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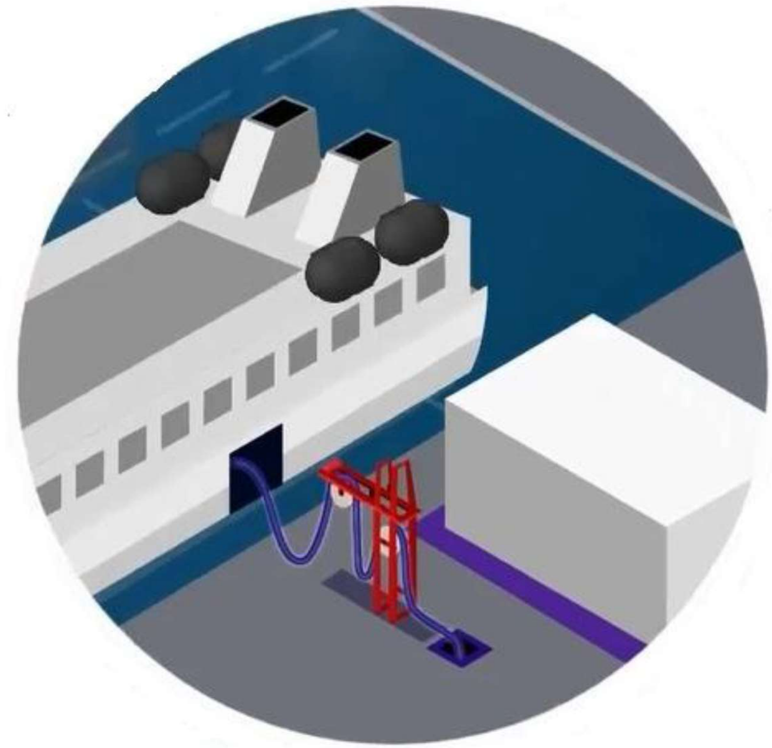
electrification
in the eastern
mediterranean

TECHNICAL EVALUATION OF POSSIBILITIES FOR ELECTRIFICATION OF SHIPS WHILE BERTHING AT THE PORT OF KOPER



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Shipping Electrification Conference on Cold Ironing for Eastern Mediterranean

Koper, 29/1/2018

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- Introduction – Our Motivation and Port of Koper, Energy, Environment and Sustainability
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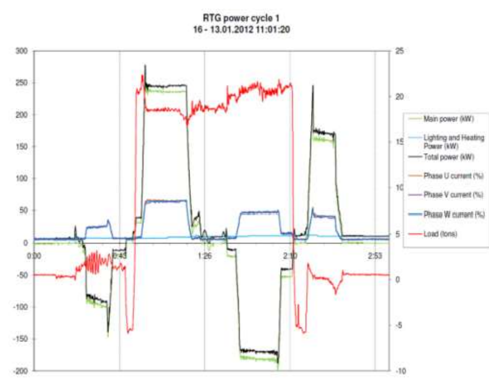
- SWOT Analysis
- Conclusion and Future Challenges

Introduction – Our Motivation and Port of Koper

- **KEY DILEMA**:
  - Paying **fuels** or **intelligent efficient technologies** and new jobs?
- Slovenia is importing almost 100% of natural gas and liquid fuels
- Primary energy costs of Slovenia: 2 billion EUR, >5% of GDP
- In terms of energy use and environmental impacts **Port of Koper** is among **the most advanced ports** in the Mediterranean
- Port of Koper sees **energy and resource efficiency** as a systematic process for continual improvement of its **competitiveness**

Introduction – Electrification and Port of Koper

- Port of Koper **actively supports** the introduction of **the most modern and cleanest technologies** that enable environmental protection at the highest achievable level
- Electricity fuelled shore to ship cranes
- **Positive experiences** with electrification of **RTG cranes**
  - use of electricity instead of diesel in RTG cranes – huge potential for cost and emissions reduction in ports



Introduction – Top ten environmental priorities of the European port sector over time

