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Combined Water and Energy Integration in the Process Industries

Pilot training 1

WP3 – D1. Developing training content

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University of Tuzla, Faculty of Technology, Tuzla, Bosnia and Herzegovina

April 13, 2022, Tirana (Albania)

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Outline of Presentation

- Motivation
- Previous collaborations and internationalisation at home
- Pilot training prepared according to the SCATE model
- What have we learned – Interactive session
- Summary and Conclussions

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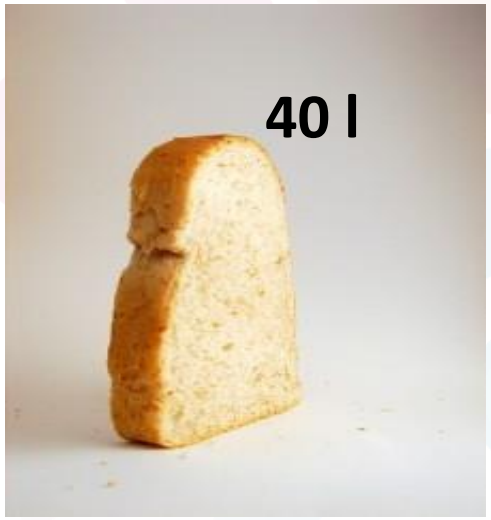
How much water is needed to produce different products?



25-30 m^3/(t soda ash)

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Why this pilot topic is important to be offered?

ENERGY Motivation WATER

Sustainability and Profitability of Processes

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Motivation

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EU Green Deal

Carbon neutral by 2050

Resource-Efficient Processes

EU targets 2030

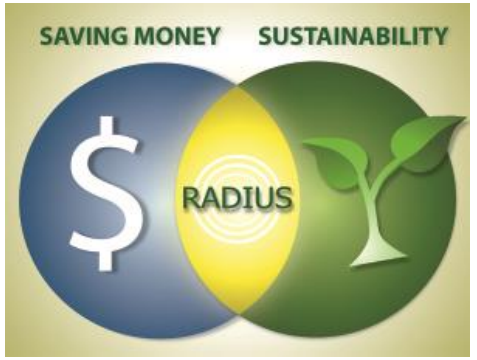
Cut emissions by at least 55% by 2030

Save Water

Save Energy

Sustainable Development Goals

Protect and Save Environment



https://safaunt.wordpress.com/

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ELSEVIER

Computers & Chemical Engineering

Volume 82, 2 November 2015, Pages 144-171

Review

Water and energy integration: A comprehensive literature review of non-isothermal water network synthesis

Elvis Ahmetović [a, b], Nidret Ibrić [a], Zdravko Kravanja [b], Ignacio E. Grossmann [c]

Show more

https://doi.org/10.1016/j.compchemeng.2015.06.011

Get rights and content

Highlights

- A comprehensive review of the synthesis of non-isothermal water networks is presented.
- Review includes studies based on pinch analysis, mathematical programming or their combination.
- Review highlights possible future directions and challenges within non-isothermal water networks.

Review Article | Published: 23 March 2021

State of the art methods for combined water and energy systems optimisation in Kraft pulp mills

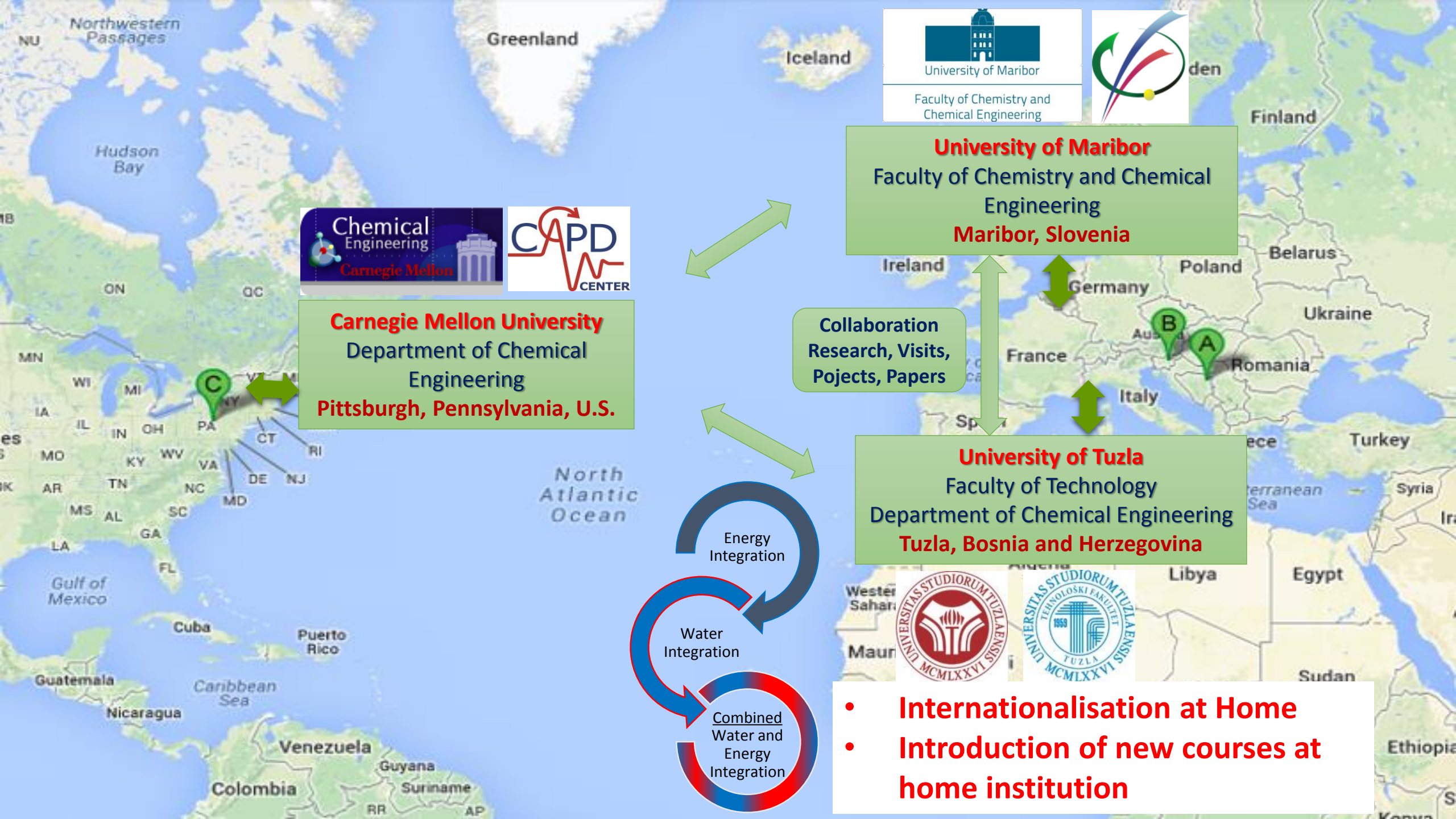
Elvis Ahmetović, Zdravko Kravanja, Nidret Ibrić, Ignacio E. Grossmann & Luciana E. Savulescu

Optimization and Engineering **22**, 1831–1852 (2021) | Cite this article

350 Accesses | **3** Citations | **1** Altmetric | Metrics

Abstract

This paper presents a state-of-the-art overview of water and energy optimisation methods with applications to Kraft pulp mills. The main conclusions are highlighted, and several research gaps are identified and proposed for future research. Kraft processes have the potential to be adapted to biorefineries for producing biofuels and other high-value products from wood biomass. Biorefineries enable opportunities to increase the revenue of the process, reduce fossil fuels usage and greenhouse gas emissions. However, to ensure an effective Kraft process transformation, the existing mill infrastructure needs to be consolidated. In this sense, the water system, the heat exchanger network and the utility system should all be optimised together. A series of systematic methods (process integration-conceptual and mathematical programming) have been identified in the literature, along with the results of several case studies that reduce water and energy consumption in Kraft processes. Initial studies in this field considered and solved separate water and energy integration problems, but recent works have been focused on the development of methods for combined water and energy integration and their application to various processes. Typical savings lead to freshwater consumption decreases between 20 and 80% and energy consumption reductions between 15 and 40%.



- **Internationalisation at Home**
- **Introduction of new courses at home institution**

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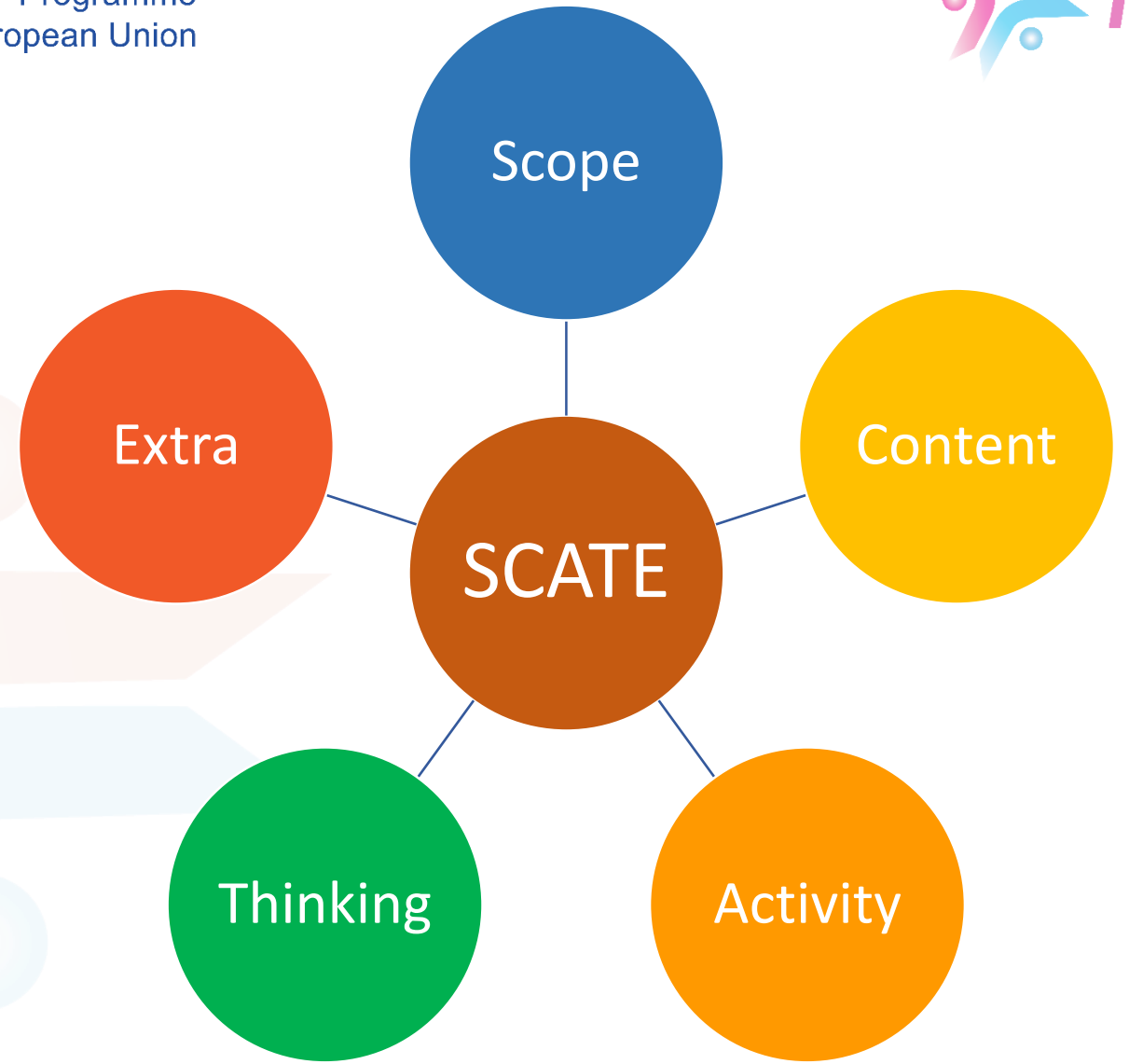

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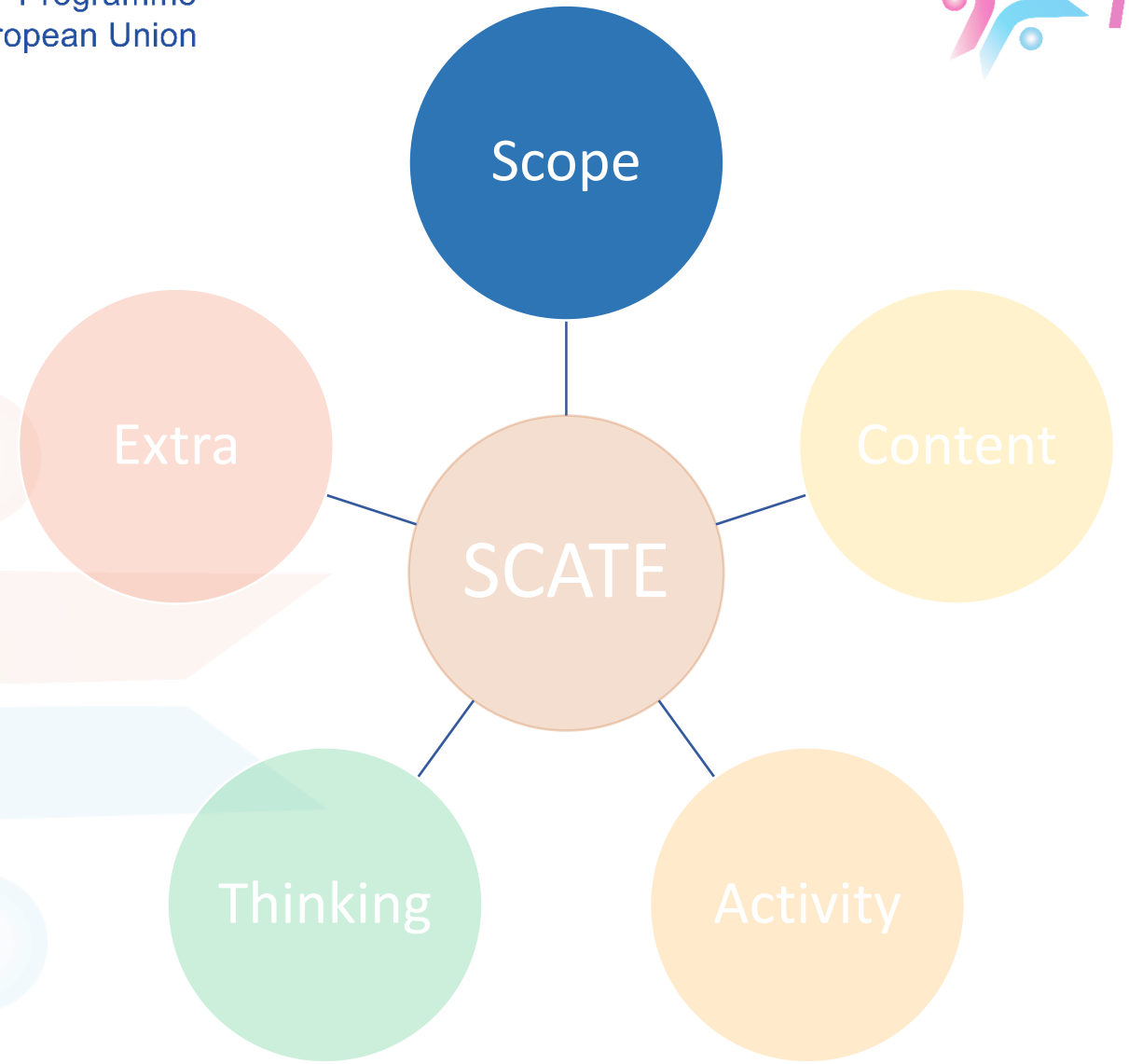

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Scope

- Number
- Title
- Introduction
- Outcomes
- Topics
- Study Guide

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Number	#C49
Title	Combined Water and Energy Integration in the Process Industries
Introduction	The scope of this course is to provide knowledge about the global consumption of water and energy, and the minimization of water and energy consumption in manufacturing processes. It increases awareness about sustainable consumption and the use of natural resources and environmental protection. This course also explains concepts of water and energy integration, water and energy networks and systematic methods for simultaneous optimization of water and energy consumption and designing optimal water and energy network.

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Outcomes	At the end of the course, participants should be able to:

- LO.1: Remember and describe the global trends of water and energy consumption
- LO.2: Understand and explain the importance of water and energy use in manufacturing processes, sustainable utilization of water and energy, and environmental protection
- LO.3: Understand, sketch and analyse the concept of combined water and energy networks
- LO.4: Classify and explain systematic methods that can be used for combined water and energy integration
- LO.5: Develop a simple case study of combined water and energy network and estimate the consumption of freshwater, hot and cold utilities

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Topics	Topics to be delievered are the folowing:

1. Global water and energy consumption and sustainability
2. Water and energy use in manufacturing processes
3. Concepts of combined water and energy networks
4. Systematic methods for combined water and energy integration
5. Case study of combined water and energy network
6. Summary

Study Guide

Required time - Total: 10 hours

Task	Time (hour/s)
Scope – Introduce the course scope and the learning outcomes	1
Content – Present the course content	4
Activities – Realize the activities for the proposed course content	2.5
Think (MCQs) – Think and answer to questions	1
Extra – Realize the extra course work	1.5

Study Guide could be easily extended for case of a higher number of total hours and ECTS

Required resources/ material

Required hardware/software:

- Computer, Internet search engines (Google, Yahoo), General Algebraic Modelling System (GAMS)
- General Algebraic Modelling System, https://gams.com/. Accessed on December 2021.

Required external resources including links and books:

- Ahmetović, E., Kravanja, Z., Ibrić, N., Grossmann, I. E., Savulescu, L. E. (2021). State of the art methods for combined water and energy systems optimisation in Kraft pulp mills. Optimization and Engineering. DOI: https://doi.org/10.1007/s11081-021-09612-4
- Savulescu, L. E., Alva-Argaez, A., 2013, 15 - Process Integration Concepts for Combined Energy and Water Integration, J. J. Klemeš. Handbook of Process Integration (PI), Woodhead Publishing: 461-483. https://doi.org/10.1533/9780857097255.4.461.
- Ahmetović, E., Ibrić, N., Kravanja, Z., Grossmann, I. E., 2015, Water and energy integration: A comprehensive literature review of non-isothermal water network synthesis, Computers & Chemical Engineering 82, 144-171. https://doi.org/10.1016/j.compchemeng.2015.06.011.
- Ahmetović, E., Grossmann, I. E., Kravanja, Z., Ibrić, N. (2017). Water Optimization in Process Industries, 487-512 (Chapter published in the book: Sustainable Utilization of Natural Resources, CRC Press, Boca Raton, Editors: P. Mondal and A. K. Dalai, DOI: https://doi.org/10.1201/9781315153292).

