UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Pametna mesta
Course title:	SMART CITIES
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	**Študijska smer**	**Letnik**	**Semestri**
Strojništvo - Razvojno raziskovalni program, druga stopnja, magistrski	Procesno strojništvo (smer)	2. letnik	1. semester

Univerzitetna koda predmeta/University course code:	0566927
Koda učne enote na članici/UL Member course code:	6022-M

Predavanja	**Seminar**	**Vaje**	**Klinične vaje**	**Druge oblike študija**	**Samostojno delo**	**ECTS**
30		30			65	5

Nosilec predmeta/Lecturer:	Andrej Kitanovski, Sašo Medved
Vrsta predmeta/Course type:	Obvezni strokovni predmet na smeri Procesno strojništvo, ki je izbirni strokovni predmet na ostalih smereh./Compulsory specialised course in the study of Process Engineering, which is an elective specialised course in other fields of study.
Jeziki/Languages:	Predavanja/Lectures: Slovenščina Vaje/Tutorial: Slovenščina

Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:	**Prerequisites:**
Izpolnjevanje pogojev za vpis v Magistrski študijski program II. stopnje Strojništvo - Razvojno raziskovalni program.	Meeting the enrollment conditions for the Master's study programme of Mechanical Engineering - Research and Development program.

Vsebina:	**Content (Syllabus outline):**
1. Trajnostna in pametna mesta: - koncepti in razlike trajnostnih in pametnih mest, - kazalniki in primeri integracije trajnostnih in pametnih gradnikov mest v pametnih mestih, - nizkoogljični in obnovljivi viri energije za trajnostno oskrbo mest.	1. Sustainable and smart cities: - concepts and types of sustainable and smart cities; - indicators and cases of implementation of sustainable and smart building blocks in smart cities; - low-carbon and renewable energy sources for sustainable supply of cities.

2. Modeliranje toplotnega odziva mest: - modeliranje mikroklime v mestih, - ukrepi za blaženje toplotnih otokov, - vpliv mikroklimatskih razmer v mestih na rabo energije, - primeri ENVIMET. 3. Koncepti za izboljšanje kakovosti okolja v pametnih mestih: - modeliranje tokov onesnažil v zunanjem okolju, - vpliv pametnih gradnikov na indeks počutja in zdravega bivanja, - vpliv energetskih sistemov na kakovost bivanja, - vpliv naravnih gradnikov na kakovost bivanja mestih, - primeri ENVIMET. 4. Tehnologije in sistemi za distribucijo energij v pametnih mestih: - koncepti razvoja pametnih distribucijskih sistemov, - pregled vseh sistemov za oskrbo mest s toploto, hladom, plinom in elektriko. 5. Sistemi daljinskega ogrevanja - toplotne podpostaje, - toplotne izgube, optimalna debelina izolacije, temperaturni režim, ukrepi za znižanje temperature povratka, - sistemska voda, črpalne postaje in hidravlične razmere, - varnost, zanesljivost, energijska učinkovitost - načrtovanje sistemov daljinskega ogrevanja. 6. Sistemi daljinskega hlajenja - proizvodnja hladu za daljinsko hlajenje, - preračun cevne mreže daljinskega hlajenja, - varnost, zanesljivost, energijska učinkovitost - načrtovanje sistemov daljinskega ogrevanja. 7. Plinovodna omrežja - magistralni cevovodi, distribucijsko omrežje, armature, - vzdrževanje tlaka, reducirne postaje in ekspanzijsko pridobivanje dela, - kompresorske postaje, hranilniki plinavarnost, zanesljivost - načrtovanje plinovodnih omrežij. 8. Električna omrežja v mestih - prenosna omrežja in pomen, - pametna električna omrežja. 9. Dinamični in vremensko vodeni modeli upravljanja sistemov daljinske energetike 1 - dinamično modeliranje hranilnikov toplote, hladu in električne energije v integralnih sistemih energijske oskrbe, - dinamično modeliranje proizvodnih enot. 10. Dinamični in vremensko vodeni modeli upravljanja sistemov daljinske energetike 2 - zajem podatkov, obdelava podatkov, daljinsko vodenje, nadzor, napovedovanje odjema energentov iz	2. Modelling the thermal response of cities: - urban microclimate; - measures for mitigation of urban heat islands; - impact of microclimate on the energy demand in cities; - ENVIMET case studies. 3. Concept and measures for improvement of outdoor environment in smart cities: - models for determination of pollutant propagation in outdoor environment; - influence of smart building blocks on wellbeing and health index; - influence of energy supply systems on outdoor living comfort in smart cities; - influence of greened building blocks on outdoor living comfort in smart cities; -ENVIMET case studies. 4. Technologies and systems for energy distribution in smart cities: - design concepts of smart distribution systems; - overview of systems for heat, cold, gas and electricity supply in smart cities. 5. District heating systems: - substations; - heat losses and optimal thermal insulation of distribution systems, operating temperature regimes, measures for increasing of energy efficiency of distribution systems; - pump stations; - reliable, safe and energy efficient operation; - design of district heating systems. 6. District cooling systems: - cold production for district cooling systems; - energy efficiency of district cooling systems; - design of pipeline network; - reliable, safe and energy efficient operation; -design of district cooling systems. 7. Gas pipelines - main pipelines, networks, appliances; - pressure maintenance, reduction gas substations, expansion work; - compressor stations, gas storages; - reliable and safe operation; - design of gas networks. 8. Electricity distribution systems: - overview of transmission networks; - smart electrical networks and systems. 9. Dynamic and weather prediction models for control of district energy supply systems 1: - transient modelling of heat, cold and electricity storages in total energy supply systems; - transient modelling of energy production. 10. Dynamic and weather prediction models for control of district energy supply systems 2: - operation data assessment, distant control and