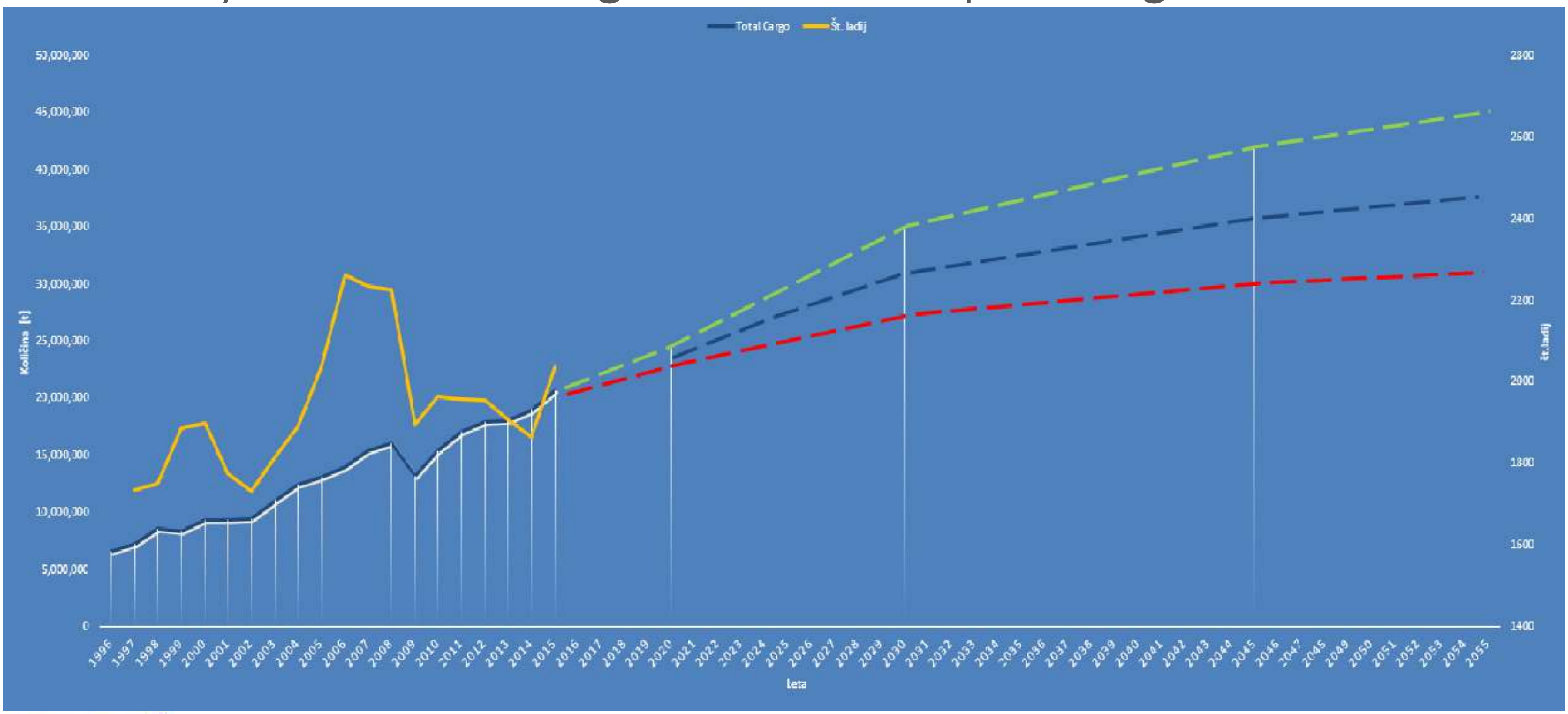
- It is all about sustainability!

	1996	2004	2009	2013
1	Port Development (water)	Garbage / Port waste	Noise	Air quality
2	Water quality	Dredging: operations	Air quality	Garbage/ Port waste
3	Dredging disposal	Dredging disposal	Garbage / Port waste	Energy Consumption
4	Dredging: operations	Dust	Dredging: operations	Noise
5	Dust	Noise	Dredging: disposal	Ship waste
6	Port Development (land)	Air quality	Relationship with local community	Relationship with local community
7	Contaminated land	Hazardous cargo	Energy consumption	Dredging: operations
8	Habitat loss / degradation	Bunkering	Dust	Dust
9	Traffic volume	Port Development (land)	Port Development (water)	Port development (land)
10	Industrial effluent	Ship discharge (bilge)	Port Development (land)	Water quality

Source European Sea Ports Organisation: ESPO Port Performance Dashboard – May 2013

Port of Koper Future Development Trends

The railway will affect cargo but not the passenger traffic!