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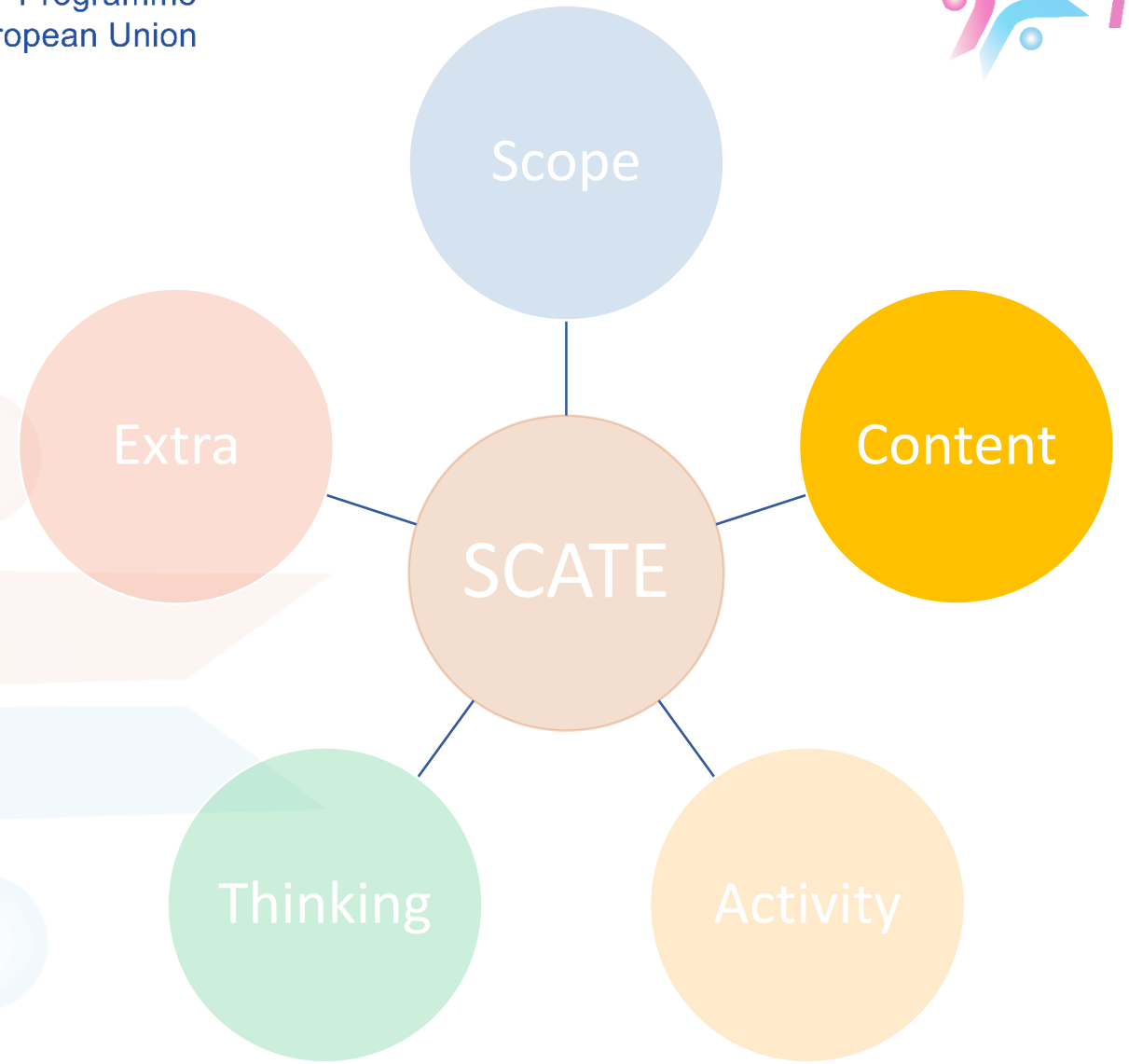

Topic 1

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INTERBA

Content

- Section Number
- Section Title
- Introduction
- Content

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INTERBA

Content Template	
Section Number	#1
Section Title	Global water and energy consumption and sustainability
Introduction	This section describes the trends of global water and energy consumption, and the sectors which are the main water and energy users. Also, the section shortly explains targets adopted by the EU and Sustainable Development Goals for achieving sustainability and environmental protection.
Content	• Global trends of water and energy consumption • Main water and energy user sectors • Sustainability and environmental protection

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- In the last 50 years, total world water consumption has tripled
- Global energy consumption will increase by about 56% by 2040
- One of the main reasons is the expected growth of the human population and their need for various products
- In the next 50 years, it is predicted that the world's population could increase by about 40-50% (Davé, 2004), which will have a direct impact on global water and energy consumption.
- The main water users are domestic, agricultural and industrial sectors
- About 70% of the total available water is consumed in agriculture, 20% in industry and 10% in domestic sector
- The recently adopted target, related to at least 55% net emissions reduction by 2030, plays an important role in achieving climate neutrality in the EU by 2050

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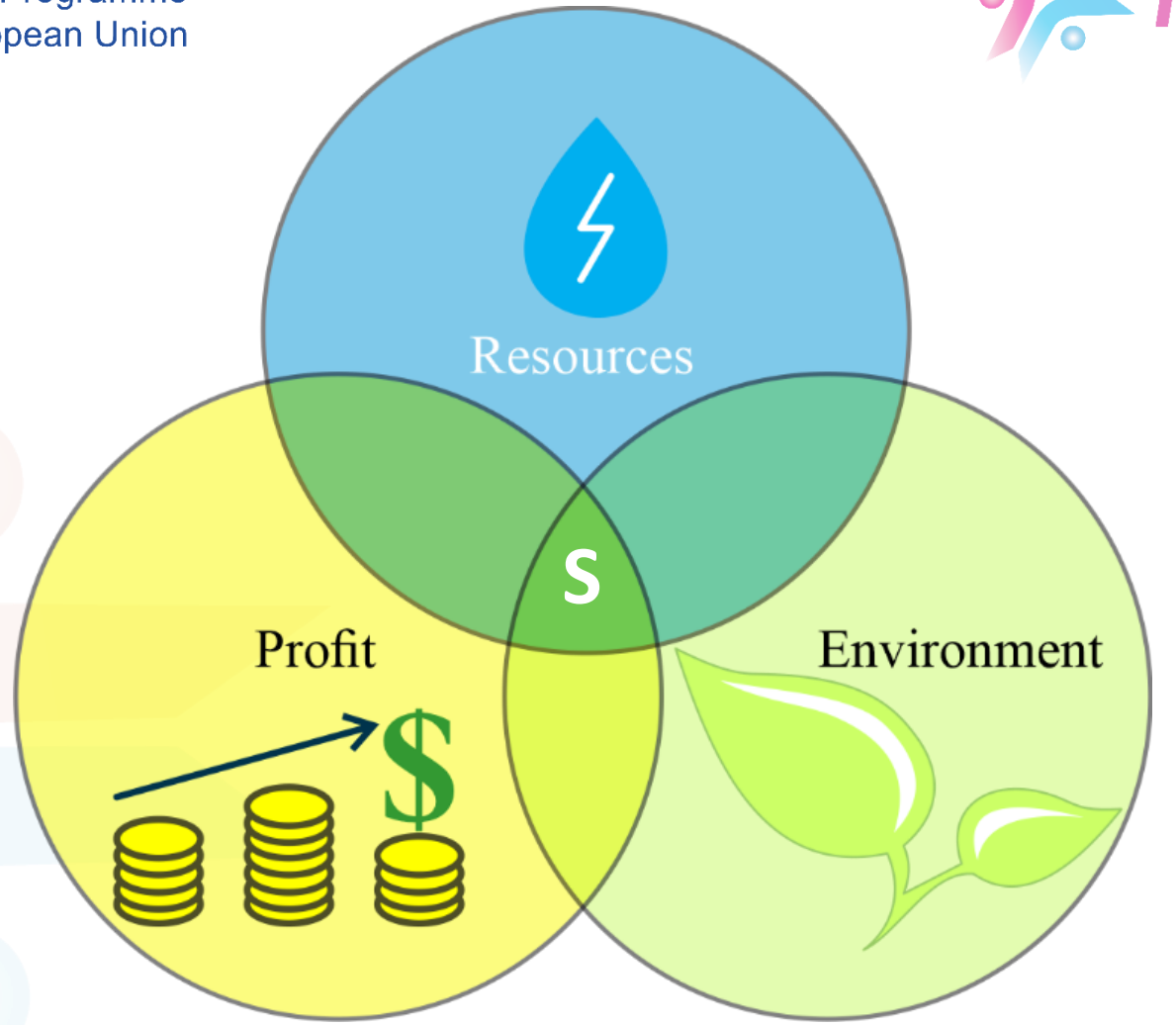

Figure 1. Sustainability (S) and links between resources, profit and environment.

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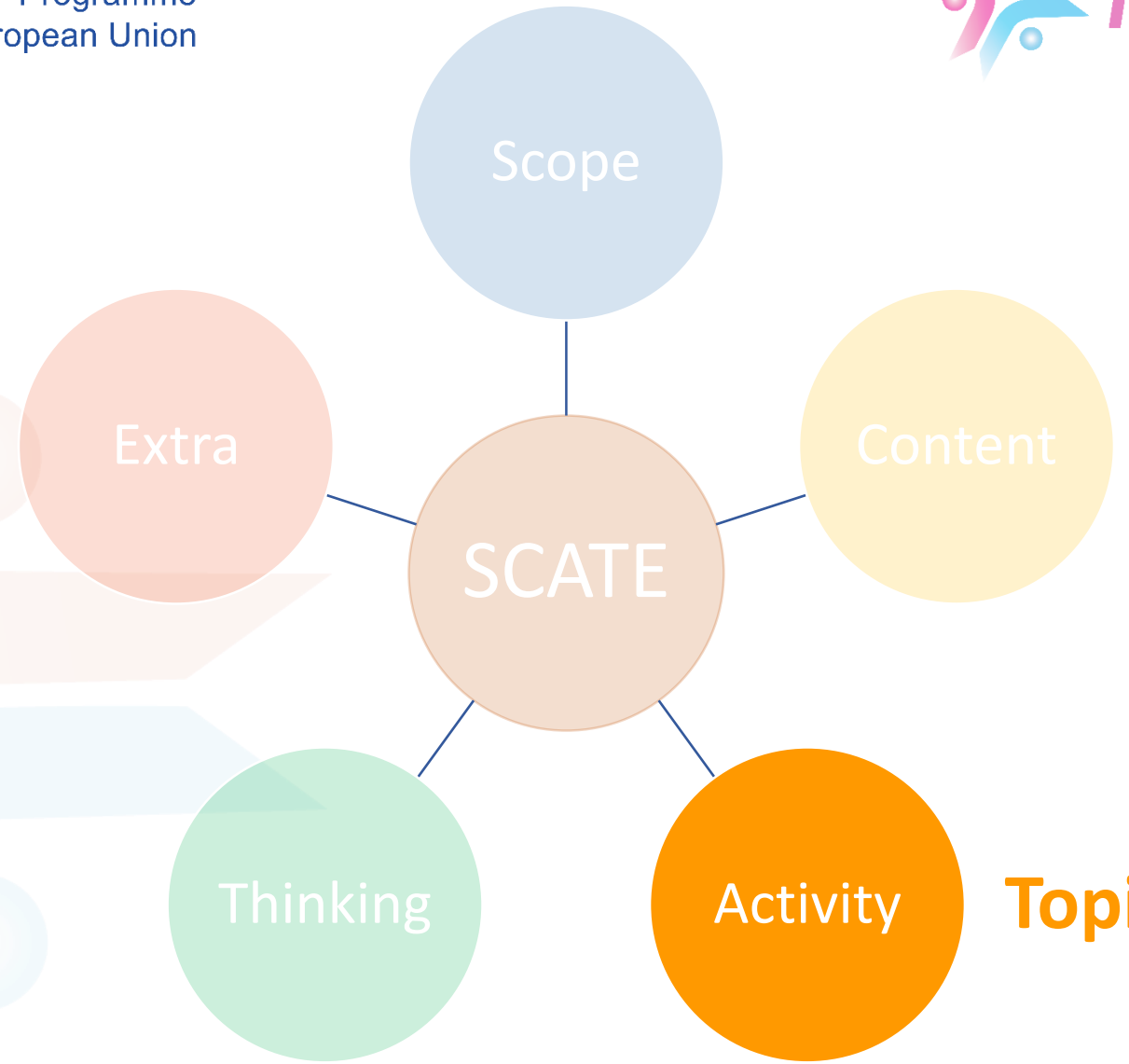

Topic 1

Activity

- Number
- Title
- Type
- Aim
- Description
- Timeline
- Assessment

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INTERBA

Activity Template	
Number	1
Title	Using internet resources to find information about global water and energy consumption
Type	Research
Aim	LO.1. The main aim of this activity it to teach participants how to find information regarding global water and energy consumption
Description	It is necessary to use different web search engines (e.g. Google, Yahoo) to find information regarding global water and energy consumption as well as consumption in different sectors (domestic, agriculture and industrial). Extract data, diagrams, and figures found on the internet to a word document with the file name „Water and Energy Consumption_ Name_Surname_Academic_Year“ and based on that write up to one-page summary/report and describe information found on the internet. This activity should be done by each participant. After 30 minutes for completing this activity, each participant should send an email to the email address of professor and attach his/her report.

Activity Template	
Timeline	• Time for internet search: 10 minutes • Time for writing a summary/report: 15 minutes • Time for writing an email to send one-page summary/report: 5 minutes
Assessment	The report written by each participant will be evaluated based on the quality of synthesising information taken from the different internet sources.

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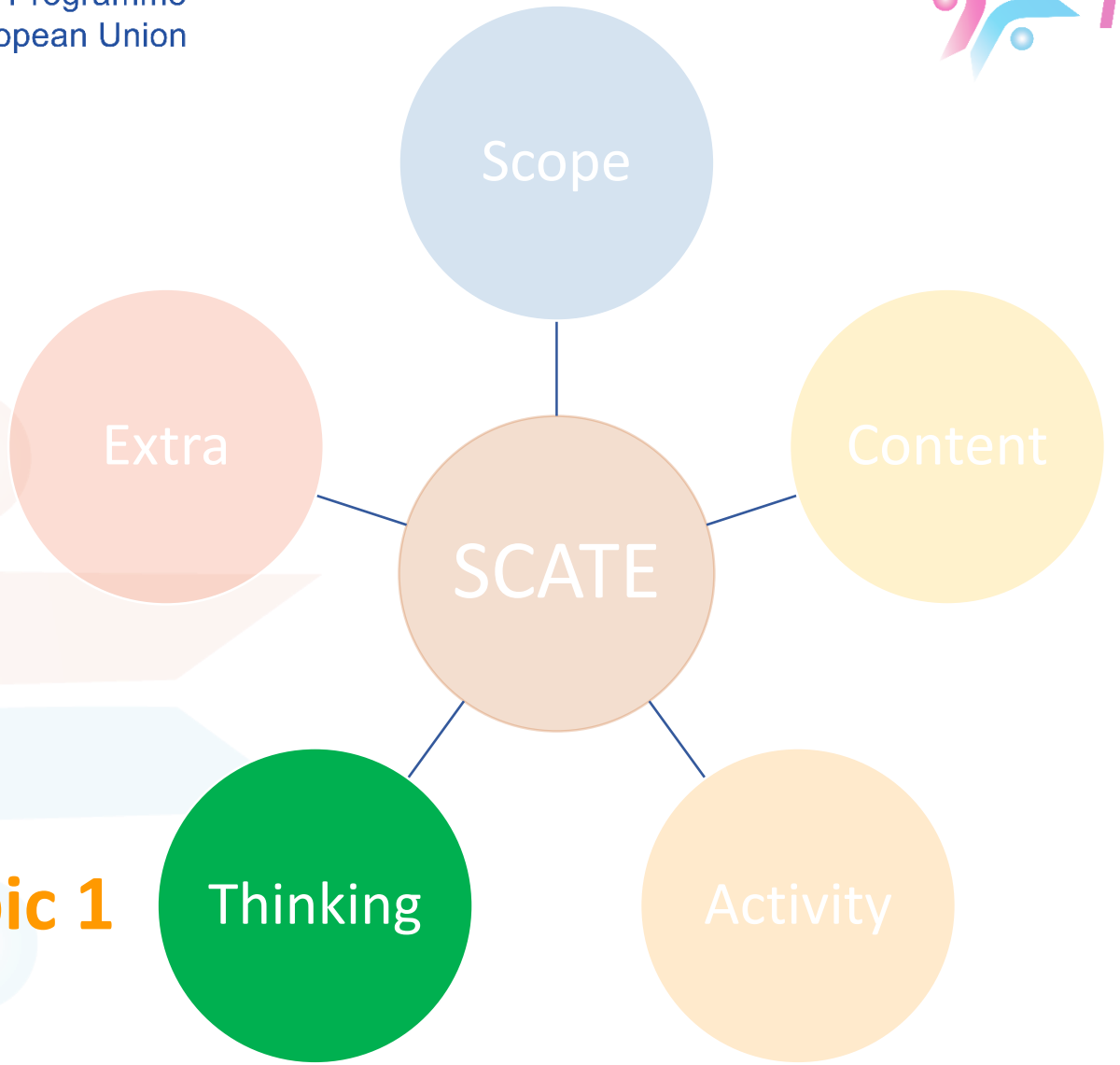

Topic 1

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Thinking

- Number
- Title
- Type
- Question
- Answers

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Think Template (MCQs)	
Number	1
Title	Global water and energy consumption
Type	Choose the correct answers
Question	Water and energy consumption in the future will be: a) Increased b) Decreased
Answers	a) Increased

Think Template (MCQs)	
Number	1
Title	Global water and energy consumption
Type	True or false
Question	Sustainabilty in the process industry can be achieved by rational use of natural resources, improved water and heat integration, and minimisation of waste streams to the environment. a)True b)False
Answers	a) True

Think Template (MCQs)	
Number	1
Title	Global water and energy consumption
Type	Choose the correct answers
Question	The recently adopted target related to net emissions reduction by 2030 plays an important role in achieving climate neutrality in the EU by 2050. According to this target net emission reduction will be reduced at least: a) 30% b) 55% c) 61%
Answers	b) 55%