distribucijskega - pametno upravljanje delovanja sistemov daljinske energetike. 11. Upravljanje z vodo in odpadki v pametnih mestih - tehnologije ravnanja, pametno upravljanje, siva in črna voda in odpadki kot energent. 12. Vodila in metode načrtovanja in presoje nič energijskih stavb - tehnologije energijske samooskrbe pametnih stavb v mestih; - podporne tehnologije za zagotavljanje energijske samozadostnosti stavb. 13. Koncept pametnih stavb in podporne tehnologije - internet stvari, indeks pripravljenosti stavb na pametna omrežja (SRI), - metode vrednotenja SRI, - pomen informacijskih tehnologij ter VR in AR tehnik za načrtovanje stavb. 14. Modeliranje pametnih tehničnih stavbnih sistemov v pametnih stavbah - metode modeliranja, - računalniški modeli, - EPBD kazalniki energijske učinkovitosti stavb. 15. Napredno spremljanje kakovosti bivalnega ugodja, energijskih in snovnih tokov v pametnih mestih - pametni monitoring, - tehnologije monitoringa, - vpliv BAC na energijsko učinkovitost stavb in mest.	management, prediction demand control; - smart control of district energy systems. 11. Water and waste management in smart cities: - concepts, smart management, grey and black water treatment, waste as energy source. 12. Guidelines and design roles for nearly and nett zero energy buildings: - concepts and technologies for energy self-sufficient smart buildings; - measures and supporting technologies for energy self-sufficient smart buildings. 13. Smart buildings: - internet of things, adaptation of buildings towards smart buildings; - building smartness indicator (SRI) - information technologies, VR and AR techniques for supporting the building design. 14. Modelling of smart building service systems: - modelling approaches; - computer tools; - EPBD indicators of buildings energy efficiency. 15. Advanced and adaptive indoor living environment design, energy and sustainability monitoring in buildings: - smart monitoring techniques; - monitoring technologies; - supporting sustainability and energy efficiency by IT.

Temeljna literatura in viri/Readings:

Medved, S., Domjan, S., Arkar, C. Sustainable technologies for nearly zero energy buildings : design and evaluation methods. Springer Nature Switzerland AG, 2019.

