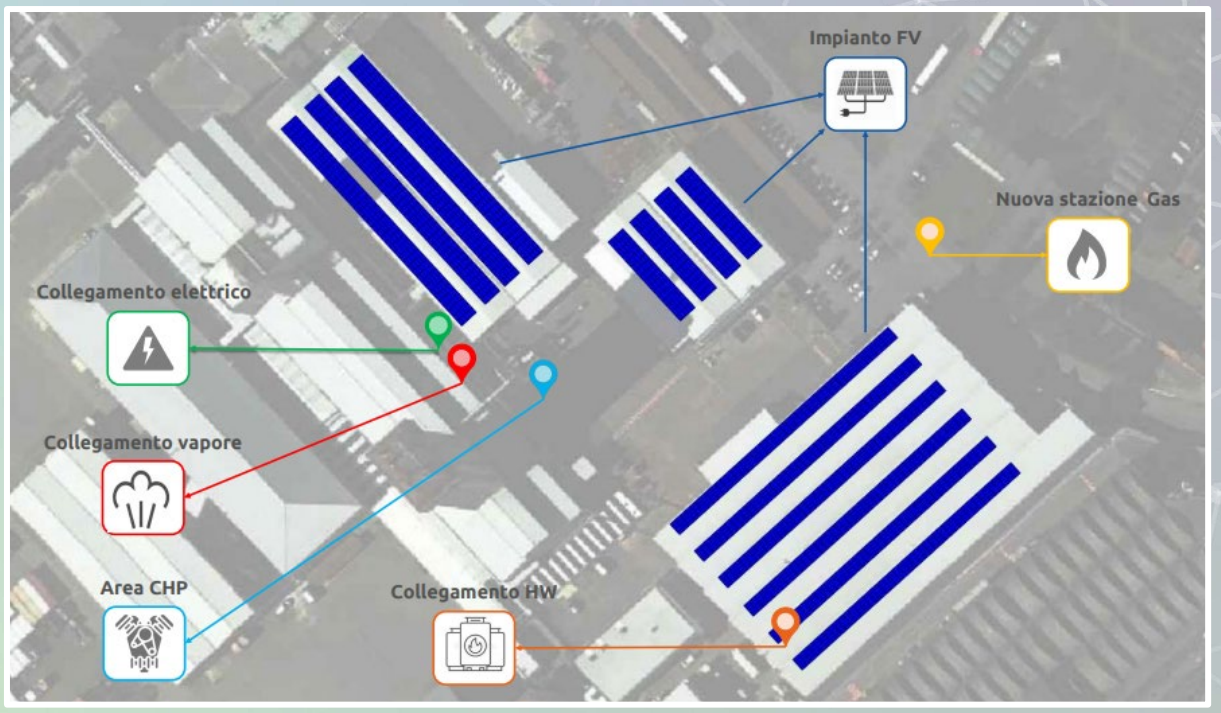
- Use of alternative energy sources:
  - Installation of a photovoltaic system
  - Preliminary evaluation for a cogeneration plant
- Recycled copper
- Increase Efficiency:
  - Technological Scrap Reduction
  - Equipment Revamping
  - New Investments
- Production process and product optimization:
  - ETE products: reduced enamel thickness (0.06 mm) ➔ fewer solvents
  - Industrial processes optimization
  - Double drawing productions reduction ➔ less energy, fewer emissions