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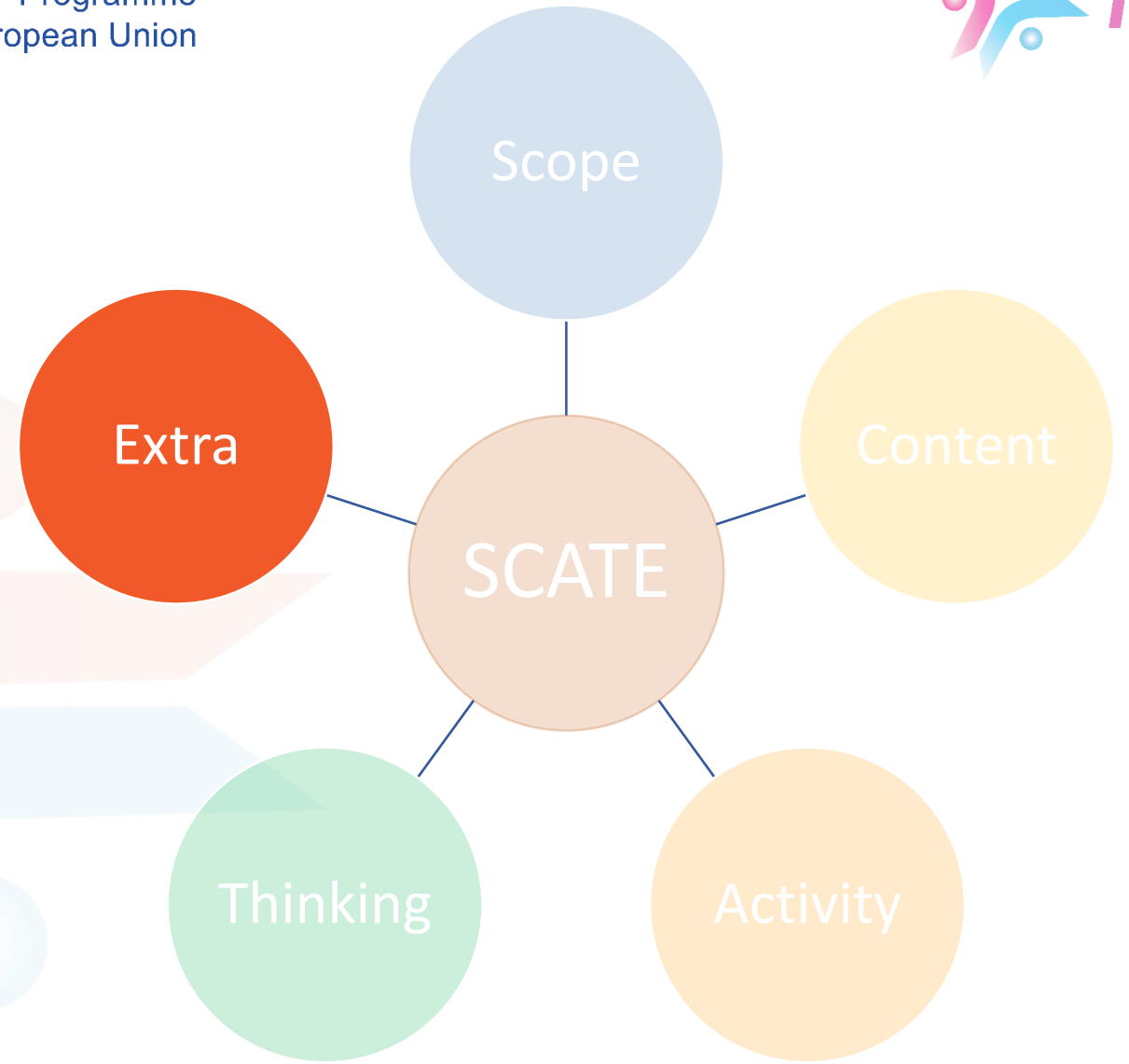
Topic 1



Extra

- Number
- Title
- Topic
- Type

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Extra Template	
Number	1
Title	Water optimisation in the process industries
Topic	Global water and energy consumption and sustainability
Type	Online content: • Global Water Use, https://www.worldometers.info/water. Assessed on January 10, 2022. • Global Water Situation, Water in the 21st Century. https://prudentwater.com/en/ globaler-wasserbericht/. Assessed on February 16, 2022. • Boretti, A., Rosa, L. Reassessing the projections of the World Water Development Report. npj Clean Water 2, 15 (2019). https://doi.org/10.1038/s41545-019-0039-9.

Extra Template	
Number	1
Title	Water optimisation in the process industries
Topic	Global water and energy consumption and sustainability
Type	• Davé, B. (2004). Water and Sustainable Development: Opportunities for the Chemical Sciences: A Workshop Report to the Chemical Sciences Roundtable. Washington (DC): National Academies Press (US); 2004. http://www.ncbi.nlm.nih.gov/books/NBK83724/. Assessed on April 02, 2014. Book chapter • Ahmetović, E., Grossmann, I. E., Kravanja, Z., Ibrić, N. (2017). Water Optimization in Process Industries, 487-512 (Chapter published in the book: Sustainable Utilization of Natural Resources, CRC Press, Boca Raton, Editors: P. Mondal and A. K. Dalai, DOI: https://doi.org/10.1201/9781315153292).

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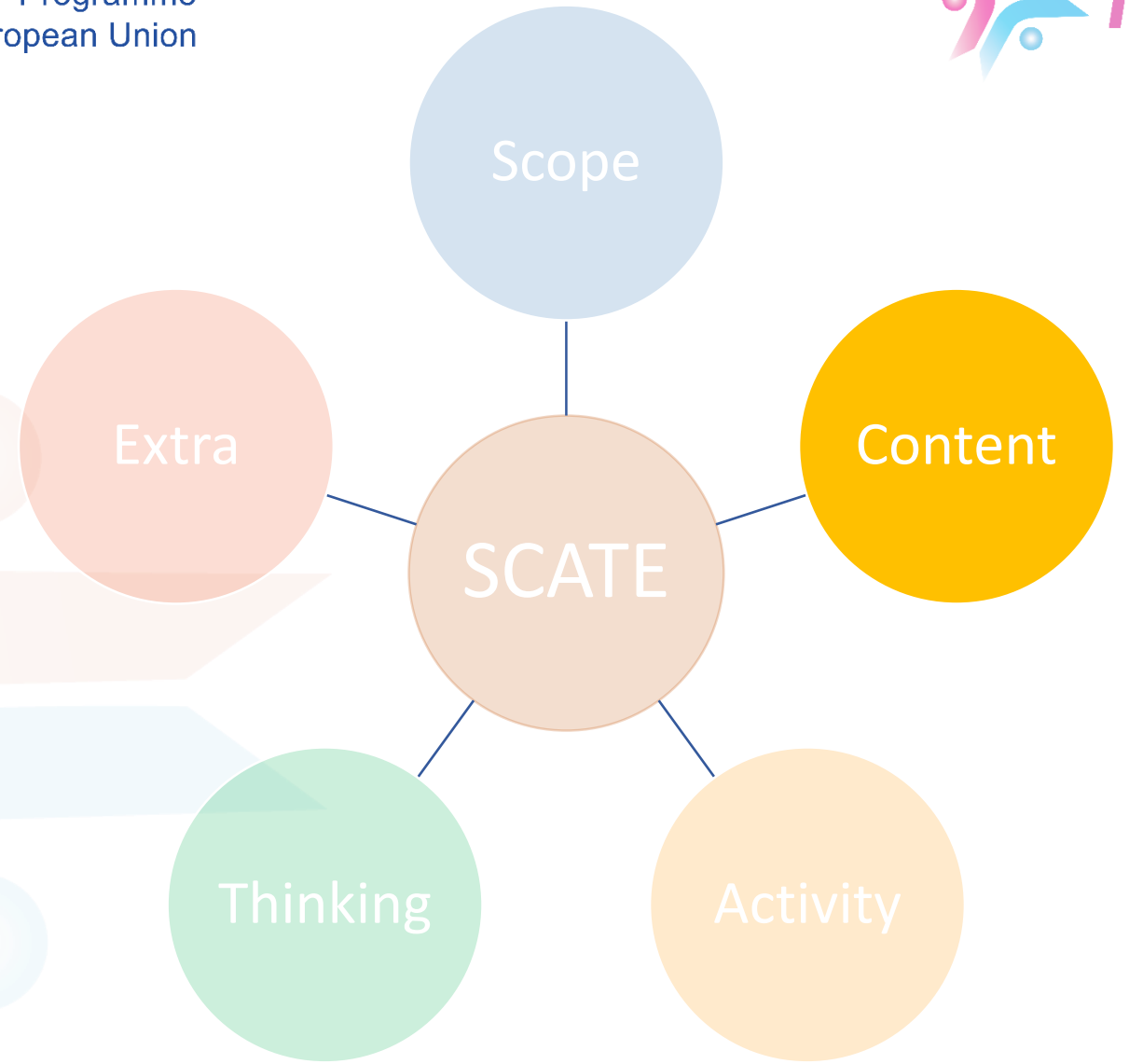

Topic 2

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INTERBA

Content

- Section Number
- Section Title
- Introduction
- Content

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Content Template	
Section Number	#2
Section Title	Water and energy use in manufacturing processes
Introduction	This section explains a technological process as a common part of various industries (e.g. chemical, food, petrochemical) and several unit operations in which water and energy are used for various purposes (e.g. washing, extraction, cooling, heating).
Content	• The use of water in a manufacturing process • The use of energy in a manufacturing process • Strong links between water and energy in manufacturing processes

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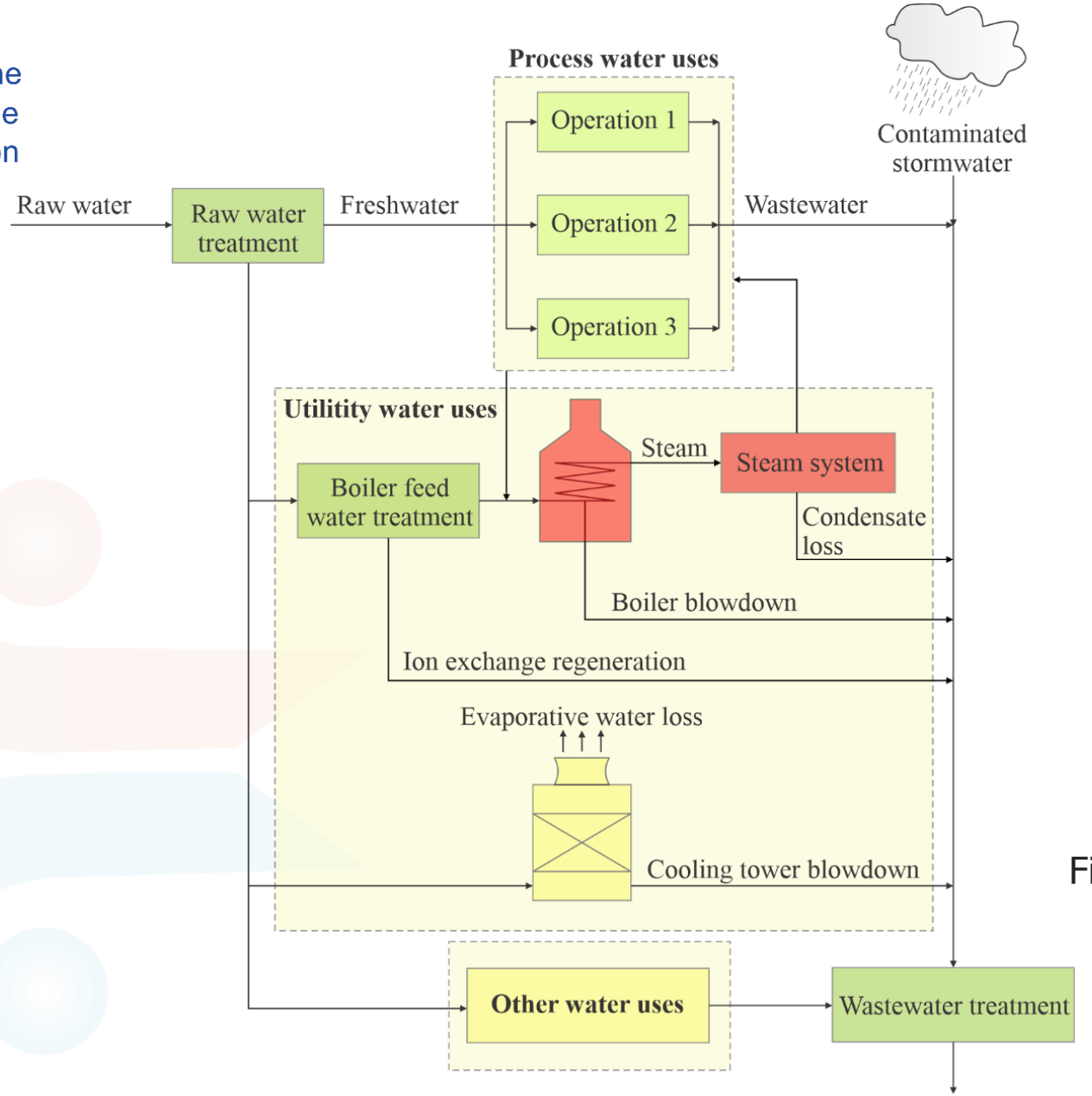

Figure 2. Water and energy use in manufacturing processes.

Use of water and energy in chemical processes

Freshwater

Wastewater

Condensate loss

Rainwater

Integrate your process to consume less resources, protect environment, and achieve sustainable solutions!

BFW

Boiler Blowdown

To environment

Ion exchange regeneration

CT Blowdown

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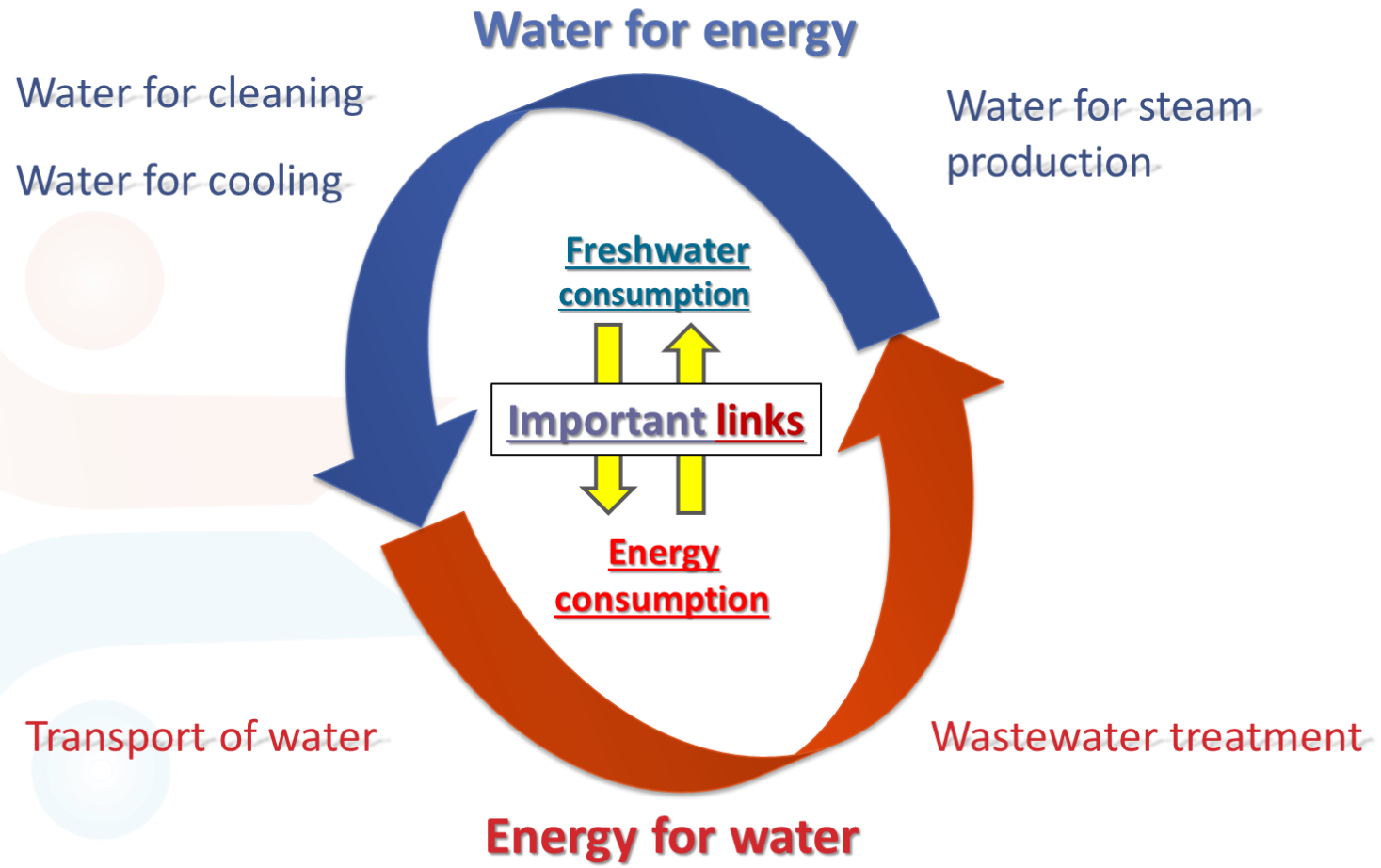
Simultaneous minimisation of water and energy