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Legislative Framework – Cold Ironing in a Vision of Sustainable Port Infrastructure

- Sustainable port infrastructure is not only a vision, but a creative, local process of establishing a solid base for further development of the neighbouring City of Koper and entire Primorska region
- EU and Slovenian alternative fuels strategy – key enabler for future development
- There is a need for a comprehensive implementation approach – "**missing link**" – clear definition of responsibilities, infrastructure and standards

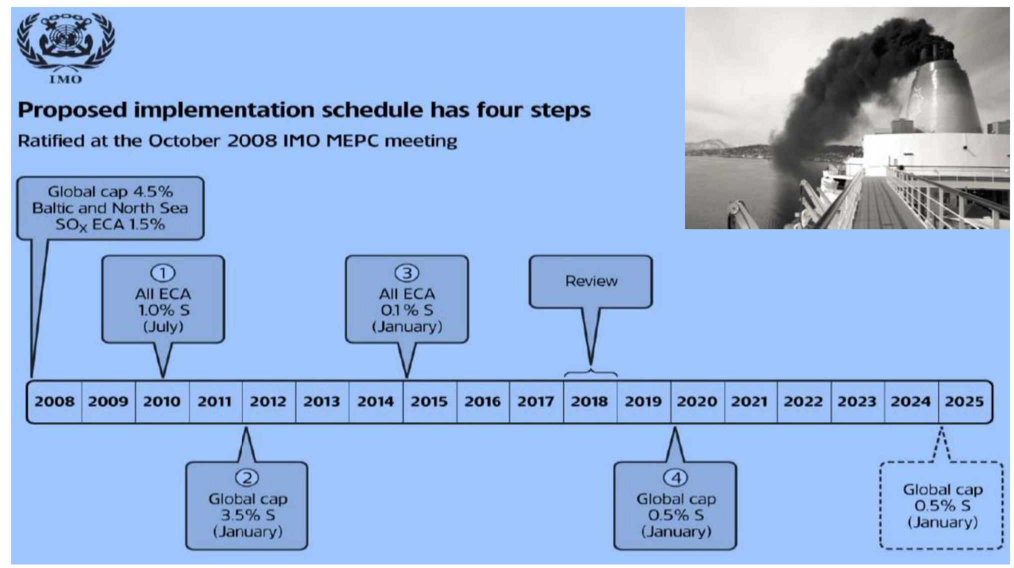
Legislative Framework – Cold Ironing

No acting obligatory international legislative SSE requirements, but directives and standards.

- **World** (United Nations)
  - UN (IMO) directive MARPOL Annex VI, rev. 2007-2008
  - IEC/ISO/IEEE standards
    - IEEE 80005-1 HV shore connection
      - Ship equipment in compliance with IEC 60092-101 and IEC 60092-503 expected, SOLAS CH II-1/D Power up to 7.5MVA.
      - (5.2) Quality of shore HV supply: tolerances, transients, harmonics, installation IEC 61936-1, IEC 62271-200, bonding (IEC 60204-11:2001)
      - (6.3) Shore to ship protection, IEC 60076 for transformers, IEC 60146-1 series for semiconductor convertors
    - IEEE 80005-2 communications monitoring and control
    - IEEE 80005-3 LV shore connection
- **Europe** (EU)
  - Directive 2005/33/EC, binding Directive 2014/94/EU
  - Technical issues: converters 50/60Hz, IEC 60034 – rotating electrical machines, on-board transformers for non-standard voltage.
- **Slovenia**
  - Energy Act, Resolution national programme – 2030 (includes SSE installation deadline 31.12. 2025)
  - Existing SIST EN standards: HVsc: 61936-1, 62271-200, 60204-11:2001, 60076, 60146-1, 60332,
  - **Plans**:
    - SIST on IEC 61363-1 (circuit breakers capacities…), IEC 60092-301 (protection)
    - up to 10% higher power throughput network,
    - V and f quality assured at HV and LV,
    - equipped port hazardous area,

Legislative Framework – Cold Ironing (2)

- Heavy Diesel Oil will be replaced till 2020 resp. 2025 with Low Sulphur Oil with max 0.1-0.5% sulphur content
- Energy efficiency index must be improved for 30% in new designed vessels until 2025
- TIER standard is reducing the gas emissions especially SOx, NOx, PM
- Positive impact of international standards – harmonization of equipment by avoiding differences in technical characteristics of systems, (voltages, power plug and socket design)



