

## Syllabus

### Course description

<b>Course title</b>	District Heating Systems Design (DHSD)
<b>Course code</b>	45515
<b>Scientific sector</b>	ING-IND/10 "Thermal Engineering and Industrial Energy Systems"
<b>Degree</b>	Master Energy Engineering
<b>Semester</b>	2
<b>Year</b>	2
<b>Academic year</b>	2021/2022
<b>Credits</b>	6
<b>Modular</b>	no

<b>Total lecturing hours</b>	50
<b>Total lab and exercise hours</b>	10
<b>Attendance</b>	Not mandatory although recommended for examples, practical analysis and DHSD projects analysis
<b>Recommended preliminary knowledge</b>	Basic knowledge of physics, thermal processes, heat transfer and energy systems analysis
<b>Connections with other courses</b>	The DHSD course presents interactions with courses pertaining the evaluations of the Energy Balance in Buildings (Advanced Application of Building Physics), Electrical Systems (Electrical Power Conversion Equipment) and includes integrations with renewable energy topics.
<b>Course page</b>	-

<b>Specific educational objectives</b>	<p>The main educational objectives of the DHSD course are:</p> <ol style="list-style-type: none"> <li>1. analysis and methodology calculation of the main technical indexes pertaining the performance parameters of a District Heating (DH) grid implementation including dedicate energy scenarios and configurations;</li> <li>2. to train the student on the use of consolidate methodology and engineering tools for the design and management of a DH network;</li> <li>3. to propose evaluations of both technical and economic analysis of a DH networks integrating conventional and/or innovative energy plants.</li> </ol>
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<b>Lecturer</b>	Prof. Maurizio Grigiante, Dr. Andrea Menapace
<b>Scientific sector of the lecturer</b>	ING-IND/10, ICAR/01
<b>Teaching language</b>	English
<b>Office hours</b>	Appointment by email and/or classroom meeting
<b>Teaching assistant (if any)</b>	-

<b>Office hours</b>	Appointment by email
<b>List of topics covered</b>	<ul style="list-style-type: none"> <li>- Energy analysis of DH networks integrated with suitable energy plants including Renewable Energies facilities.</li> <li>- District heating procedures and methodologies actually adopted for the design and testing of a DH network.</li> <li>- Procedures actually adopted for the determination of the thermal loads involved in DH systems.</li> <li>- Analysis of the control systems and the facilities involved in the DH management.</li> <li>- Economic energy analysis aiming at estimating the most important parameters (Pay Back Time, VAN, Proficiency Index) applied to real case of DH networks including the connected energy plant facilities.</li> </ul>
<b>Professional applications of the covered topics</b>	<p>The skills acquired attending this course provide to the students a relevant and extended background of competences actually widely expected by energy companies specifically dedicated to DH design, energy service companies (ESCO), industries producing DH components and control devices. Furthermore, the competences covered by this course allow the student to pursue a career as energy management by applying to dedicated master/courses aiming at integrating the acquired basic background in economic and management issues proposed during the course.</p>
<b>Teaching format</b>	<p>Lecture materials will be provided to the students by the teachers and will be as well proposed and discussed as class lectures utilizing both blackboard and slides. Calculations and design methods will be used to integrate the class lectures with the use, for some applications, of suitable software.</p>

<b>Learning outcomes</b>	<p><b>(1) Knowledge and Understanding:</b></p> <ol style="list-style-type: none"> <li>1. Fundamentals knowledge regarding the energy balance of a DH network including the global energy evaluation of the connected plants.</li> <li>2. Capability of applying the procedures conventionally adopted for the design of a DH pipe lines network both from a thermal and mechanical point of view.</li> <li>3. Detailed analysis of a generic energy power plant facility involving heating, cooling and power production including CHP engines.</li> <li>4. Determination procedures adopted to calculate the most relevant parameters and indexes pertaining the performances of the DH network.</li> </ol>
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	<p><b>(2, 3) Applying Knowledge and Understanding &amp; Making Judgements:</b></p> <ol style="list-style-type: none"> <li>1. Knowledge pertaining the operative tools utilized for the design of a DH network: central plant potentiality estimation, design of the DH network involving the definitions of the geometrical parameters of the pipe lines and evaluation of the most important fluid flow parameters (mass flow rate, pressure drop...).</li> <li>2. Sensibility analysis aiming at evaluating the impact and the technical meaning of the indicated parameters and indexes pertaining the performances of the designed DH including those derived from the economical evaluation.</li> <li>3. Setting up of the economic analysis of the global DH plant and simulations of different scenarios to evaluate the impact of the main cost variations terms in the expected management profitability.</li> </ol> <p><b>(4) Communication Skills:</b></p> <ol style="list-style-type: none"> <li>1. Enhancing the capability and the ability of proposing and discussing the complex negotiation dealing with the decision and the realization of a DH including also the presentation of management competences including technical and economic issues.</li> <li>2. Capability in communicating the proposed design solutions based on the local conditions to which the DH proposal has to be addressed.</li> </ol> <p><b>(5) Ability to Learn</b></p> <ol style="list-style-type: none"> <li>1. Lifelong learning capability through the acquisition of critical tools and critical evaluation of systems.</li> </ol>
<p><b>Assessment</b></p>	<p>The assessment is based on the presentation of the DH design project selected by the student in accordance to the constraints and indications of the teachers. The questions aim at evaluating both the basic and applied knowledge acquired during the course. Particular attention is paid to verify the capability of the student to critically discuss the analysis of different solutions both from a technical, design and economical point of view. Furthermore, the evaluation is extended to test the global competences of the topic issue proposed during the course. Attention will be paid to the personal technical judgment capacity of the student, the mastery of technical concepts and the correct use of the technical language.</p>

