ENERGETSKA OSKRBA MEST

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Energetska oskrba mest
Course title:	COMMUNITY-INTEGRATED ENERGY SYSTEMS
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni (od študijskega leta 2023/2024 dalje)	Procesno strojništvo (smer)	3. letnik	1. semester	obvezni

Univerzitetna koda predmeta/University course code:	0563387
Koda učne enote na članici/UL Member course code:	3038-V

Predavanja /Lectures	Seminar /Seminar	Vaje /Tutorials	Klinične vaje /Clinical tutorials	Druge oblike študija /Other forms of study	Samostojno delo /Individual student work	ECTS
30		30			40	4

Nosilec predmeta/Lecturer:	Andrej Kitanovski, Ciril Arkar

Izvajalci predavanj:	
Izvajalci seminarjev:	
Izvajalci vaj:	
Izvajalci kliničnih vaj:	
Izvajalci drugih oblik:	

Izvajalci praktičnega usposabljanja:	
Vrsta predmeta/Course type:	Izbirni strokovni predmet/Elective specialised course

Jeziki/Languages:		
	Predavanja/Lectures:	Slovenščina
	Vaje/Tutorial:	Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Izpolnjevanje pogojev za vpis v Visokošolski strokovni študijski program I. stopnje Strojništvo - Projektno aplikativni program.	Meeting the enrollment conditions for the MECHANICAL ENGINEERING - Project Oriented Applied Programme.

Vsebina:	**Content (Syllabus outline):**
1. Energetska oskrba pametnih mest: Centralni in lokalni sistemi; Razmerja med energenti; Razmerja med neobnovljivimi in obnovljivimi viri; Trendi razvoja in pametna omrežja. 2. Elementi sistemov za energetsko oskrbo mest: Viri in ponori energije; Razvod omrežij; Končni porabniki in podpostaje; Običajno in napredno vodenje. 3. Sistemi daljinskega ogrevanja in hlajenja, oskrbovani iz soproizvodnje ali trigeneracije toplote, električne energije in hladu: Pregled sistemov v svetu in dobre prakse; Primerjalna analiza energetske učinkovitosti posameznih sistemov; Trendi razvoja sistemov poligeneracije. 4. Sistemi daljinskega ogrevanja in hlajenja, oskrbovani z obnovljivimi viri energije: Daljinsko ogrevanje in hlajenje s soncem; Biomasni sistemi daljinskega ogrevanja in hlajenja;	1. Energy supply in smart cities: • District and local systems; • Energy sources and carriers; • Non-renewable and renewable energy sources; • Characteristics and perspectives of smart grids. 2. Components of district community systems: • Energy sources and sinks; • Planning of distribution systems; • End users and substations; • Basic and advanced controlling. 3. District heating and cooling systems connected to the combined heat, cold and electricity production: • Overview and best case examples; • Comparative analysis of district systems efficiency; • Development trends and perspectives of polygeneration systems. 4. District heating and cooling systems connected to the combined heat, cold and electricity production: • Solar district heating and cooling systems;

 Geotermalni sistemi daljinskega ogrevanja in hlajenja.

5. Toplotne črpalke za hlajenje ali ogrevanje v daljinskih energetskih sistemih I:
 Vrste centralnih enot toplotnih črpalk in njihove karakteristike;
 Dopolnilne (t.i. »booster« toplotne črpalke);
 Povezljivost toplotnih črpalk in ostalih proizvodnih virov.

6. Toplotne črpalke za hlajenje ali ogrevanje v daljinskih energetskih sistemih II:
 Naravni viri in ponori za toplotne črpalke v sistemih daljinske energetike;
 Specifičnost plinsko-gnanih toplotnih črpalk za sisteme daljinskega ogrevanja in hlajenja;
 Načrtovanje sistemov s toplotnimi črpalkami.

7. Sistemi daljinske energetike, oskrbovani z odpadno energijo procesov, ali energijo iz energijske pretvorbe odpadkov:
 Komunalni odpadki kot energent sistemov daljinskega ogrevanja;
 Odpadna toplota industrijskih procesov v daljinski energetiki;
 Dodajanje bio-plina v plinskih omrežjih.

8. Pregled in značilnosti sistemov daljinskega ogrevanja:
 Osnove načrtovanja sistemov daljinskega ogrevanja;
 Osnovni elementi;
 Obratovalne značilnosti;
 Metode in ukrepi za doseganje zanesljivosti distribucije.