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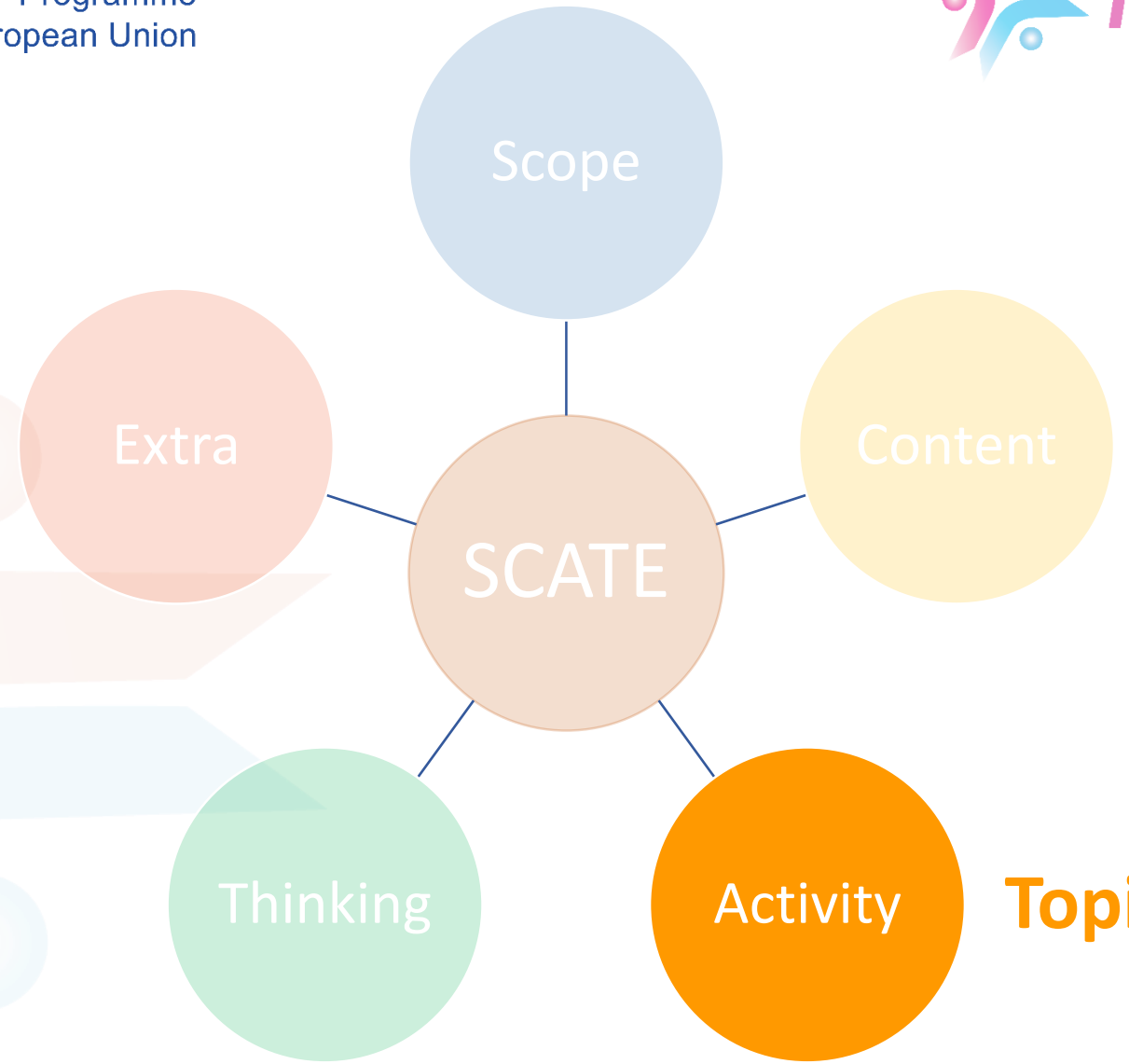

Topic 2

Activity

- Number
- Title
- Type
- Aim
- Description
- Timeline
- Assessment

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Activity Template	
Number	2
Title	Review literature and internet sources.
Type	Research and reflection
Aim	LO.2 The aim of this activity is to teach participants to review literature and internet sources to find and analyse different manufacturing processes related to water and energy consumption.
Description	Each participant should review the literature and internet sources to find at least two real manufacturing processes (one in the food industry and the second in the chemical industry), and write up to one-page report to summarise information about water and energy consumption in these processes. Also, the names of water-using process units should be written in this report for each of the selected processes. After 30 minutes for completing this activity, each participant should send an email to the email address of professor and attach his/her report. The file name of report should be given as following „Analysing Different Manufacturing Processes_ Name_Surname_Academic_Year“.

Activity Template	
Timeline	• Review literature and internet sources: 10 minutes • Writing a summary report: 15 minutes • Discussing during the assessment: 5 minutes
Assessment	Each participant should present his/her report in the class and highlight the most important information. Assessment will be based on the quality of the submitted written report and its presentation.

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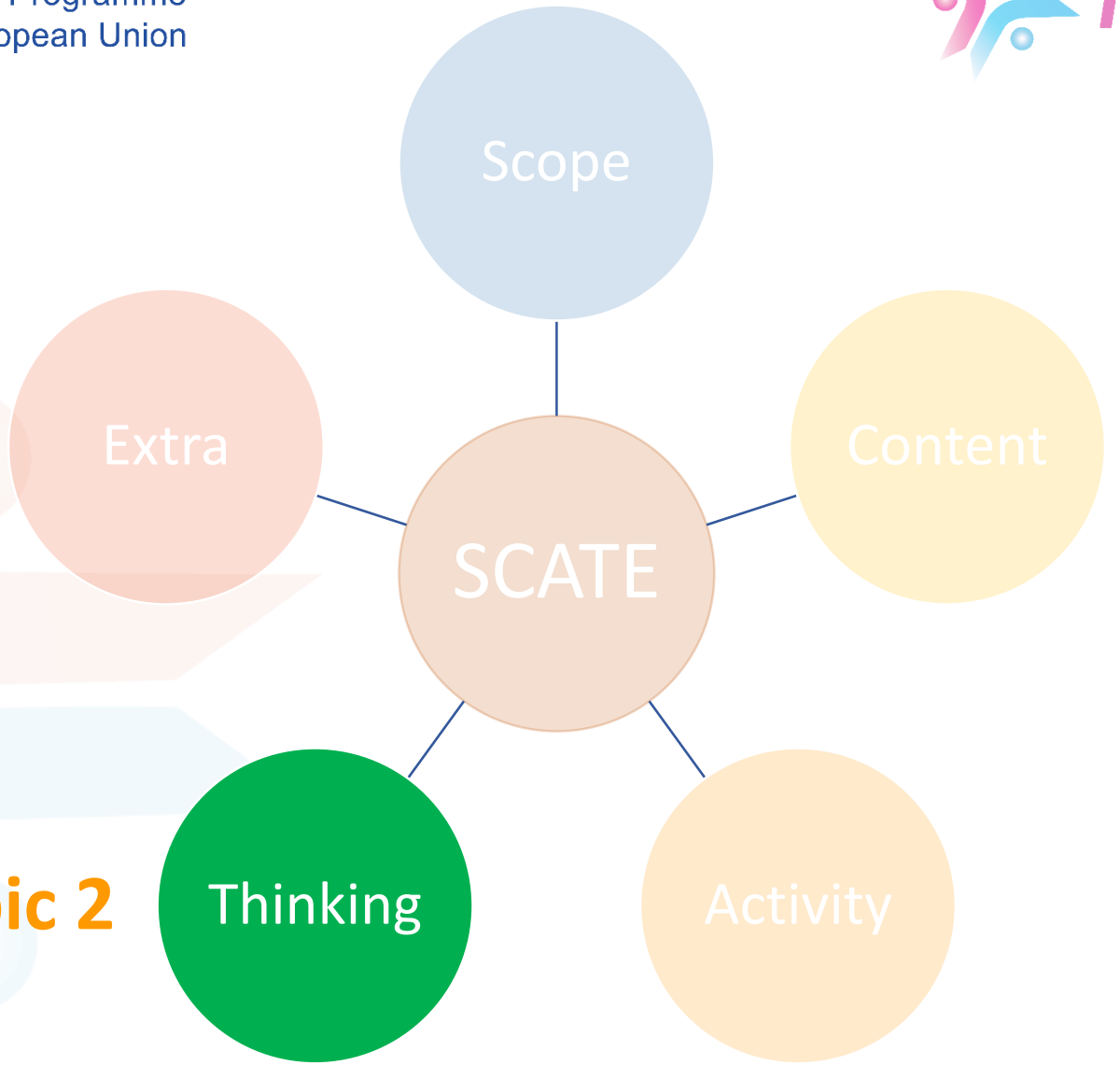

Topic 2

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Thinking

Number	Title	Type	Question	Answers

Think Template (MCQs)	
Number	2
Title	Water and energy use in manufacturing processes
Type	Fill the gaps
Question	Water can be used in manufacturing processes as: a) _____ b) _____
Answers	a) Process water b) Utility water

Type	Choose the correct answer
Question	Due to water recirculation in the process, the freshwater consumption and wastewater generation will be: a) Increased b) Decreased c) Partialy increased then significantly decreased d) None of the above answers
Answers	b) Decreased

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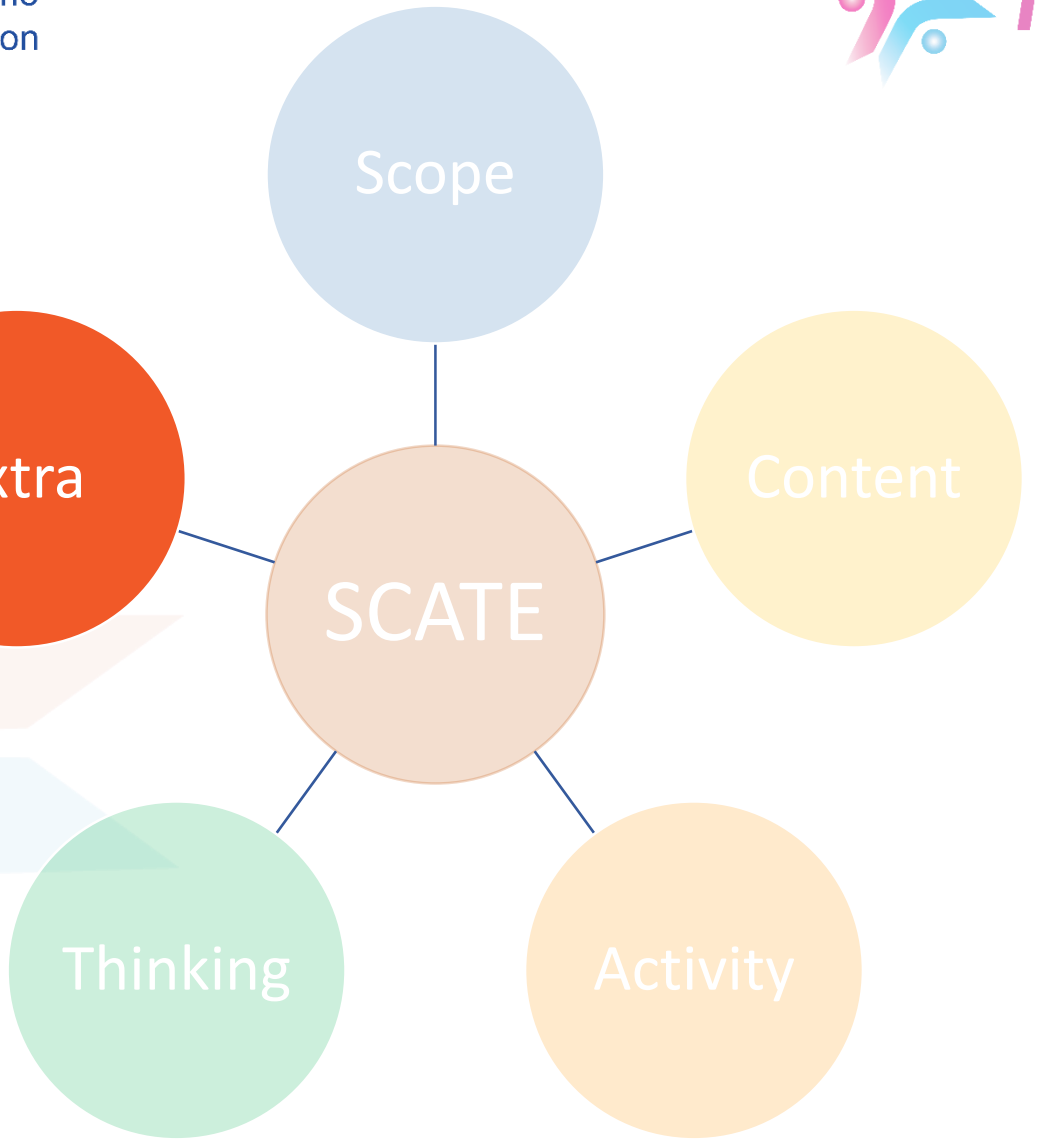
INTERBA

Topic 2



Extra

- Number
- Title
- Topic
- Type

Extra Template	
Number	2
Title	Water use in industry and industrial water reuse and wastewater minimization
Topic	Water and energy use in manufacturing processes
Type	Online content • Förster, Jürgen. Water use in industry, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive: Water_use_in_industry. Accessed on February 16, 2022. Book • Mann, J., G., Liu, Y.A. Industrial water reuse and wastewater minimization. New York: McGraw Hill; 1999.

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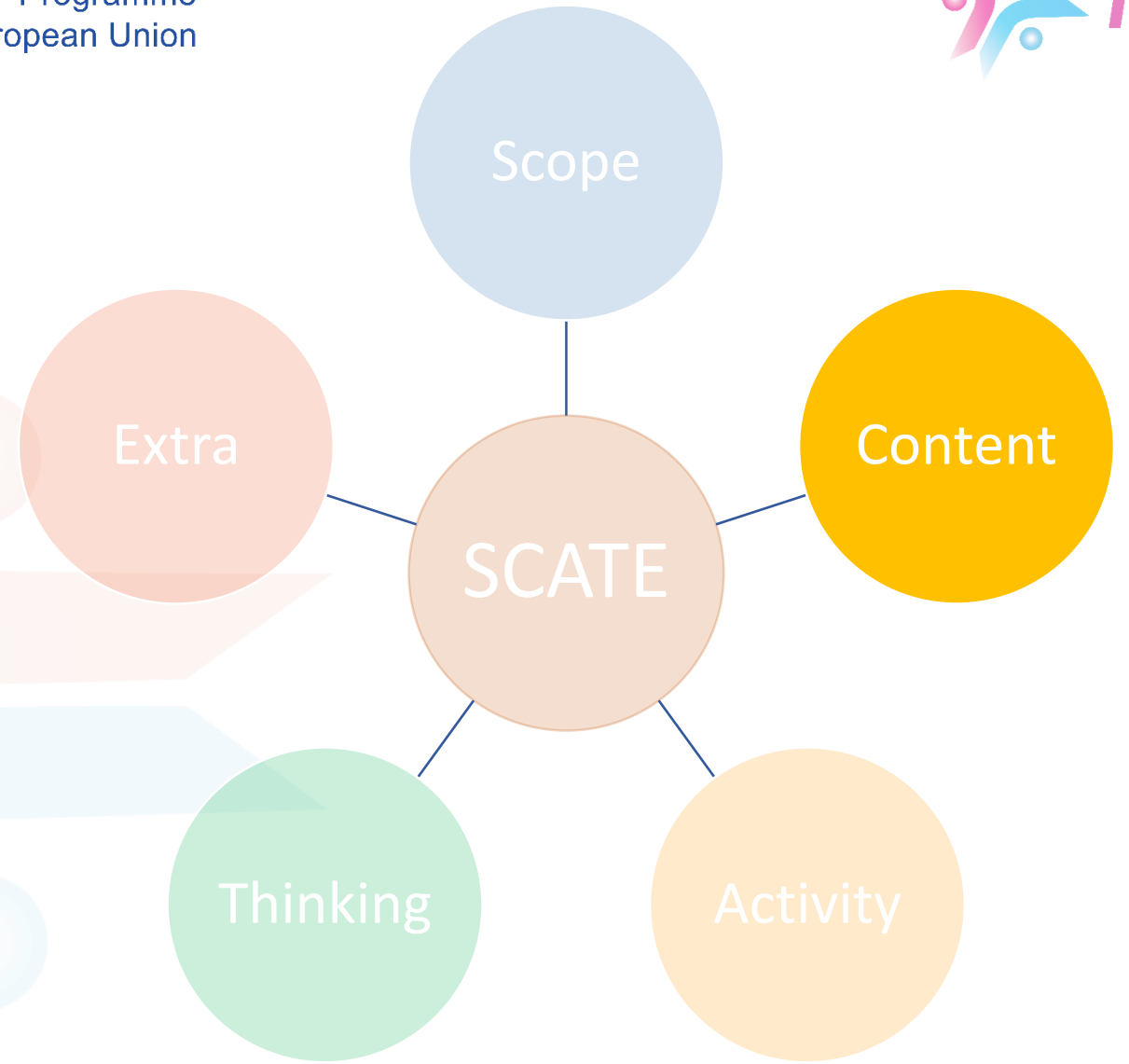

Topic 3

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Content

- Section Number
- Section Title
- Introduction
- Content

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Content Template	
Section Number	#3
Section Title	Concept of combined water and energy networks
Introduction	This section presents and explains the concept of combined water and energy networks and their interconnections and water and heat integration within manufacturing processes.
Content	• A concept of combined water and energy networks • A process unit network (water network-WN), a heat exchanger network (HEN) and a wastewater treatment network (WTN) • Water and heat integration opportunities to minimise external hot and cold utilities

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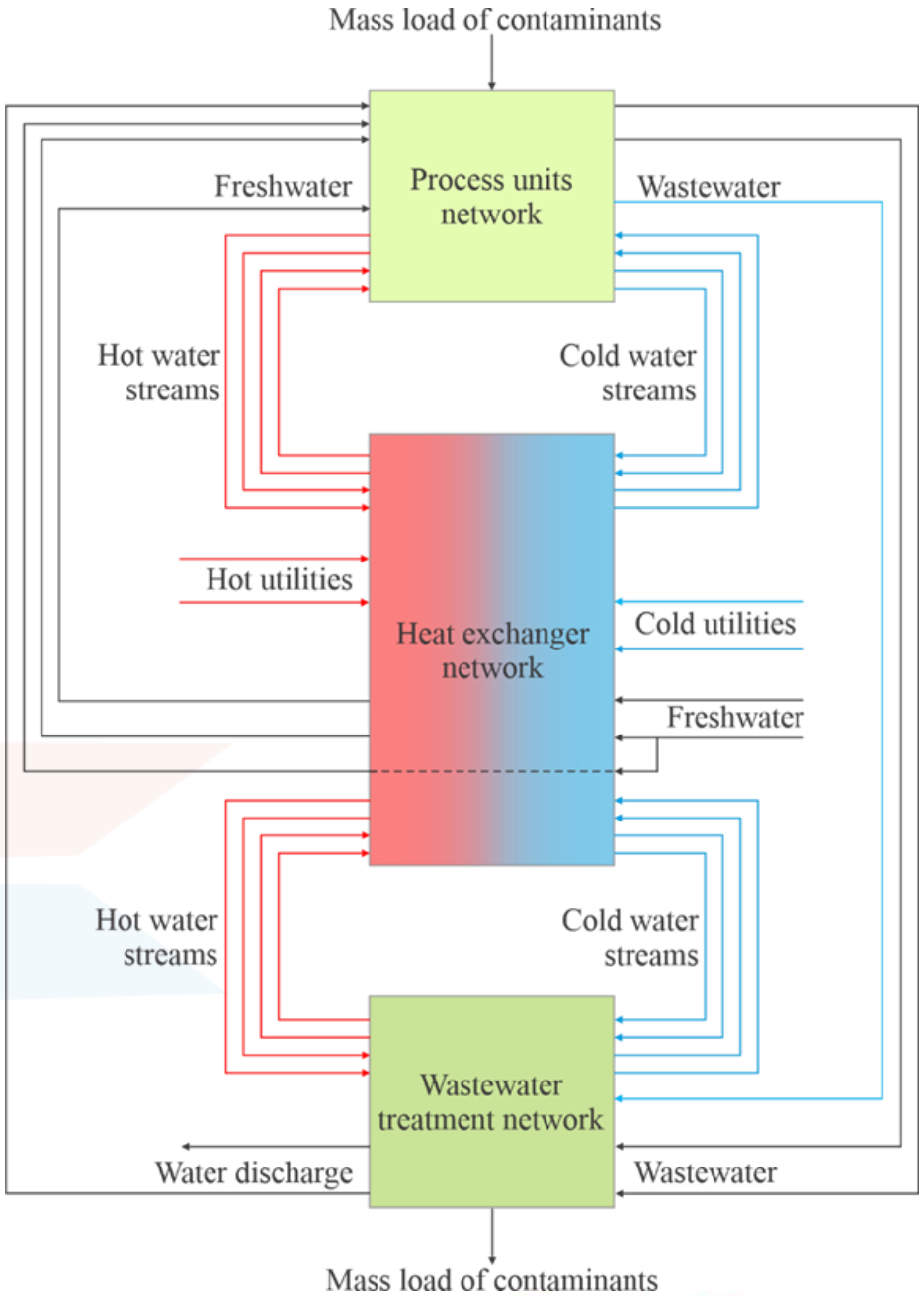

Figure 3. Concept of combined water and energy networks.