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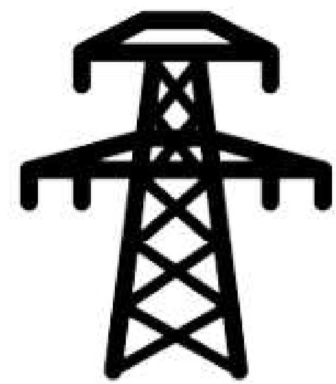
Connection to Slovenian Electric Power System

- Huge impact on Slovenian electric power system:
  - CI demand in Port of Koper comparable to a smaller Slovenian city or a hydropower plant on the Drava river

RTP Nova Gorica 110/20kV	60 MVA
HE Vuzenica (3x26MVA)	78 MVA
CI Port of Koper	**78 MVA**
RTP Koper 110/35/20kV	100 MVA

  - considerable peak demand increase (present peak demand in Slovenia ~2 GW)
  - Intermittent demand (ships are connected and disconnected frequently)
- New connection of Port of Koper to the transmission network (110 kV) is required (planned by ELES). This will:
  - improve the power supply reliability and
  - lower network tariffs.



Existing Installation of Cold Ironing – Variety of Solutions, Voltage Levels and Approaches

Year of introduction	Port name	Country	Capacity (MW)	Frequency (Hz)	Voltage (kV)	Ship types making use of OPS	Number of berths with OPS installed
2000-2010	Gothenburg	Sweden	1.25-2.5	50 & 60	6.6 & 11	RoRo, ROPAX	6
2000	Zeebrugge	Belgium	1.25	50	6.6	RoRo	1
2001	Juneau	U.S.A	7-9	60	6.6 & 11	cruise	1
2004	Los Angeles	U.S.A	7.5-60	60	6.6	container, cruise	24
2005-2006	Seattle	U.S.A	12.8	60	6.6 & 11	cruise	2
2006	Kemi	Finland		50	6.6	ROPAX	
2006	Kotka	Finland		50	6.6	ROPAX	
2006	Oulu	Finland		50	6.6	ROPAX	
2008	Antwerp	Belgium	0.8	50 & 60	6.6	container	
2008	Lübeck	Germany	2.2	50	6	ROPAX	
2009	Vancouver	Canada	16	60	6.6 & 11	cruise	2
2010	San Diego	U.S.A	16	60	6.6 & 11	cruise	3
2010	San Francisco	U.S.A	16	60	6.6 & 11	cruise	1
2010	Verkö, Karlskrona	Sweden	2.5	50		cruise	
2011	Long Beach	U.S.A	16	60	6.6 & 11	cruise	1
2011	Oslo	Norway	4.5	50	11	cruise	1
2011	Prince Rupert	Canada	7.5	60	6.6		1
2012	Rotterdam	Netherlands	2.8	60	11	ROPAX	2
2012	Ystad	Sweden	6.25-10	50 & 60	11	cruise	
2013	Trelleborg	Sweden	0-3.2	50	10.5		6

Source: World Ports Climate Initiative – Ports using OPS

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Existing Installation of Cold Ironing – Variety of Solutions, Voltage Levels and Approaches (2)

Vessel type	Voltage level							
	380 V	400 V	440 V	450 V	460 V	6,6 kV	10 kV	11 kV
Container vessels (< 140 m)	42 %	16 %	42 %	/	/	/	/	/
Container vessels (> 140 m)	6 %	79 %	/	3 %	/	12 %	/	/
Container vessels (total)	19 %	6 %	64 %	2 %	/	9 %	/	/
RO – RO and vehicle vessels	/	30 %	20 %	43 %	7 %	/	/	/
Oil and product tankers	13 %	/	40 %	47 %	/	/	/	/
Cruise ships (< 200 m)	14 %	18 %	59 %	9 %	/	/	/	/
Cruise ships (> 200 m)	/	/	12 %	/	/	48 %	4 %	36 %
Cruise ships (total)	6 %	9 %	34 %	4 %	/	26 %	2 %	19 %