9. Pregled in značilnosti sistemov daljinskega hlajenja:
 Osnove načrtovanja sistemov daljinskega hlajenja;
 Osnovni elementi;
 Obratovalne značilnosti;
 Metode in ukrepi za doseganje zanesljivosti distribucije.

10. Pregled in značilnosti sistemov distribucije plina:

- Biomass district heating and cooling systems;
- Geothermal district heating and cooling systems.

5. Heat pumps for cooling and heating in district energy supply systems I:

- Types of centralized heat pump systems and their characteristics;
- Booster heat pumps;
- Connectivity of heat pumps and other energy production sources.

6. Heat pumps for cooling and heating in district energy supply systems II:

- Natural sources and sinks for heat pumps in district energy systems;
- Specifics of gas-driven heat pumps for district heating and cooling;
- Planning of systems with heat pumps.

7. District energy supply systems based on waste heat and waste treatment plants:

- Municipality waste as energy source for district heating;
- Industrial waste heat utilization in district heating systems;

Feeding of gas networks with bio-gas.

8. Overview and characteristics of district heating systems:

- Basics of system design;
- Components and appliances;
- Operating conditions;
- Methods and measures for reliable operation and supply.

9. Overview and characteristics of district cooling systems:

- Basics of system design;
- Components and devices;
- Operating conditions;Methods and measures for reliable operation and supply.

10. Overview and characteristics of district gas distribution systems: Basics of gas distribution pipelines;

- Components and devices;

□ Osnove načrtovanja sistemov distribucije plina; □ Osnovni elementi; □ Obratovalne značilnosti; □ Kompresorske, reducirne postaje in hranilniki; □ Metode in ukrepi za doseganje zanesljivosti distribucije. 11. Inženirske metode za določitev toplotne učinkovitosti v ceveh in cevnih mrežah sistemov daljinskega ogrevanja in hlajenja: □ Toplotne izgube in dobitki omrežij daljinskega ogrevanja in hlajenja; □ Izboljšave energijske učinkovitosti povezav. 12. Inženirske metode za določitev tokovnih razmer v ceveh in cevnih mrežah sistemov daljinske energetike: □ Hidravlične povezave in razmere v sistemih (predstavitev numeričnega orodja Termis); □ Raba energije za transport energije; □ Izboljšave energijske učinkovitosti prenosa energentov. 13. Električna omrežja in oskrba mest: □ Uvod v pametna električna omrežja; □ Specifičnost povezav; □ Nadzor in upravljanje prenosnih in distribucijskih omrežij. 14. Okoljski vidiki energetske oskrbe mest: □ Kazalniki kakovosti okolja v mestih; □ Emisije onesnažil, ki jih povzroča; □ Inženirska orodja za modeliranje širjenja onesnažil v mestih. 15. Povečanje učinkovitosti energetskih sistemov v mestih na nivoju rabe energije: □ Ukrepi na razvodu; □ Hranilniki toplote in električne energije; □ Na odjemu, v stavbah; □ Na odjemu, industrijski porabniki.	• Operating conditions; • Compressor, pressure reduction stations, large scale gas storages; • Methods and measures for reliable operation and supply. 11. Engineering methods for evaluation of energy efficiency of distribution networks of district heating and cooling systems: • Heat loses and heat gains in pipelines; • Principles for increase of energy efficiency of district energy networks. 12. Engineering methods for evaluation of hydraulic conditions in pipelines of district energy systems: • Hydraulic conditions in pipelines and networks (using Termis); • Energy demand for energy transport in networks; • Measures for improving the energy efficiency of transported energy carriers. 13. Electricity grids and electricity supply in cities: • Basics of smart grids; • Transmission network specifics; • Control and management of transmission network systems. 14. Environmental aspects of energy supply in cities: • Environmental quality indicators in urban environment; • Environment pollution caused by energy transformation and use • Engineering methods for modelling of pollutant imission in urban environment. 15. Measures for increasing the efficiency of energy supply in cities: • Measures for distribution systems; • Thermal and electrical storages; • Measures at demand – buildings, industry users.