Cogeneration Plant Project

INTERNAL COMBUSTION ENGINE

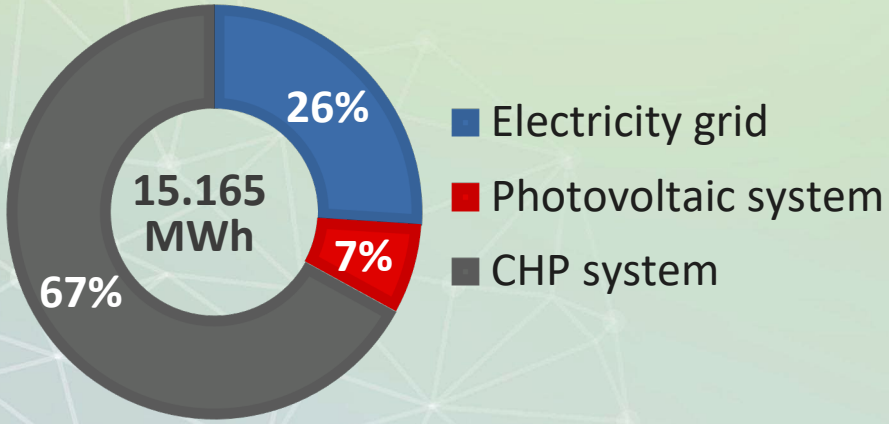
INDUSTRIAL BOILER

ADDITIONAL PHOTOVOLTAIC SYSTEM

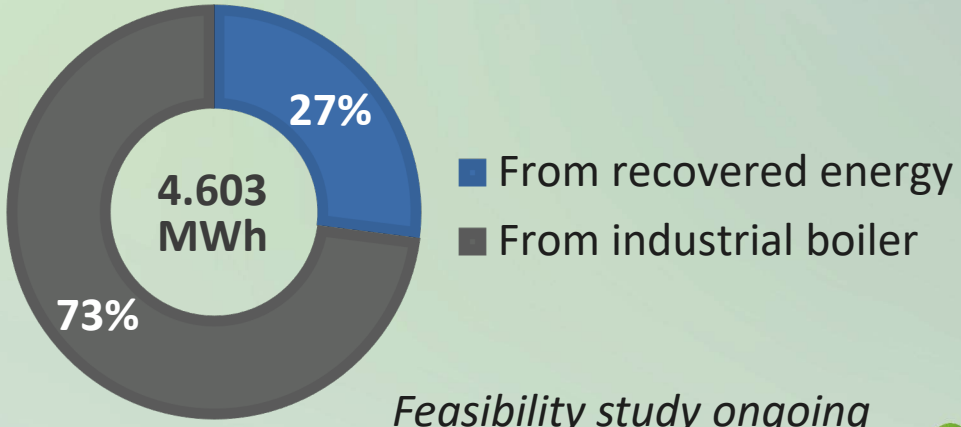


Layout in progress

ELECTRICAL REQUIREMENT



STEAM REQUIREMENT

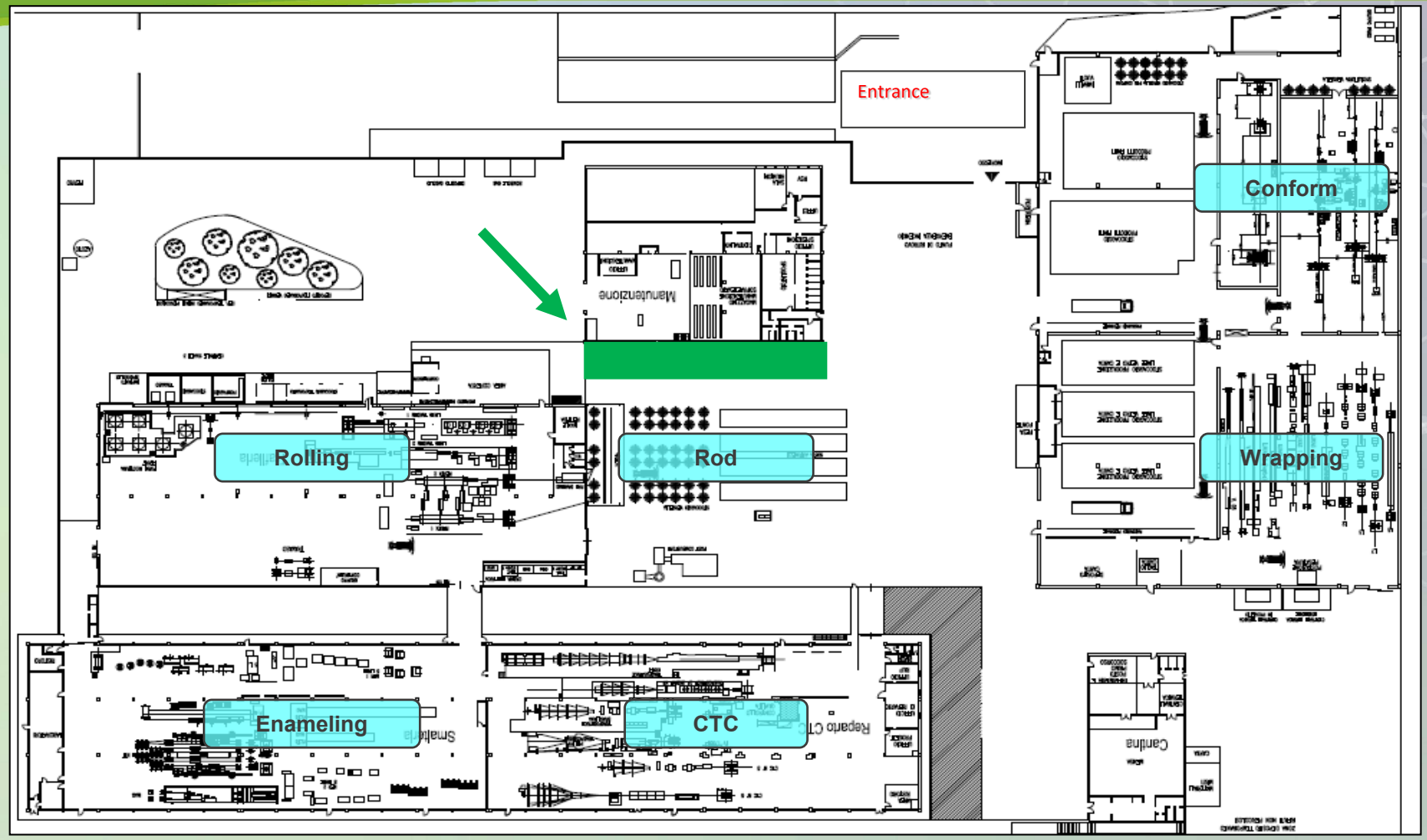


Feasibility study ongoing

Photovoltaic System Project

PHOTOVOLTAIC SYSTEM INSTALLATION:

- Surface: 50 m^2
- Power: 11.00 kWh/year
- Mandatory for the Italian regulations
- To cover the energy needs from the office buildings



Feasibility study ongoing

Gas Consumption Reduction 2022–2023

OPTIMIZATION ACTIONS:

- Annealing Oven Revamping
- Reduction of Production Processes Requiring an Annealing Cycle
- Solvents Post Burner Revamping

Gas Consumption Reduction (m^3/ton) achieved Q4/2022 – Q4/2023:

-18% Gas Consumption

Electricity Consumption Reduction 2021–2024

OPTIMIZATION ACTIONS:

- Process Optimization
- Overall Equipment Effectiveness Increase (OEE) + Technological Scrap Reduction
- Equipment Revamping
- New Investments (Industrial Compressors and Chillers)
- Raw Materials Optimization Vertically Integrated within Superior Essex

Electricity Consumption Reduction (MWh/ton) achieved Q1/2021 – Q1/2024:

-12% Energy Consumption

Conclusions

PRODUCTION PROCESS:

- No repetitive orders: In 90% of the cases, every order is a unique item code produced just once
- All products are customized accordingly to the customer design and requirements

SOURCING LIMITATIONS:

- 100% Green Energy is not yet widely available nor affordable
- Green Copper as base material is not yet widely available on the market
- Hydrogen-based energy production processes are still being developed and will need HVDC PT and cables

Essex Energy has embraced the concept of 'conscientious use' in regards to its resource consumption, in order to create a greener future. We believe that by focusing on our production processes we can reduce carbon emissions and industrial waste

Our Motto

The future is NOW

Back Up Slides

Other Departments

PAPER DEPARTMENT

- Number of lines: 6 (for single or multiple conductors)
- Paper, Nomex, Polyester, Mica tapes
- Max triple possible
- Range: 4 – 130 mm²

GLASS AND GLASS-POLYESTER DEPARTMENT

- Bare and enameled conductors
- Range: 4 – 80 mm²
- Capacity: ~ 300 t/month
- Inline Controls:
  - Copper surface
  - Blister
  - Optical layer control