Vessel type	Frequency	
	50 Hz	60 Hz
Container vessels (< 140 m)	63 %	37 %
Container vessels (> 140 m)	6 %	94 %
Container vessels (total)	26 %	74 %
RO – RO and vehicle vessels	30 %	70 %
Oil and product tankers	20 %	80 %
Cruise ships (< 200 m)	36 %	64 %
Cruise ships (> 200 m)	-	100 %
Cruise ships (total)	17 %	83 %

Vessel type	Average power demand [MW]	Peak power demand [MW]	Peak power demand for 95 % of vessels [MW]
Container vessels (< 140 m)	0.17	1	0.8
Container vessels (> 140 m)	1.2	8	5
Container vessels (total)	0.8	8	4
RO – RO and vehicle vessels	1.5	2	1.8
Oil and product tankers	1.4	2.7	2.5
Cruise ships (< 200 m)	4.1	7.3	6.7
Cruise ships (> 200 m)	7.5	11	9.5
Cruise ships (> 300 m)	10	20	12.5

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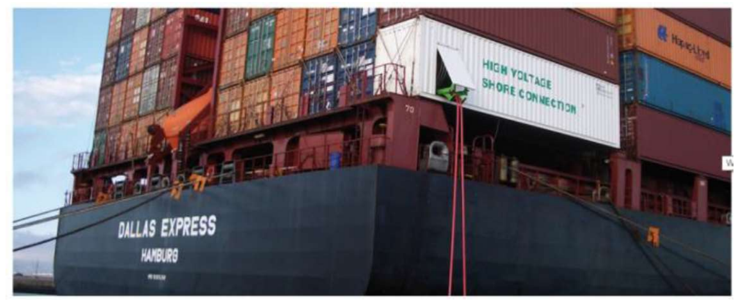
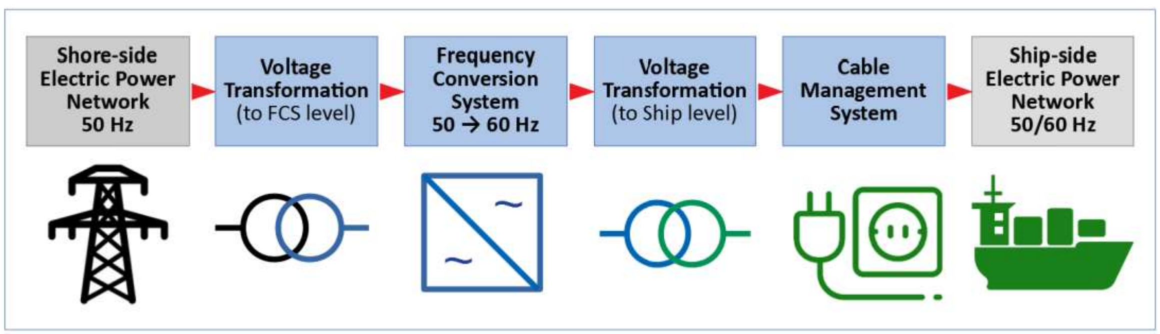
Cold Ironing – Shore-Side Installations

- General electrical requirements covered by international standards:
  - Standard **IEC/ISO/IEEE 80005-1** – High Voltage Shore Connection Systems
- **Frequency conversion system**:
  - European power system operates at **50 Hz** → majority of ships require **60 Hz** power supply:
    - 50 and 60 Hz local port grids for ships are needed.
  - Frequency converter system is a heart of local port grid
    - modern products are based on power electronics,
    - modular solutions available (power upgrade),
    - significant investment cost item.
- Connection **voltage transformation**:
  - Different voltage levels required by ships (0.4, 0.69, 6.6, 11 kV…)
- Not all ships are equipped for cold ironing - conversions required





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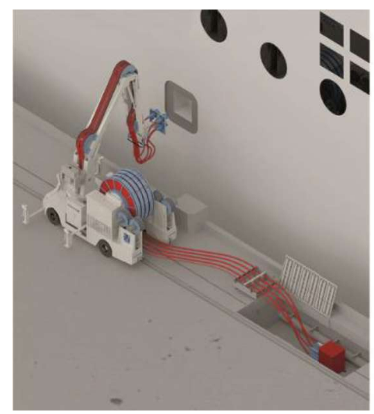
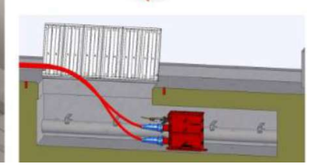
Cold Ironing – Cable Management System