	<p style="text-align: center;"><b>Formative assessment (assessed ILOs: 2,3,5)</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Actions</i></th> <th style="text-align: center;"><i>Duration/time line</i></th> </tr> </thead> <tbody> <tr> <td>- analysis and discussion of the criteria to be adopted for the DH design project;</td> <td>during the first part of the course (first weeks);</td> </tr> <tr> <td>- discussion of the basic elements of the selected project;</td> <td>second month of the course;</td> </tr> <tr> <td>- interactive classroom questions pertaining both the relevant topics of the selected projects and the main subjects of the course;</td> <td>during the entire duration of the course;</td> </tr> <tr> <td>- classroom presentation of the guideline followed to design the DH project</td> <td>Final part of the course.</td> </tr> </tbody> </table> <p style="text-align: center;"><b>Summative assessment (assessed ILOs: 1,2,3,4)</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Actions</i></th> <th style="text-align: center;"><i>Duration</i></th> </tr> </thead> <tbody> <tr> <td>Presentation of the DH project based on the discussion of the topics a), b), c), d) indicated in the following section.</td> <td>About 1 hour following the schedule exam sections.</td> </tr> </tbody> </table>	<i>Actions</i>	<i>Duration/time line</i>	- analysis and discussion of the criteria to be adopted for the DH design project;	during the first part of the course (first weeks);	- discussion of the basic elements of the selected project;	second month of the course;	- interactive classroom questions pertaining both the relevant topics of the selected projects and the main subjects of the course;	during the entire duration of the course;	- classroom presentation of the guideline followed to design the DH project	Final part of the course.	<i>Actions</i>	<i>Duration</i>	Presentation of the DH project based on the discussion of the topics a), b), c), d) indicated in the following section.	About 1 hour following the schedule exam sections.
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<b>Assessment language</b>	English														
<b>Evaluation criteria and criteria for awarding marks</b>	<p>The final mark will be determined as average of the mark evaluation referred to the selected project elaboration (70%) and the mark of the oral (30%) presentation and discussion. The global mark must be at least 18.</p> <p>The oral exam is focused on testing the knowledge (80%) of the topics issues proposed during the course, the capability of providing a critical overview of the choices adopted for the selected project. Furthermore, further aspects like clarity of presentation, correctness in use of technical terms ad language, capability of providing simply numerical elaborations and energy conversions, is constitutive (20%) of the oral mark.</p>														

	<p>The project evaluation is dedicated to test the capability of the student in the following topics:</p> <ol style="list-style-type: none"> <li>a) fundamental knowledge and applications of the studied procedures adopted in the selected project;</li> <li>b) critical evaluation of the consistency between the preliminary analysis and the obtained results of the project elaborations;</li> <li>c) the completeness of the design project including the accuracy of technical details of both the design and the corresponding economic analysis;</li> <li>d) novelties and originality introduced in different steps of the global development of the project.</li> </ol> <p>The awarding marks are equally subdivided among the indicated points of the evaluation.</p>
<p><b>Required readings</b></p>	<p>Lessons, digital documents and slides provided by the teachers</p>
<p><b>Supplementary readings</b></p>	<p><b>Books</b></p> <ul style="list-style-type: none"> <li>• District Heating and Cooling, S. Freederiksen, S. Werner, Studentlitteratur AB, LUND 2017.</li> <li>• Advanced District Heating and Cooling (DHC) Systems, Editorial Reviews, Woodhead Publishing 2015.</li> <li>• Il Riscaldamento Urbano, ANNUARIO 2021, Associazione Italiana Riscaldamento Urbano (AIRU).</li> <li>• Teleriscaldamento e Sistemi Energetici Integrati, ENEA 2008.</li> </ul> <p><b>Scientific Literature</b></p> <p>Selected papers published in the years 2021-21 in peer review scientific journals among which <i>Energy, Applied Energy, Sustainable Energy Technologies and Assessments</i>.</p>