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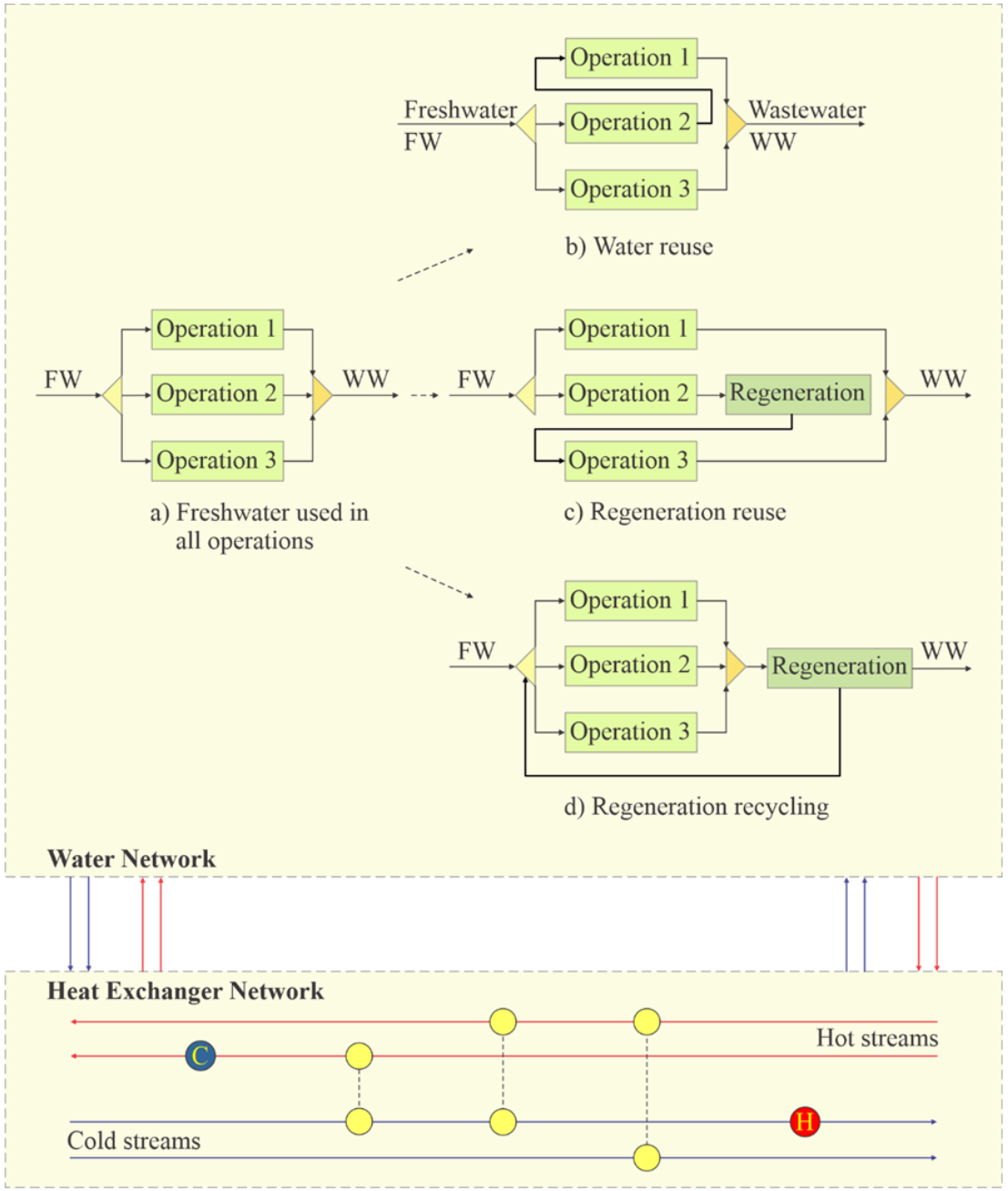

Figure 4. Concepts of water and energy integration.

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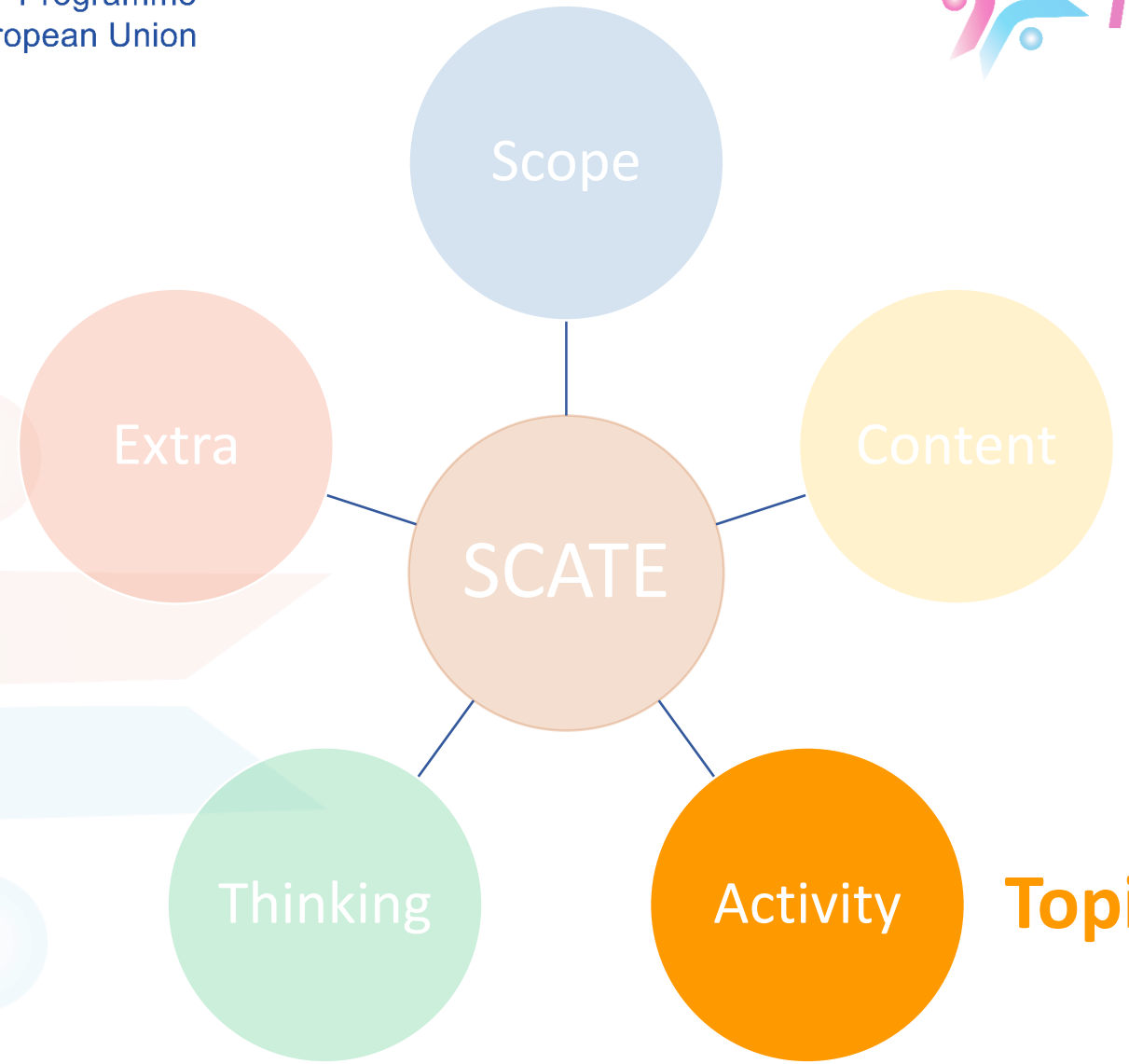

Topic 3

Activity

- Number
- Title
- Type
- Aim
- Description
- Timeline
- Assessment

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Activity Template	
Number	3
Title	Analysing the concept of combined water and energy networks
Type	Review and Reflection
Aim	LO.3 The aim of this activity is to teach participant to be familiar with a concept of water and energy network and understand the importance of water and heat integration for reduction of hot and cold utilities.
Description	Each participant will review and analyse Figure 3 and Figure 4 presented in the section 3, and describe potential water and heat integration options in both figures. A summary report (maximum one page) should be written by each participant. After 30 minutes for completing this activity, each participant should send an email to the email address of professor and attach his/her report. The file name of report should be given as following „Analysing Combined Water and Energy Network_ Name_Surname_Academic_Year“.

Activity Template	
Timeline	• Review literature and internet sources: 10 minutes • Writing a summary report: 15 minutes • Discussing during the assessment: 5 minutes
Assessment	Each participant should present his/her report in the class and explain water and heat integration options in both figures. Assessment will be based on the quality of the submitted written report and its presentation.

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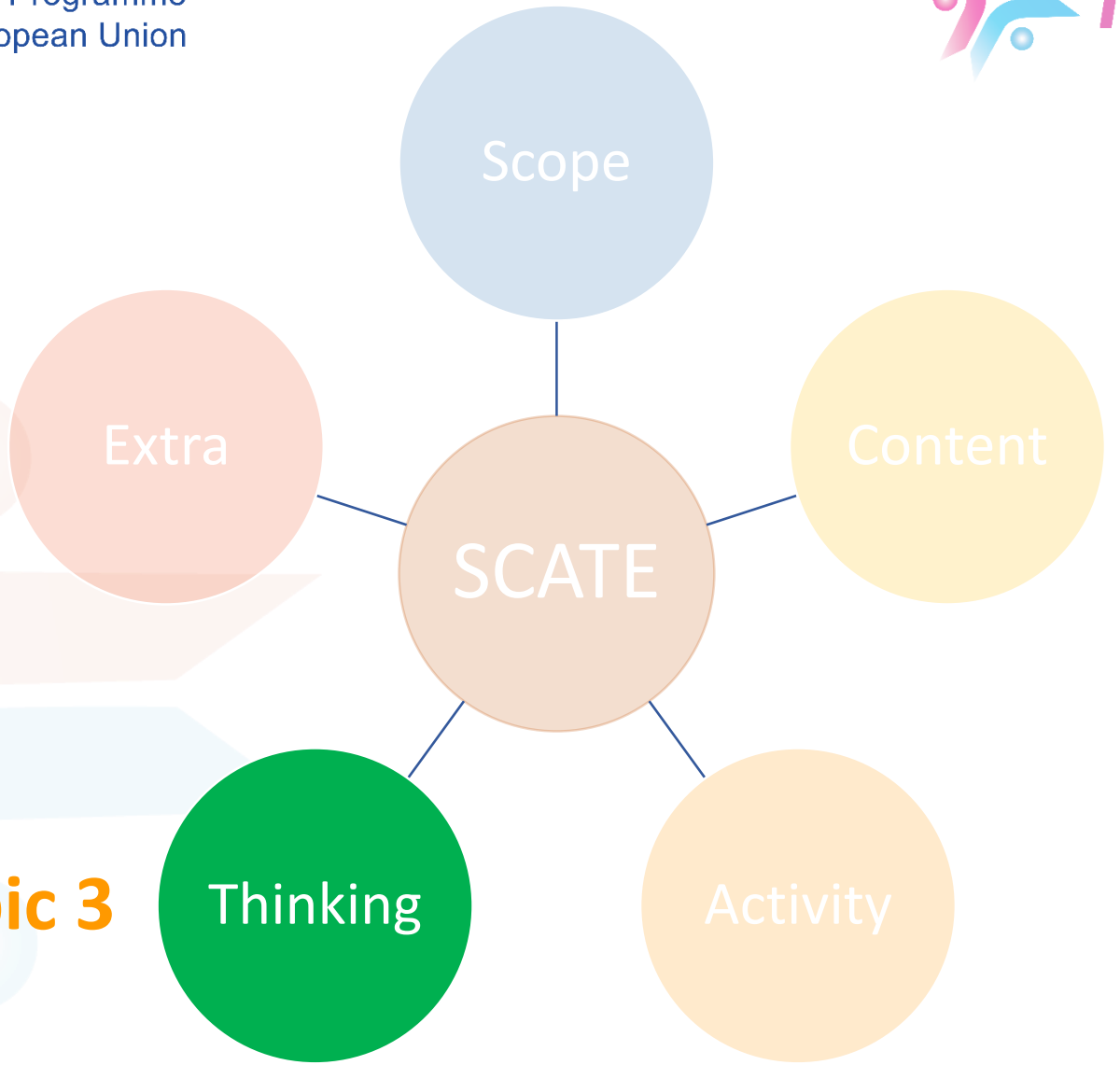

Topic 3

Thinking

Number	Title	Type	Question	Answers

Think Template (MCQs)	
Number	3
Title	Concepts of combined water and energy networks
Type	True or false
Question	In combined water and energy networks, a process units network, a heat exchanger network, and a wastewater treatment network are combined: a) True b) False
Answers	a) True

Think Template (MCQs)	
Number	3
Title	Concepts of combined water and energy networks
Type	True or false
Question	Simultaneous optimisation of water and energy consumption can be considered in combined water and energy networks. a) True b) False
Answers	a) True

Think Template (MCQs)	
Number	3
Title	Concepts of combined water and energy networks
Type	True or false
Question	Wasterwater reuse, wastewater regeneration and reuse, and wastewater regeneration and recycle present the main concepts for water integration. a) True b) False
Answers	a) True

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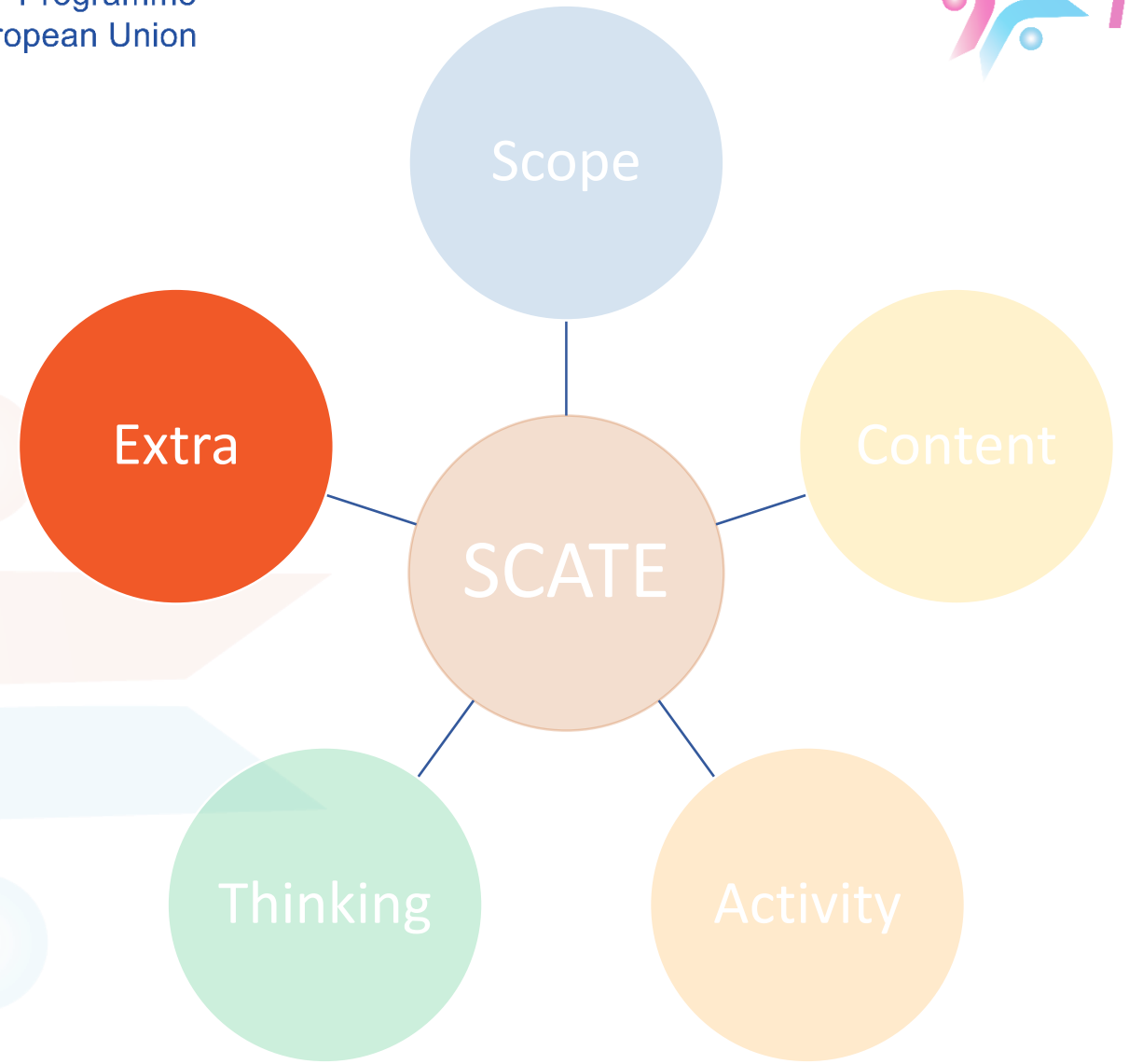
Topic 3



Extra

Number

Title

Topic

Type

Extra Template	
Number	3
Title	Integration of Combined Heat and Power Systems
Topic	Concepts of combined water and energy networks
Type	Book chapter • El-Halwagi, M. M., 2017, Chapter 8 - Integration of Combined Heat and Power Systems, M. M. El-Halwagi. Sustainable Design Through Process Integration (Second Edition), Butterworth-Heinemann: 239-273.