- Different requirements for different types of ship, e.g.:
  - cruise ships: cable reel required in port
  - container ships: own cable reels
- Fixed and mobile solutions are available
- Berth adaptations (complex, cost intensive)
- Automatization is required for faster connection





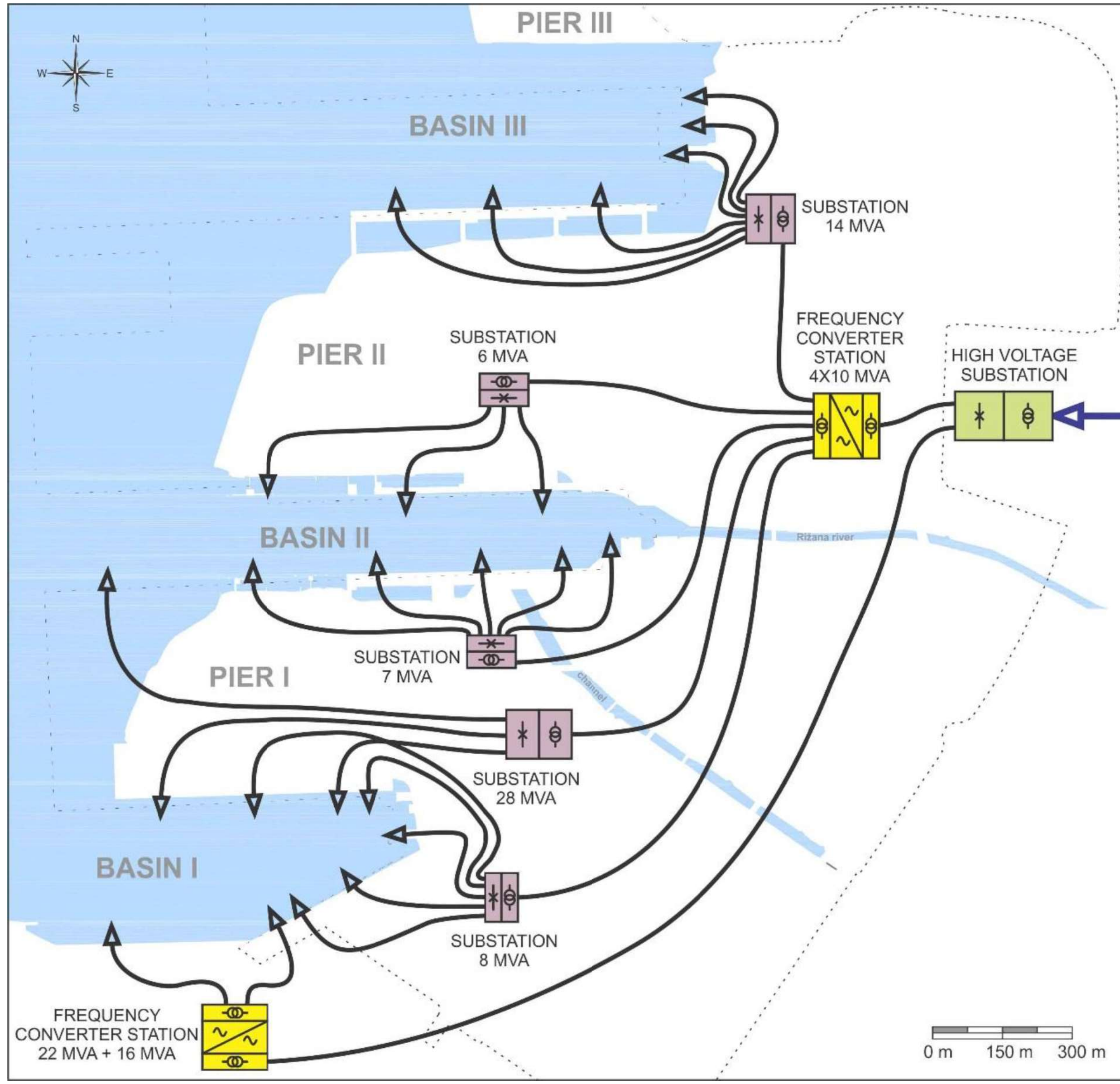
CI in Port of Koper

Situation:

- **22 berths** for container ships, Ro-Ros, tankers, bulk carriers, general cargo ships, cruise ships
- **integrated approach solution** would enable quality and **phased construction**

Proposed CI system:

- **two converter stations** for **cruise ships** (22 MVA (30 × 25 m) + 16 MVA (30 × 16 m)
- **centralized converter station** for **other ships** (modular solution: 4x10 MVA (32 × 28 m))
- converter stations **total installed power 78 MVA**
- **five local substations** for final **distribution of power** (from 9 × 7 m to 15 × 8 m)
- connection to the **high voltage transmission network** (110 kV/20 kV)



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Port of Koper and Cold Ironing Construction in Phases

Cold ironing project analysis

- Few variations of cold ironing system implementation were analyzed.
- All essential elements of the cold ironing system were treated and evaluated:
  - construction work,
  - converter stations and substations,
  - cable connections and
  - ship connection cable management system.
- The precise analysis enabled a qualitative evaluation of the individual phases and the overall investment.

Advantages of phased construction

- Phased construction enables the financial feasibility of the project and the gradual adaptation to the requirements.
- Phased construction allows acquiring of experience and more efficient implementation of the following phases.
- The sequence of subsequent phases can be adjusted or changed.
- Quality planning and integrated approach for cold ironing enable the possibility of synergistic implementation of other necessary investments in Port of Koper.

CI Investment

Initial phase: connection to the 110 kV grid
(15,26 million EUR)

1st phase: first module of the converter station + container terminal 1
(7,97 million EUR)

2nd phase: second module of the converter station + container terminal 2
(5,80 million EUR)

3rd phase: third module of the converter station + container terminal 3 + substation for basin I
(6,15 million EUR)

4th phase: substations for basin II
(3,71 million EUR)

5th phase: forth module of the converter station + substation for basin III
(5,20 million EUR)

6th phase: first cruise ships converter station
(12,20 million EUR)

7th phase: second cruise ships converter station
(6,82 million EUR)

Overall estimated investment costs:
63,11 million EUR

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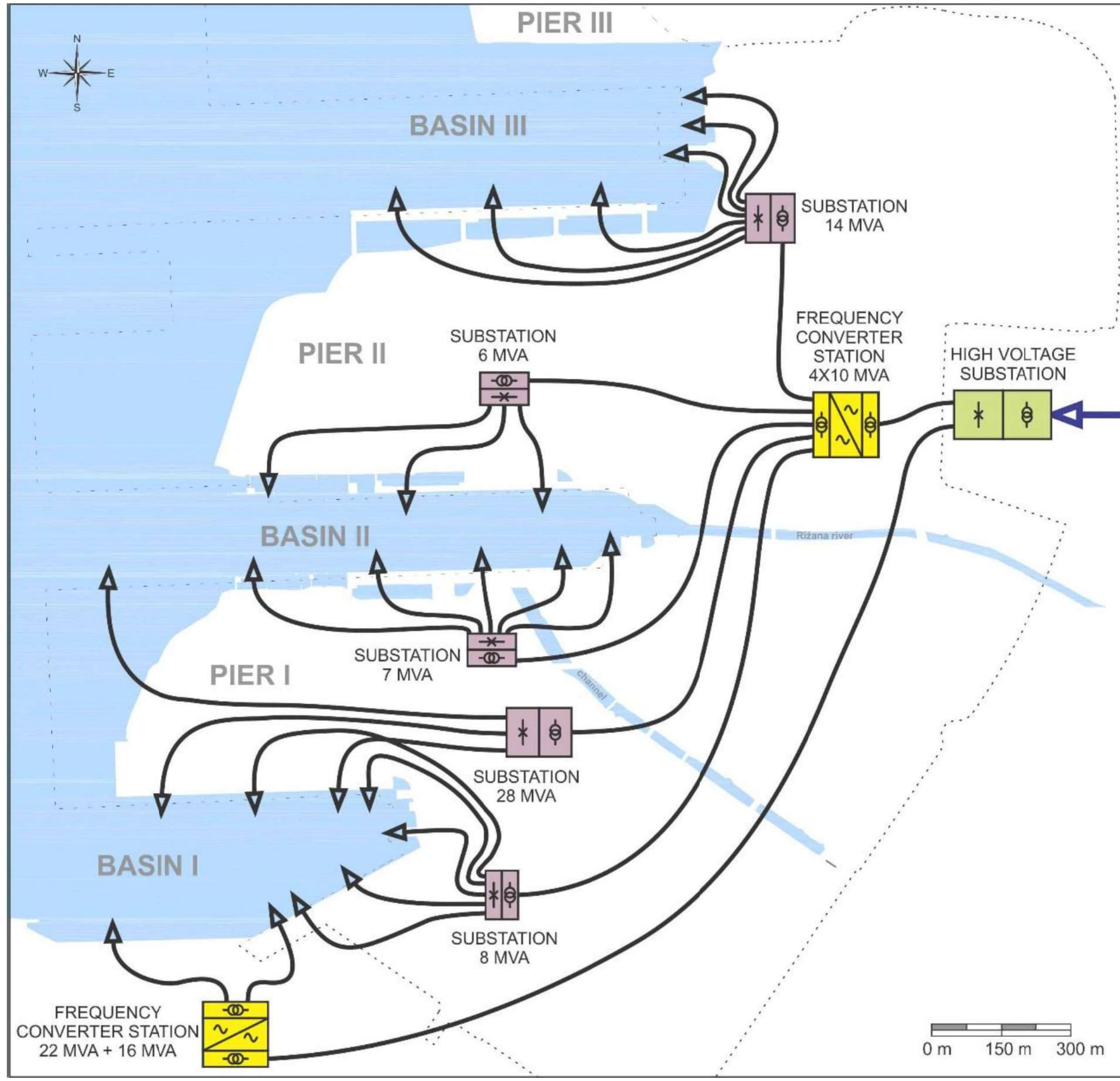