Temeljna literatura in viri/Readings:

1. Danny Harvey, L. D. A handbook on low-energy buildings and district-energy systems : Fundamentals, techniques and examples. Earthscan, 2006.
2. Sørensen, B. Renewable energy conversion, transmission and storage. Elsevier Inc., 2007.
3. Tränkler, H.-R., Schneider, F. Das intelligente haus : Wohnen und Arbeiten mit zukunftsweisender Technik. Richard Plaum Verlag GmbH, 2001.
4. Eastop, T. D., Croft, D. R. Energy efficiency for engineers and technologists. Longman Group UK Limited, 1990.
5. Kraushaar, J. J., Ristinen, R. A. Energy and problems of a technical society. John Wiley & Sons, Inc., 1984.
6. Svend Frederiksen, Sven Werner, District Heating and Cooling, 2013
7. A.Kitanovski, A.Poredoš, Daljinsko hlajenje, 2001
8. Monti (Ed.), D. Pesch (E.), K.Ellis (Ed.), P. Mancarella (Ed.), Energy Positive Neighborhoods and Smart Energy Districts: Methods, Tools, and Experiences from the Field, 2016
9. R. Wiltshire (Editor)Advanced District Heating and Cooling (DHC) Systems, 2015
10. Marc A. Rosen, S. Koohi-Fayegh, Cogeneration and District Energy Systems: Modelling, analysis and optimization (Energy Engineering), 2016
11. 10. Bernd M. Buchholz, Zbigniew A. Styczynski, Smart Grids: Fundamentals and Technologies in Electric Power Systems of the future, 2nd Edition, Springer, 2020

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Spoznati pomen, trende, tehnologije, inženirske metode načrtovanja in okoljske ter stroškovne vidike sistemov za distrubucijo energentov v mestih. Kompetence: 1. S2-PAP, P3-PAP: Sposobnost samostojnega dela v okviru znanj s področja poznavanja delovanja, načrtovanja in planiranja komunalnih energetskih sistemov. 2. S11-PAP, P3-PAP: Sposobnost reševanja strokovnih problemov v svojem delovnem okolju.	Education goals: 1. Learn about technologies, design methods, trends, environmental issues and economics, and acquire engineering methods for energy distribution in cities. Competence: 1. S2-PAP, P3-PAP Ability to work independently with the obtained knowledge on the design, operation and planning of district energy systems. 2. 2. S11-PAP, P3-PAP: Ability to solve professional problems in work environment.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Z1: Poglobljeno strokovno teoretično in praktično znanje na področju načrtovanja, optimizacije in vodenja sistemov za distribucijo energentov v mestih.	Knowledge: Z1: Thorough professional theoretical and practical knowledge in a field of design, optimization and management of energy distribution systems in cities that is supported with a broad theoretical

Spretnosti: S1.2: Obvladovanje zahtevnih, kompleksnih procesov načrtovanja sistemov za generacijo in prenos in rabo energentov z centralnimi- daljinskimi sistemi v mestih.	and methodological basis. Skills: S1.2 Mastering complex design processes for generation, distribution and use of energy carriers with district energy systems in cities.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Klasične oblike poučevana: P1: Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov. P3: Avditorne vaje, kjer se teoretično znanje s predavanj podkrepi z računskimi primeri. P4: Laboratorijske vaje z namenskimi didaktičnimi pripomočki z dostopom na daljavo. Moderne oblike poučevanja: P6: Interaktivna predavanja. P8: Izdelava in predstavitev aplikativnih seminarskih nalog. P15: Uporaba video vsebin kot priprava na predavanja in vaje.	Conventional teaching methods: P1: Auditorial lectures with solving selected field-specific theoretical and applied use cases. P3: Auditorial exercises, in which theoretical content from the lectures is supplemented with practical examples. P4. Laboratory work with special purpose didactic computer tools and test object with remote access. Contemporary and flexible teaching methods: P6: Interactive lectures. P8. Making and presenting applied seminar exercises. P15. Applying multimedia presentations for preparations to the lectures and exercises.