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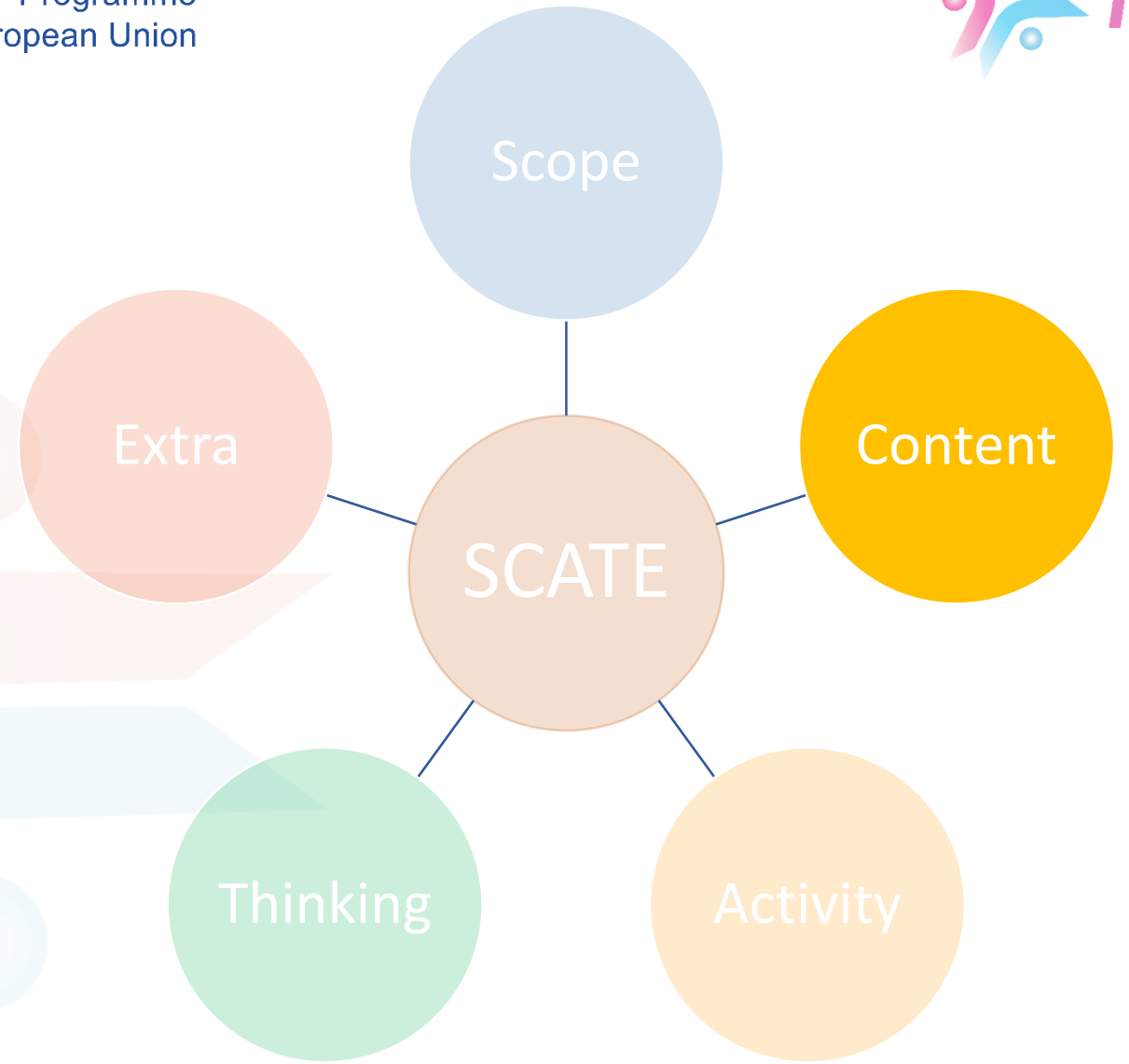

Topic 4

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INTERBA

Content

- Section Number
- Section Title
- Introduction
- Content

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INTERBA

Content Template	
Section Number	#4
Section Title	Systematic methods for water and energy integration
Introduction	This section explains the systematic synthesis and solution methods (sequential and simultaneous) for water and energy integration in manufacturing processes including pinch analysis, mathematical programming and their combinations (hybrid method).
Content	• Classifications of systematic methods for water and energy integration in manufacturing processes • Pinch analysis (PA), mathematical programming (MP) and their combinations (hybrid method) • Advantages and disadvantages of the methods

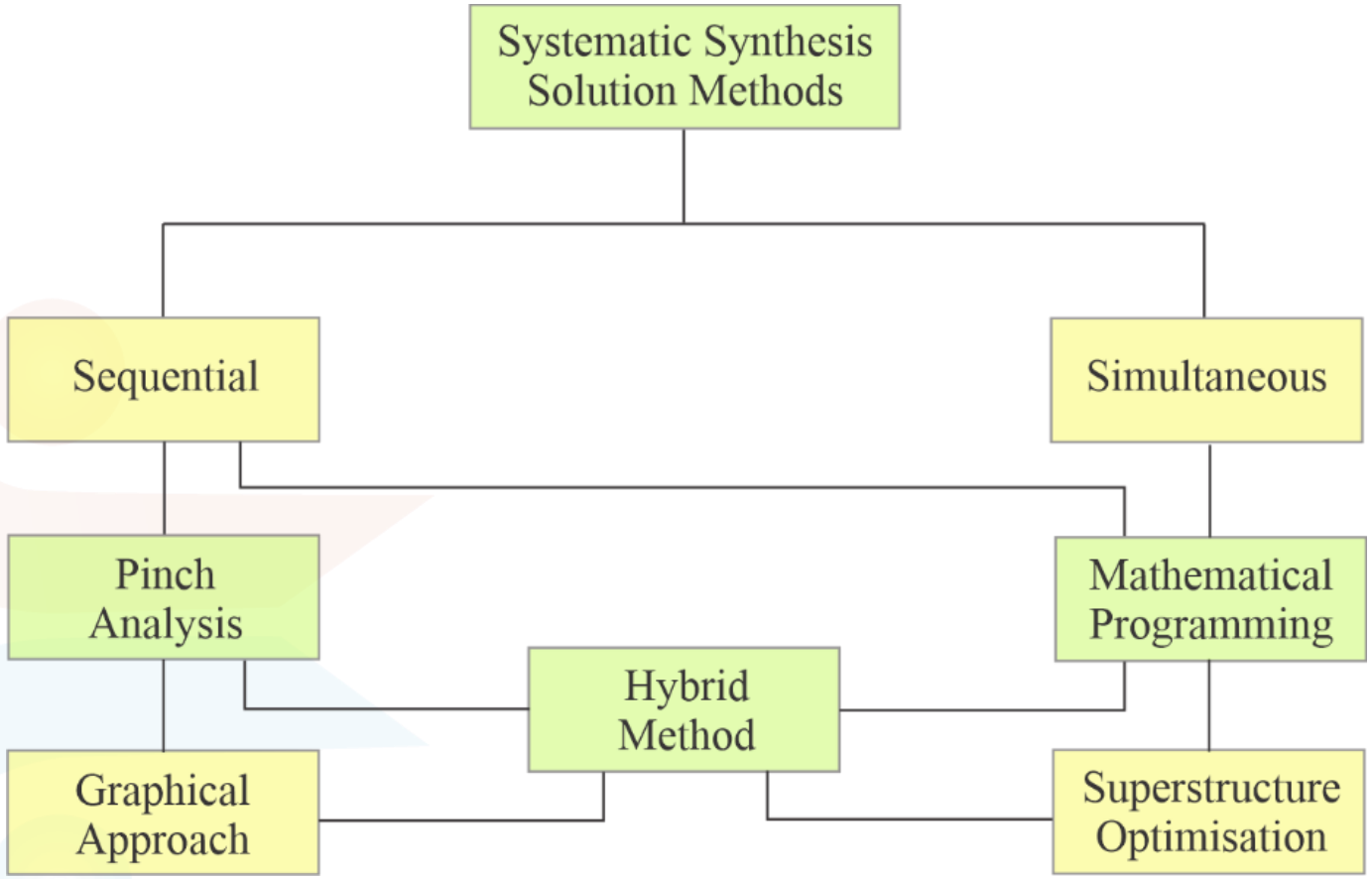

Figure 5. Classifications of systematic methods for water and energy integration in manufacturing processes.

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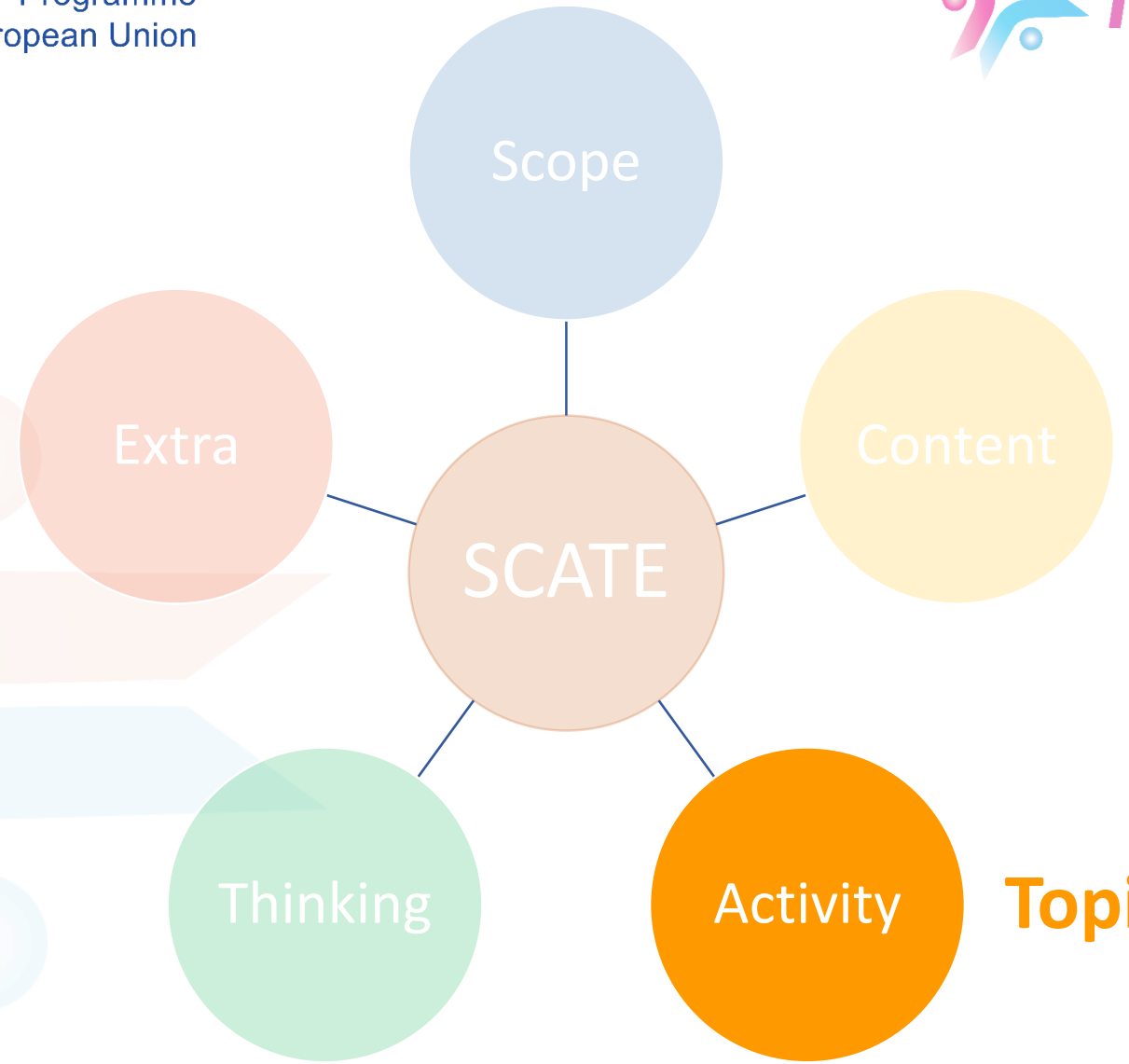

Topic 4

Activity

- Number
- Title
- Type
- Aim
- Description
- Timeline
- Assessment

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Activity Template	
Number	4
Title	Systematic methods for combined water and energy integration
Type	Review and Reflection
Aim	LO.4 The aim of this activity is to classify and explain systematic methods for combined water and energy integration and their features.
Description	Each participant should review the section 4, and web sources to write up to one-page report to summarise information about systematic methods and their advantages/disadvantages. After 30 minutes for completing this activity, each participant should send an email to the email address of professor and attach his/her report. The file name of report should be given as following „Systematic Methods_Name_Surname_Academic_Year“.

Activity Template	
Timeline	• Review Section 4 and internet sources: 10 minutes • Writing one page report: 15 minutes • Discussing during the assessment: 5 minutes
Assessment	Each participant should present his/her report in the class and highlight the most important information. Assessment will be based on the quality of the submitted written report and its presentation.

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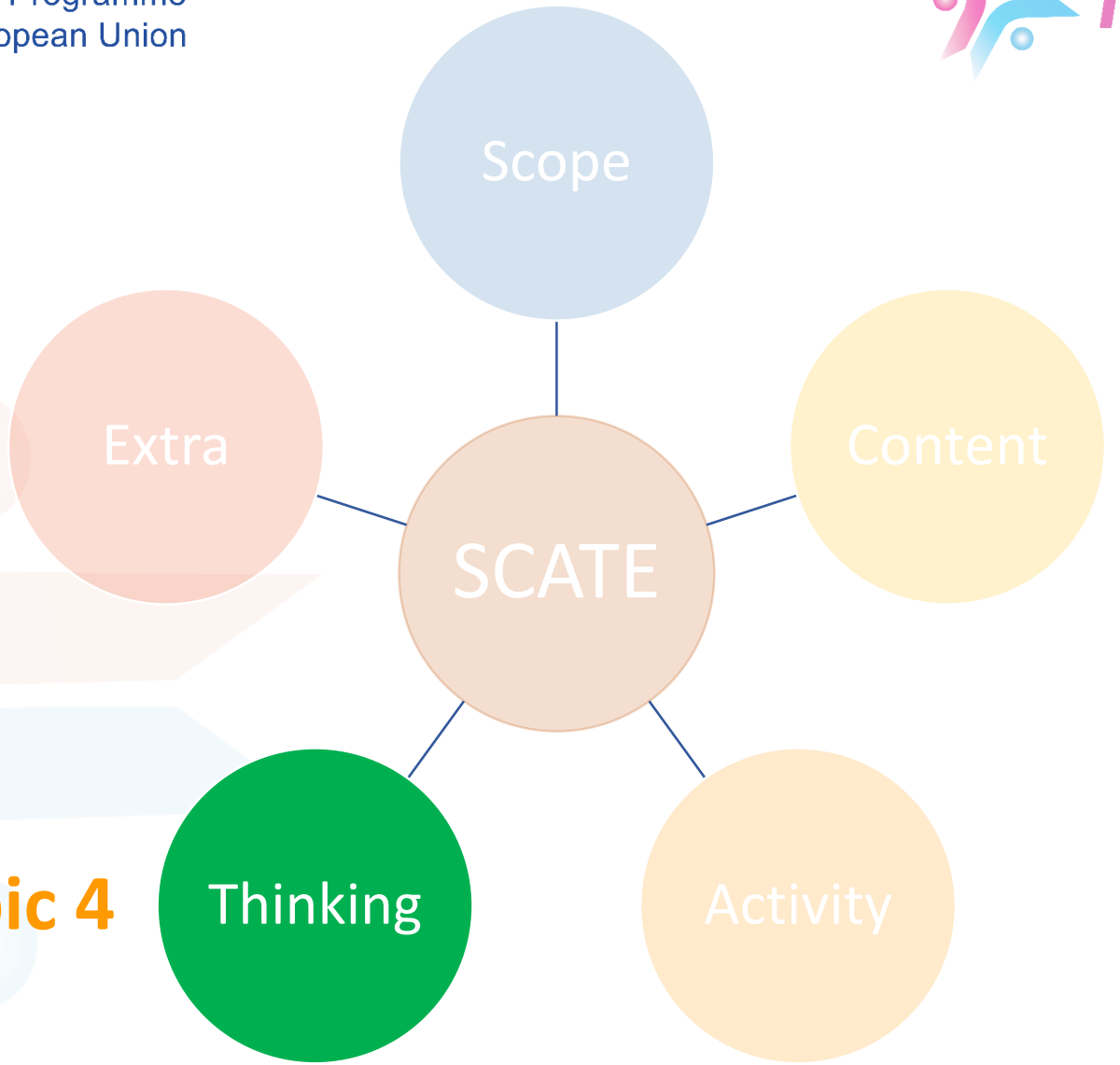

Topic 4

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INTERBA

Thinking

Number	Title	Type	Question	Answers

Think Template (MCQs)	
Number	4
Title	Systematic methods for combined water and energy integration
Type	True or false
Question	Pinch analysis is a mathematical programming approach based on superstructure optimisation. a) True b) False
Answers	a) False

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Think Template (MCQs)	
Number	4
Title	Systematic methods for combined water and energy integration
Type	True or false
Question	Mathematical programming approach can be used for considering the trade-offs between investment and operating cost to find the best solution. a) True b) False
	a) True