SWOT Analysis – Case Study Port of Koper

	Internal	External
POSITIVE	**Strengths** • Trend setting – maintaining competitiveness and leading position in the Adriatic • New working places and increasing competences • Increasing local and national economy – tourism and industry • Environmental excellence for gaining support from the local communities for future development projects	**Opportunities** • Pilot projects and EU funding • Local air quality improvement • International legislation support • New services and jobs, strong push for local SMEs – exporting knowledge to other ports
NEGATIVE	**Weaknesses** • High investment costs for infrastructure and consequently high cost per MWh • There is a need for a retrofitting actions on ships • Cold ironing is still in the early development phase and too new for many ports and ship owners • Different voltage and frequency levels on the ship and port side, and impact of max power demand • Cold Ironing currently competes with the fuel which is not taxed (difference in tax on the electricity and the fuel) • Longer loading and unloading periods • Around 3000 m^2 of surface area for the equipment	**Threats** • Unsecure future development and cargo • Unsecure future development of tourism • Unclear national energy strategies • Long-lasting spatial planning procedures – bureaucratic burden • Impact on the transmission system • Beside Cold Ironing other technologies are also being piloted in various ports

SWOT Analysis – Case Study Port of Koper (2)

- Analysis confirms that the **harmonization of interests** between the state, City of Koper, Port of Koper and citizens is **the first and necessary step**!
- Successful Cold Ironing development strategy must be adaptive
- Analysis revealed the following open issues:
  - How to create an incentivizing system for financing Cold Ironing infrastructure?
  - How to stimulate ship owners to use Cold Ironing technologies without jeopardizing economic development and open market mechanisms?

Conclusion and Future Challenges

- **Electrification** has a **potential to unlock significant** energy and environmental benefits
- **Cold Ironing** requires **significant modification** of the existing electricity grid, which is a **very expensive** and **relatively long lasting process**
- **EU must formulate** appropriate regulations or provide incentive measures in order to encourage ports to upgrade existing systems and implement electrification projects
- **Upgrade of exiting high voltage infrastructure – insufficient spatial planning** (slow procedures) can be significant barrier on the implementation level

Conclusion and Future Challenges (2)

- **Ship owners** are facing big challenges – **sustainable transformation and replacement** of the traditionally diesel powered engines by electricity and alternative fuels
- Cold Ironing – **two variables in the equation** – high investments are required from both shore and ship side
- **Copy-paste planning - the most frequent mistake**!
- **Each port is unique** - has to develop its own strategy for sustainable and climate friendly development
- **Cooperation with other ports** and exchange of experiences is **more than desirable and it has to be stimulated**, but **concrete solutions** have to be based on **priorities and peculiarities of each individual port**

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our future charged

Thank you

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