Načini ocenjevanja:	**Delež/ Weight**	**Assessment:**
Teoretične vsebine (predavanja).	50,00 %	Theory
Samostojno delo na vajah.	25,00 %	Tutorials
Seminar	25,00 %	Individual seminar work

Reference nosilca/Lecturer's references:

Andrej Kitanovski:

1. DUH ČOŽ, Tjaša, **KITANOVSKI, Andrej**, POREDOŠ, Alojz. Primary energy factor of a district cooling system. *Strojniški vestnik*, ISSN 0039-2480, Dec. 2016, vol. 62, no. 12, str. 717-729, SI 123, ilustr., doi: 10.5545/sv-jme.2016.3777. [COBISS.SI-ID 15130651], [JCR, SNIP, WoS]
2. POTOČNIK, Primož, VIDRIH, Boris, **KITANOVSKI, Andrej**, GOVEKAR, Edvard. Analysis and optimization of thermal comfort in residential buildings by means of a weather-controlled air-to-water heat pump. *Building and environment*, ISSN

0360-1323. [Print ed.], Aug. 2018, vol. 140, str. 68-79, [COBISS.SI-ID 16069915], [JCR, SNIP, WoS]

3. POREDOŠ, Primož, VIDRIH, Boris, **KITANOVSKI, Andrej**, POREDOŠ, Alojz. A Thermo-economic and emissions analysis of different sanitary-water heating units embedded within 4th-generation district-heating systems. V: BEYENE, Asfaw (ur.). 30th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, July 2-6, 2014, San Diego, California : ECOS 2017, 2017, f. 2667-2680, ilustr. [COBISS.SI-ID 15585307]
4. POREDOŠ, Alojz, **KITANOVSKI, Andrej**. District heating and cooling for efficient energy supply. V: *Proceedings*, International Conference on Electrical and Control Engineering, Sep. 16-18, 2011, Yichang, China, (IEEE catalog numer, CFP1173J-PRT). [S. l]: Institut of Electrical and Electronics Engineers. 2011, str. 5238-5241. [COBISS.SI-ID 12003099]
5. VIDRIH, Boris, **KITANOVSKI, Andrej**. *Primerjalna tehnično-ekonomska analiza ogrevanja in hlajenja stavb s pomočjo plinsko gnanih toplotnih črpalk : končno poročilo*. Ljubljana: Fakulteta za strojništvo, Laboratorij za hlajenje in daljinsko energetiko, 2018. 80 f., ilustr. [COBISS.SI-ID 16418331]

Ciril Arkar:

1. MEDVED, Sašo, DOMJAN, Suzana, ŽIŽAK, Tej, **ARKAR, Ciril**. *Razlagalni dokument PURES 2022 in TSG-1-004:2022*. Ljubljana: Fakulteta za strojništvo, Laboratorij za okoljske tehnologije v stavbah LOTZ, 2022. 135 f., graf. prikazi. [COBISS.SI-ID 98466563]
2. **ARKAR, Ciril**, ŽIŽAK, Tej, DOMJAN, Suzana, MEDVED, Sašo. Comparative analysis of free cooling of photovoltaics – phase change versus evaporative cooling. *Journal of energy storage*. [Print ed.]. May 2022, vol. 49, str. 1-13, ilustr. ISSN 2352-152X. https://www.sciencedirect.com/science/article/pii/S2352152X22001967, DOI: 10.1016/j.est.2022.104162. [COBISS.SI-ID 97940227]
3. ŽIŽAK, Tej, DOMJAN, Suzana, MEDVED, Sašo, **ARKAR, Ciril**. Efficiency and sustainability assessment of evaporative cooling of photovoltaics. *Energy*. Sep. 2022, vol. 254, pt. a, str. 1-12, ilustr. ISSN 0360-5442. https://www.sciencedirect.com/science/article/pii/S036054422201163X, DOI: 10.1016/j.energy.2022.124260. [COBISS.SI-ID 108992259]
4. MEDVED, Sašo, DOMJAN, Suzana, **ARKAR, Ciril**. Contribution of energy storage to the transition from net zero to zero energy buildings. *Energy and buildings*. [Print ed.]. Apr. 2021, vol. 236, str. 1-13, ilustr. ISSN 0378-7788. https://www.sciencedirect.com/science/article/pii/S0378778821000359?via%3Dihub, DOI: 10.1016/j.enbuild.2021.110751. [COBISS.SI-ID 51396355]
5. MEDVED, Sašo, DOMJAN, Suzana, **ARKAR, Ciril**. *Sustainable technologies for nearly zero energy buildings : design and evaluation methods*. Cham: Springer, cop. 2019. XV, 388 str., barvne ilustr. Springer tracts in civil engineering. ISBN 978-3-030-02821-3. ISSN 2366-259X. https://link.springer.com/book/10.1007%2F978-3-030-02822-0. [COBISS.SI-ID 16490011]