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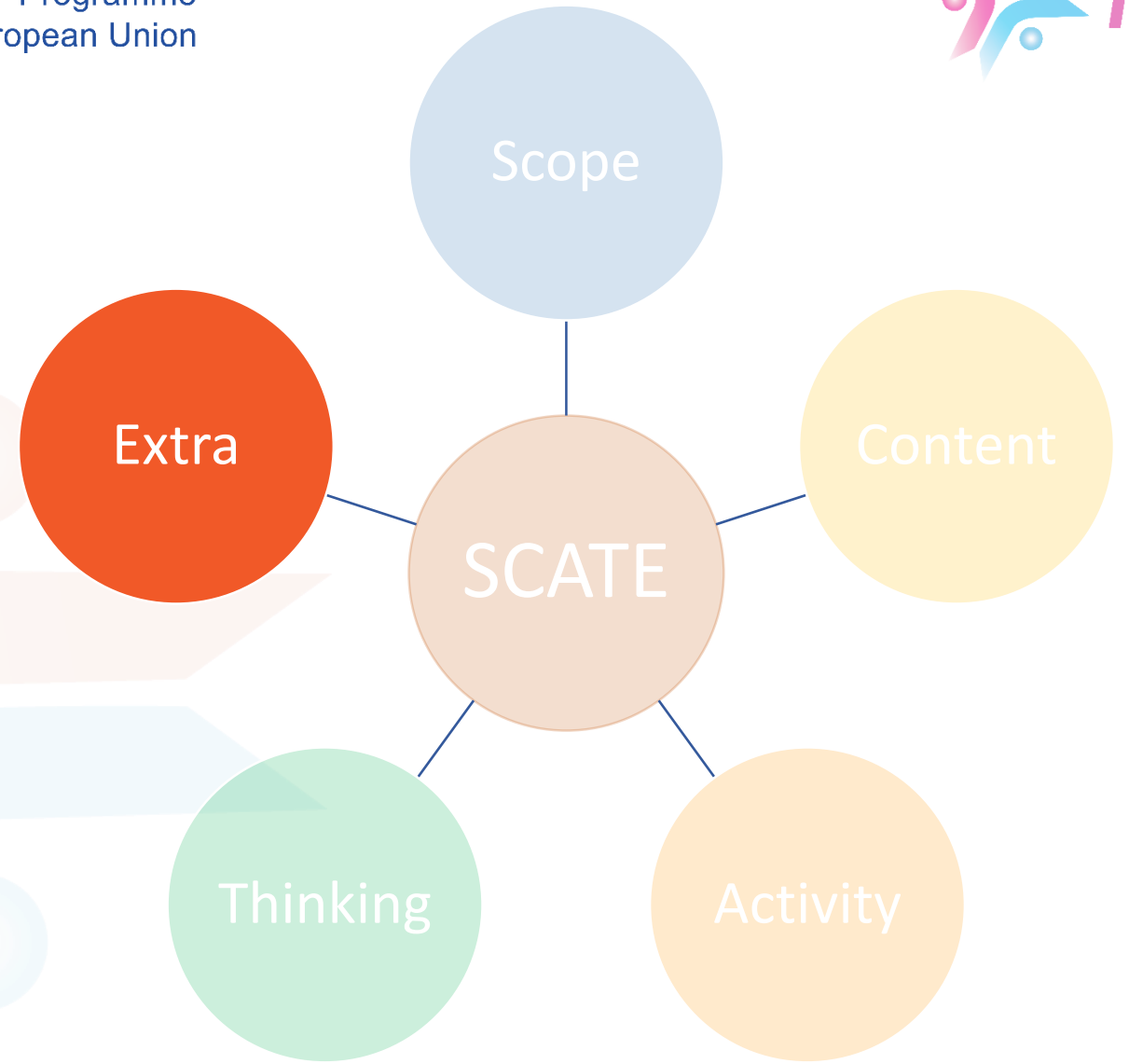
Topic 4



Extra

- Number
- Title
- Topic
- Type

Extra Template	
Number	4
Title	Water and energy integration: Review
Topic	Systematic methods for combined water and energy integration
Type	Online content Review paper • Ahmetović, E., Ibrić, N., Kravanja, Z., Grossmann, I. E., 2015, Water and energy integration: A comprehensive literature review of non-isothermal water network synthesis, Computers & Chemical Engineering 82, 144-171. https://doi.org/10.1016/j.compchemeng.2015.06.011.

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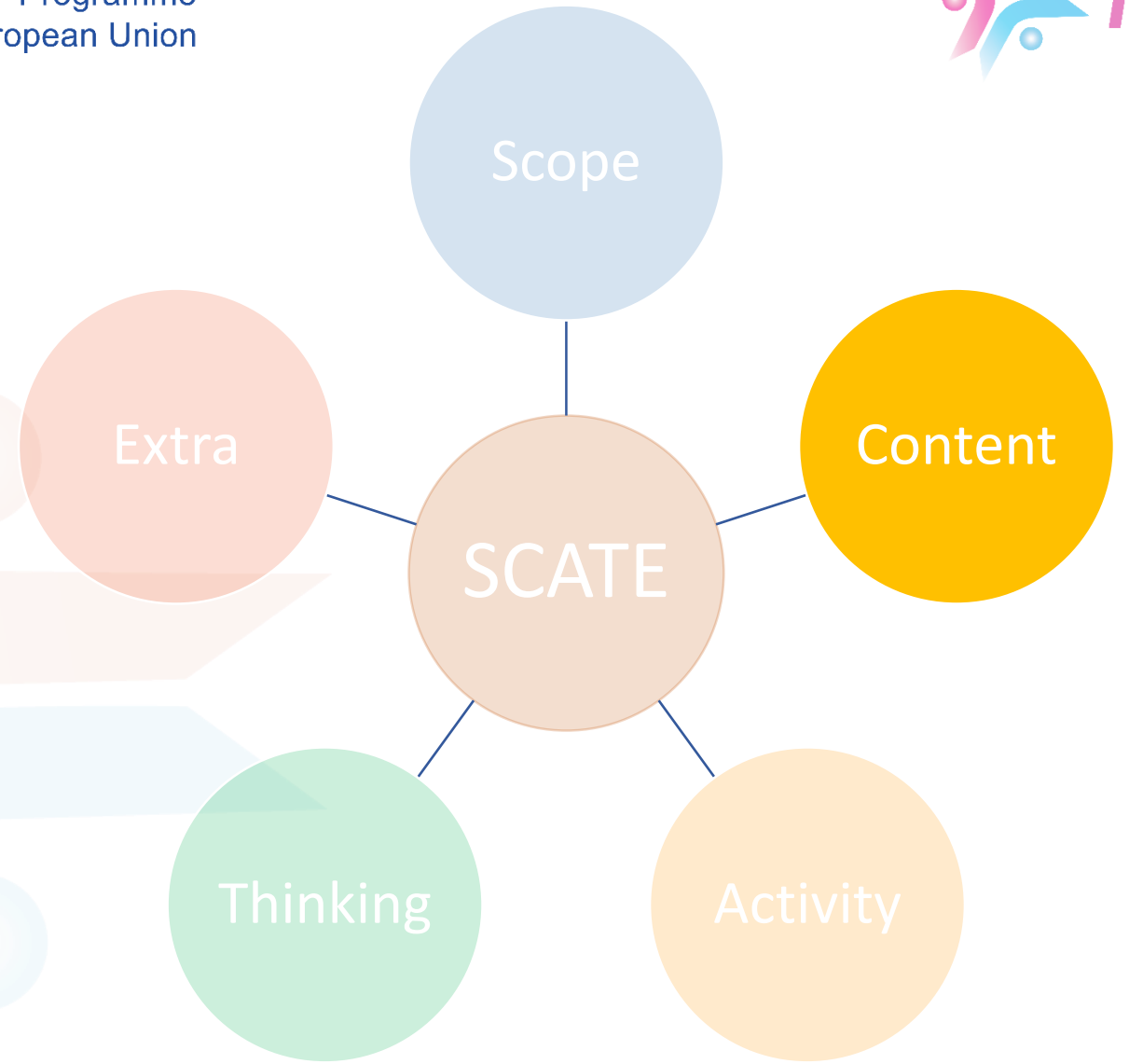

Topic 5

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INTERBA

Content

Section Number

Section Title

Introduction

Content

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INTERBA

Content Template	
Section Number	#5
Section Title	Case study of combined water and energy networks
Introduction	This section presents a case study with two process units to demonstrate networks without water and heat integration (conventional network) and with water and heat integration (combined water and energy network or heat-integrated water network). Also, the section shows the optimal design of combined water and energy network with the minimum total annualized cost obtained by mathematical programming approach.
Content	• Network design without water and heat integration (conventional network) • Combined water and energy network superstructure • Optimal design of combined water and energy network • Comparison of results for Case Study

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Table 1. Problem data for water-using units for Case Study.

Process unit	Contaminant mass load (g/s)	Maximum inlet contaminant concentration (ppm)	Maxiumum outlet contaminant concentration (ppm)	Limiting water flow rate (kg/s)	Temperature (°C)
PU1	5	50	100	100	100
PU2	30	50	800	40	75

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Table 2. Cost and operating parameters for Case Study.	
Freshwater cost	0.375 $/t
Cooling utility cost (cooling water)	189 $/(kW·y)
Heating utility cost (low pressure steam, 120°C)	377 $/(kW·y)
Fixed charge for heat exchangers	8000 $
Area cost coefficient for heat exchangers	1200 $/m^2
Cost exponent for exchangers	0.6
Overall heat transfer coefficient	0.5 kW/(m^2·°C)
Working hours of plant per year	8000 h
Inlet and outlet temperatures of cooling water	10°C and 20°C
Temperatures of freshwater and wastewater	20°C and 30°C
Specific heat capacity of water	4.2 kJ/(kg·°C)

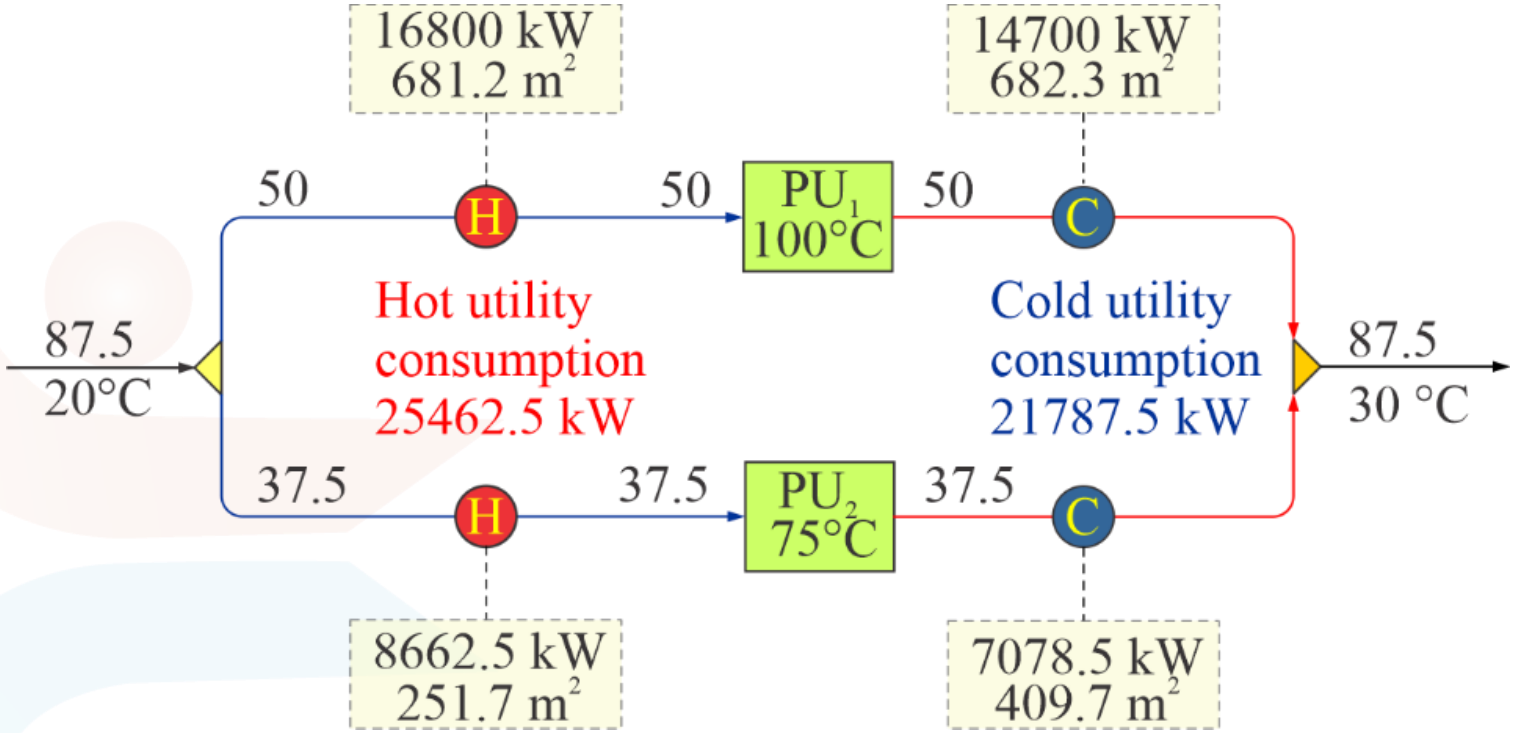

Figure 6. Network design without water and heat integration (conventional network).

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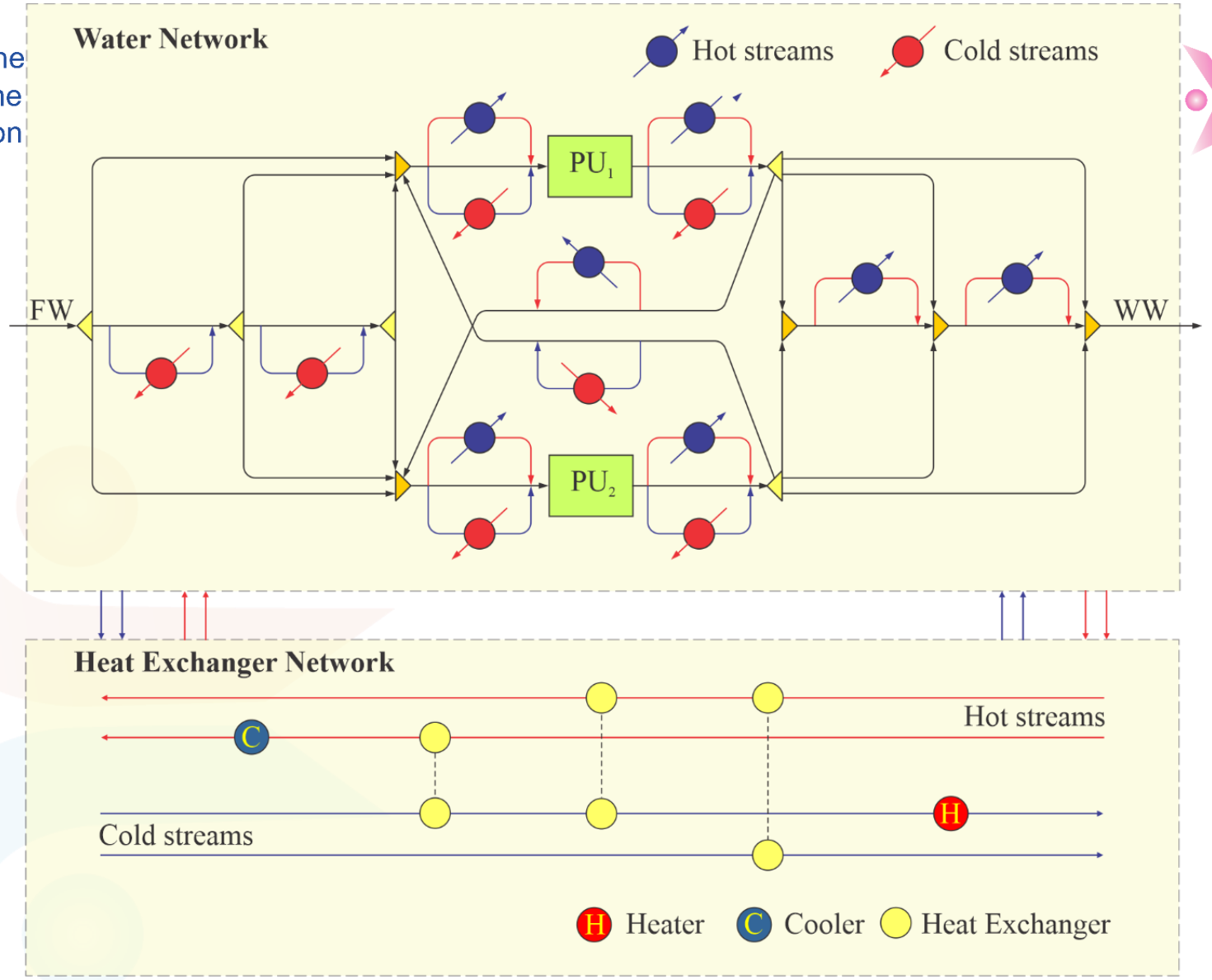

Figure 7. Combined water and energy network superstructure.

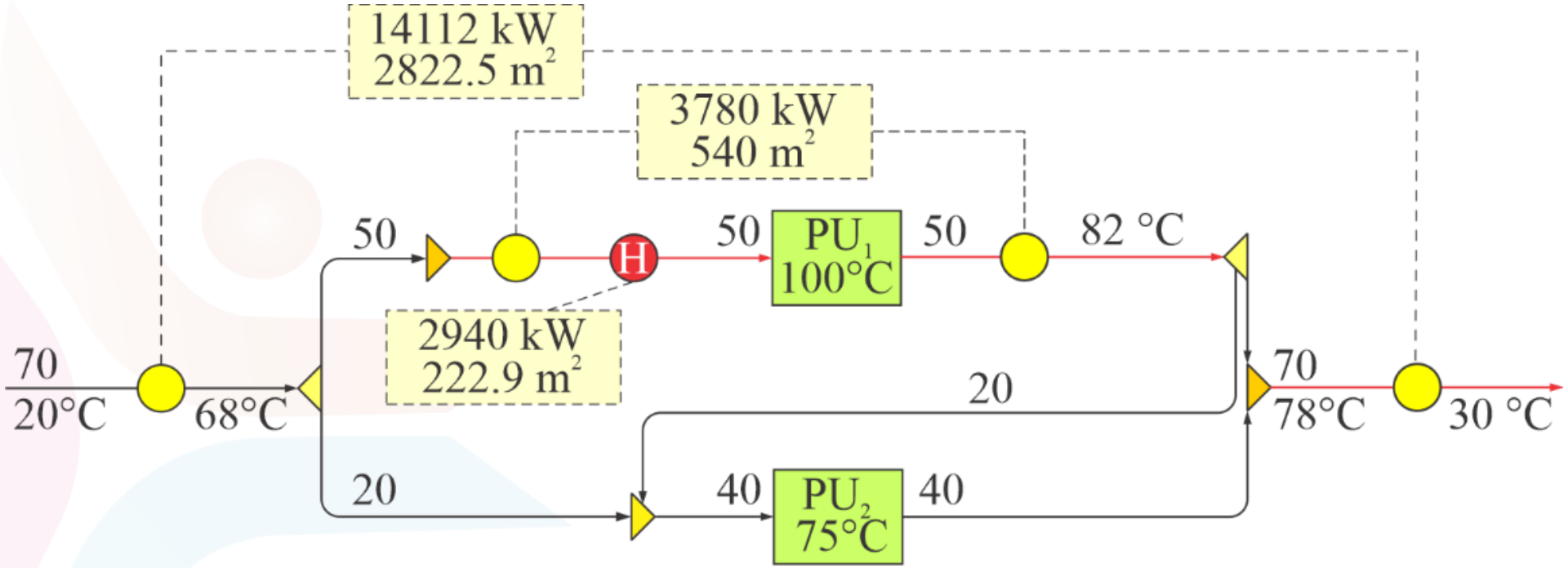

Figure 8. Optimal design of combined water and energy network.

Table 3. Comparison of results for Case Study.

	Conventional network	Optimal network design
Freshwater consumption (kg/s)	87.5	70
Hot utility consumption (kW)	25,462.5	2940
Cold utility consumption (kW)	21,787.5	0
Freshwater cost ($/y)	945,000	756,000
Hot utility cost ($/y)	9,599,363	1,108,380
Cold utility cost ($/y)	4,117,838	0
Investment cost ($/y)	229,751	248,189
Total annual cost ($/y)	14,891,951	2,112,569

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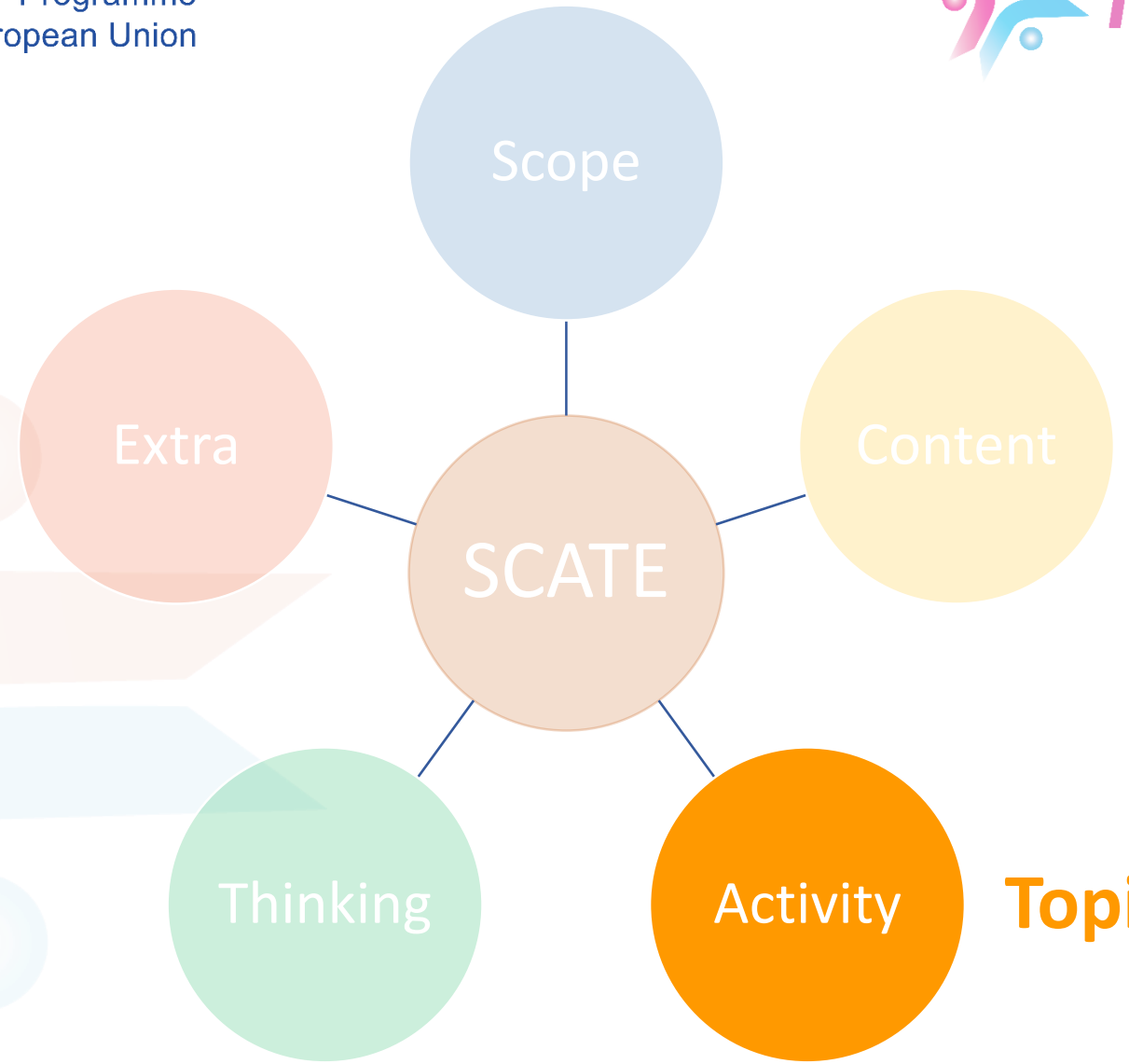

Topic 5

Activity

- Number
- Title
- Type
- Aim
- Description
- Timeline
- Assessment

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INTERBA

Activity Template	
Number	5
Title	Case Study Analysis
Type	Review and Reflection
Aim	LO.5 The aim of this activity is to understand and analyse a conventional network and combined water and energy networks related to the freshwater consumption and the hot and cold utility consumption, check the material and heat balances, and calculate the total annualised costs of both networks.
Description	Each participant will revisit the fifth section, and identify a conventional network and a network with water reuse within the superstructure. Sketch and describe both these networks in a report (maximum one page) and check the material and heat balances, and calculate the total annualised costs of both networks. After 30 minutes for completing this activity, each participant should send an email to the email address of professor and attach his/her report. The file name of report should be given as following „Case Study Analysis_Name_Surname_Academic_Year“.

Activity Template	
Timeline	• Review the fifth section: 10 minutes • Writing a summary report: 15 minutes • Discussing during the assessment: 5 minutes
Assessment	Each participant should present his/her report in the class. Assessment will be based on the quality of the submitted written report and its presentation.

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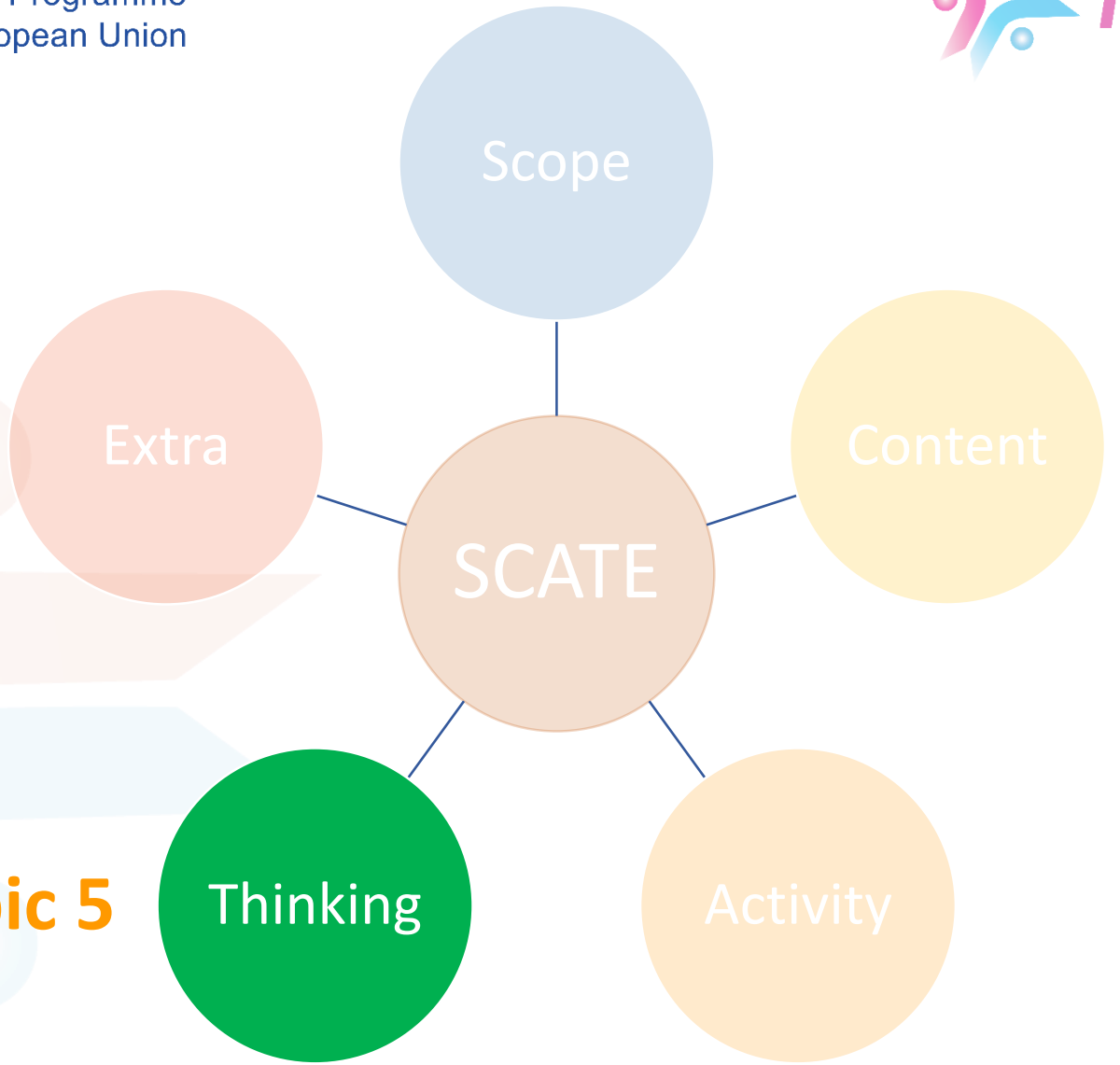

Topic 5

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INTERBA

Thinking

Number	Title	Type	Question	Answers

Think Template (MCQs)	
Number	5
Title	Case study analysis
Type	True or False
Question	By reducing water consumption in the manufacturing process, energy consumption can be also reduced. a) True b) False
Answers	a) True

Think Template (MCQs)	
Number	5
Title	Case study analysis
Type	True or False
Question	By reducing energy consumption in the manufacturing process, water consumption can be also reduced. a) True b) False
Answers	a) True

Think Template (MCQs)	
Number	5
Title	Case study analysis
Type	True or False
Question	Mathematical programming approach can be used for simultaneous optimisation of water and energy integration in different manufacturing processes. a) True b) Fasle
Answers	a) True

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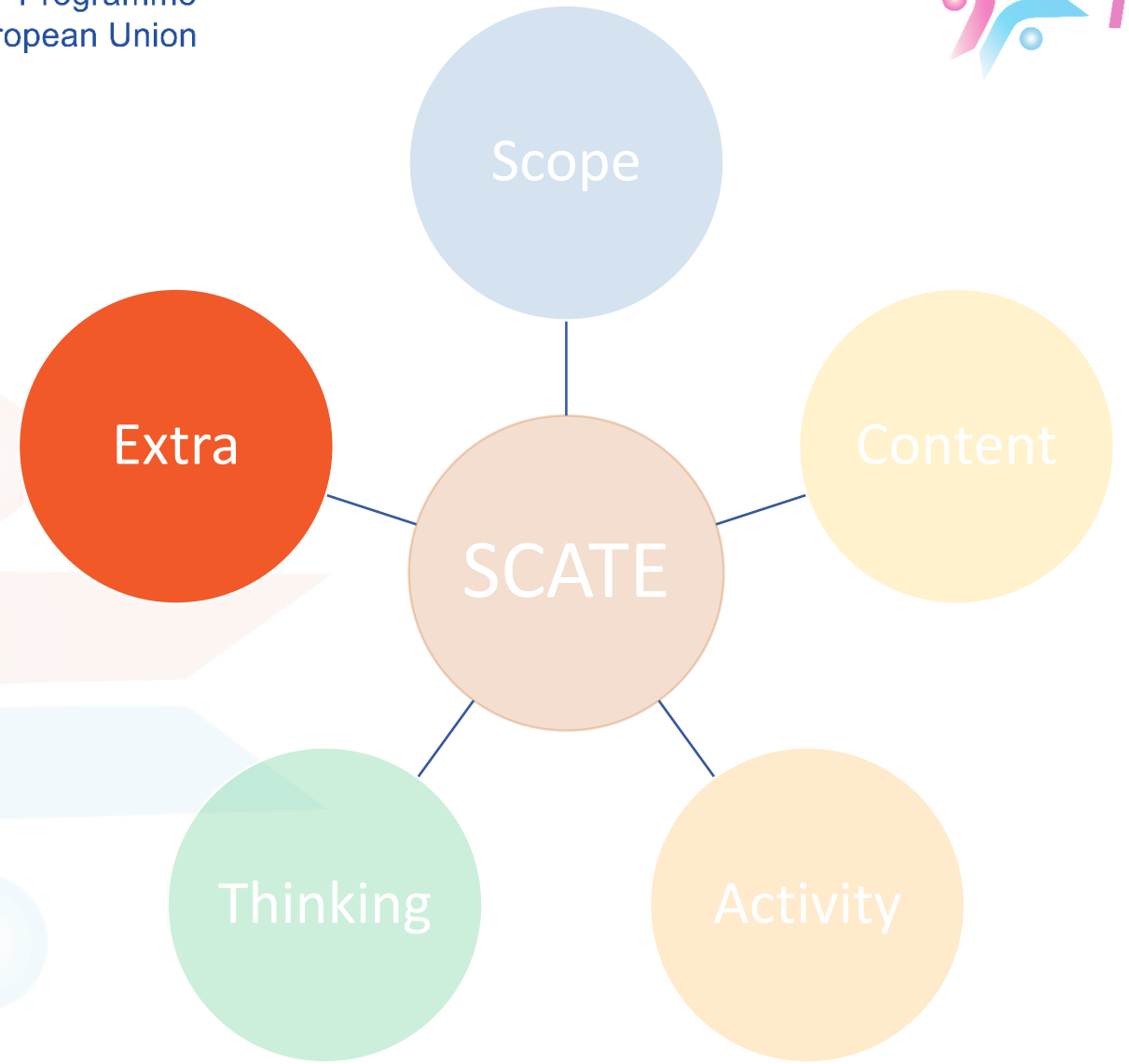
Topic 5



Extra

- Number
- Title
- Topic
- Type

Extra Template	
Number	5
Title	Superstructure development and designs of heat-integrated process-water networks
Topic	Case study of combined water and energy network
Type	Online content Conference abstract • Ahmetović, E., Kravanja, Z. (2012). Effects of the different stages of superstructure development on the efficiencies and designs of heat-integrated process-water networks. The AIChE 2012 Annual meeting, October 28-November 2, 2012, Pittsburgh, Pennsylvania, United States. Video presentation • Ahmetović, E., Ibrić, N., Kravanja, Z., Grossmann, I.E., A Mathematical Programming Approach for Water and Energy Optimisation: A Case Study of a Kraft Pulp Mill. The 4th Sustainable Process Integration Laboratory Scientific Conference - Energy, Water, Emission & Waste in Industry and Cities, November 18-20, 2020, SPIL2020.0226.https://www.youtube.com/watch?v=eORb-MaOzeQ&t. Accessed on January 10, 2022.

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INTERBA

What have we learned?

Write one keyword related to the content presented in this pilot project.

Water and energy consumption in the future will be:

Increased

Decreased

Sustainabilty in the process industry can be achieved by rational use of natural resources, improved water and heat integration, and minimisation of waste streams to the environment.

True

False

The recently adopted target related to net emissions reduction by 2030 plays an important role in achieving climate neutrality in the EU by 2050. According to this target net emission reduction will be reduced at least:

30%

55%

61%

90%

In combined water and energy networks, a process units network, a heat exchanger network, and a wastewater treatment network are combined:

True

False

Simultaneous optimisation of water and energy consumption can be considered in combined water and energy networks.

True

False

Wasterwater reuse, wastewater regeneration and reuse, and wastewater regeneration and recycle present the main concepts for water integration.

True

False

Pinch analysis is a mathematical programming approach based on superstructure optimisation.

True

False

Mathematical programming approach can be used for considering the trade-offs between investment and operating cost to find the best solution.

True

False

By reducing water consumption in the manufacturing process, energy consumption can be also reduced.

True

False

By reducing energy consumption in the manufacturing process, water consumption can be also reduced.

True

False

Mathematical programming approach can be used for simultaneous optimisation of water and energy integration in different manufacturing processes.

True

False

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Summary - Conclussions

INTERBA

Global water and energy consumption and sustainability

Water and energy use in manufacturing processes

Concepts of combined water and energy networks

Systematic methods for combined water and energy integration

Case study of combined water and energy network

Monday April 13, 2022	Day 1
09:00 – 10:00	**Session 1:** Combined Water and Energy Integration in the Process Industries **Name of experts who will cover the session topic:** Elvis Ahmetović and Nidret Ibrić **Institution:** University of Tuzla, Faculty of Technology, P9-UNTZ **Description of session** This session describes the scope of the course, global water and energy consumption, sustainability, water and energy use in manufacturing processes, concepts of combined water and energy networks and systematic methods, and a case study of combined water and energy networks. **Topic covered:** Pilot training prepared in line with the SCATE model

Specific session evaluation:	
• The session was relevant to the training aims and objectives:	SD – D – N – A – SA
• The session provided useful information:	SD – D – N – A – SA
• The session was delivered successfully with professionalism:	SD – D – N – A – SA
• Positive remarks for the specific session:	
• Negative remarks for the specific session:	

SD – Strongly Disagree, D – Disagree, N – Neutral, A- Agree, SA – Strongly Agree

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INTERBA

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Department of Chemical Engineering
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Bosnia and Herzegovina

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