Energy and climate in the urban built environment. Ur.: M. Santamouris, James & James, London, 2001.

Lenz, B., Schreiber, J., Stark, T. Sustainable buildings services : Principles, systems, concepts. Detail Green Books, München, 2011.

Daniels, K., Hammann, R. E. Energy design for tomorrow. Edition Axel Menges, Stuttgart / London, 2009.

Glücklich, D., et al. Ökologisches Bauen : Von Grundlagen zu Gesamtkonzepten. Deutsche Verlags-Anstalt, München, 2005.

Cilji in kompetence:	**Objectives and competences:**
Cilji: 1. Spoznati koncepte načrtovanja, lastnosti gradnikov in vodenja tehničnih sistemov v pametnih mestih. 2. Spoznati koncepte in podporne tehnologije pametnih in nič energijskih stavb ter osvojiti	Education goals: 1. Learn about concepts, building blocks and management of technology systems in smart cities. 2. Learn about concepts and supporting technologies of smart and nearly/nett energy

znanja za njihovo energetsko modeliranje in presojo. 3. Pridobiti znanje na področju modeliranja in vodenja sistemov energijske oskrbe v pametnih mestih in pametnih stavbah. Kompetence: 1. Širitev sposobnosti kritičnega, analitičnega in sintetičnega mišljenja. Razvijanje novega znanja in razumevanje področja pametnih mest, pametnih tehničnih sistemov in pametnih stavb (S1-MAG+P1-MAG) 2. Usposobljenost za delo v skupini in interdisciplinarno povezovanje. (S9-MAG+P4-MAG)	buildings and gain the knowledge for energy modelling and evaluation of smart buildings. 3. Learn about concepts for modelling and management of district energy supply systems in smart cities and smart buildings. Competence: 1. S1-RRP, P1-RRP The ability to define, understand and creatively solve professional challenges in field of smart cities, smart technical systems and smart buildings and mastering of basic theoretical skills for design and assessment of smart cities and smart buildings. 2. S9-RRP, P4-PPR Adherence to safety, functional, economic and environmental principles in study field.

Predvideni študijski rezultati:	**Intended learning outcomes:**
Znanja: Z2. Poglobljeno teoretično, metodološko in analitično znanje z elementi raziskovanja, ki je osnova za razumevanje konceptov načrtovanja in vrednotenja pametnih mest in modeliranja gradnikov z vidika trajnostne energetike in ravnanja s snovmi. Spretnosti: S2.1. Obvladovanje zelo zahtevnih kompleksnih procesov načrtovanja in presoje energetskih procesov in okoljevarstvenih ukrepov z uporabo numeričnih orodij na področju energijske oskrbe in ravnanja s snovmi v pametnih mestih. S2.2. Uporaba računalniških podpornih tehnologij za načrtovanje pametnih mest, omrežij in stavb.	Knowledge: Z2: Thorough theoretical, methodological, analytical knowledge with elements of research work that form a basis for very demanding professional work. Skills: S2.1 Mastering very demending and complex work processes and methodological tools in specialised professional fields of energy supply and material flows treatment. S2.1 Mastering very demending and complex work processes and methodological tools in specialised professional fields of design and management of smart cities and smart buildings.

Metode poučevanja in učenja:	**Learning and teaching methods:**
Klasične oblike poučevanja 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	Coventional teaching methods: P1: Auditorial lectures with solving selected field-specific theoretical and applied use cases. P3: Auditorial exrecises, in which theoretical content from lectures is supported with practical examples. P4. Laboratory work with dedicated computer tools and test equipment with remote access. Contemporary and flexible teaching methods: P6: Interactive lectures. P8. Making and presenting applied seminar exercises.

nalog P15 Uporaba video vsebin kot priprava na predavanja in vaje	P15. Application of multimedia presentations for preparation 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:

Sašo Medved

1. ŠUKLJE, Tomaž, HAMDY, Mohamed, ARKAR, Ciril, HENSEN, Jan, MEDVED, Sašo. An inverse modeling approach for the thermal response modeling of green façades. *Applied energy*, ISSN 0306-2619, Feb. 2019, vol. 235, str. 1447-1456.
2. ŠUKLJE, Tomaž, MEDVED, Sašo, ARKAR, Ciril. On detailed thermal response modeling of vertical greenery systems as cooling measure for buildings and cities in summer conditions. *Energy*. [Print ed.]. Nov. 2016, vol. 115, pt. 1, str. 1055-1068, ilustr. ISSN 0360-5442.
3. MEDVED, Sašo, BABNIK, Miha, VIDRIH, Boris, ARKAR, Ciril. Parametric study on the advantages of weather-predicted control algorithm of free cooling ventilation system. *Energy*, ISSN 0360-5442. [Print ed.], Aug. 2014, vol. 73, str. 80-87.
4. VIDRIH, Boris, MEDVED, Sašo. Multiparametric model of urban park cooling island. *Urban Forestry and Urban Greening*, ISSN 1618-8667, 2013, vol. 12, iss. 2, str. 220-229.
5. MEDVED, Sašo, DOMJAN, Suzana, ARKAR, Ciril. *Sustainable technologies for nearly zero energy buildings : design and evaluation methods*, (Springer tracts in civil engineering). Cham: Springer, cop. 2019.
6. DOMJAN, Suzana, ARKAR, Ciril, MEDVED, Sašo. *Dynamic model of building's thermal response : Primary school Strem*. Ljubljana: Fakulteta za strojništvo, Dec. 2017. 23 f., ilustr. [COBISS.SI-ID 15837979]
7. ARKAR, Ciril, MEDVED, Sašo. *PET tool : Das Urbanscape Gründach-System Leistungsbewertungs werkzeug*. [Ljubljana: Fakulteta za strojništvo, 2017]. 1 optični disk (CD-ROM), ilustr. [COBISS.SI-ID 15542555]

Andrej Kitanovski

1. POREDOŠ, Primož, KITANOVSKI, Andrej, POREDOŠ, Alojz. Exergy analyses of low-temperature district heating systems with different sanitary hot-water boosters. *Entropy*, ISSN 1099-4300, Apr. 2019, vol. 21, iss. 4, f. 1-14. [COBISS.SI-ID 16569371], [JCR, SNIP, WoS]
2. POREDOŠ, Primož, VIDRIH, Boris, KITANOVSKI, Andrej, POREDOŠ, Alojz. A thermo-economic and emissions analysis of different sanitary-water heating units embedded within fourth-generation district-heating systems. *Journal of energy resources technology : Transactions of the ASME*, ISSN 0195-0738, 2018, vol. 140, iss. 12, str. 122003-1-122003-8,[COBISS.SI-ID 16164123], [JCR, SNIP, WoS]
3. DUH ČOŽ, Tjaša, KITANOVSKI, Andrej, POREDOŠ, Alojz. Exergoeconomic optimization of a district cooling network. *Energy*, ISSN 0360-5442. [Print ed.], Sep. 2017, vol. 135, str. 342-351, [COBISS.SI-ID 15891995], [JCR, SNIP, WoS]
4. POREDOŠ, Primož, KITANOVSKI, Andrej, MAROVT, Franc. Vloga toplotnih črpalk v sistemih daljinske energetike = The role of heat pumps in district energy systems. V: *Trajnostna in čista oskrba z energijo za ogrevanje in hlajenje = Sustainable and clean energy supply for heating and cooling : zbornik povzetkov*, Mednarodna konferenca SZE 2019, Portorož, 31. marec - 2. april 2019. Ljubljana: Slovensko združenje za energetiko. 2019, str. 98-99. [COBISS.SI-ID 16557339]
5. POTOČNIK, Primož, VIDRIH, Boris, KITANOVSKI, Andrej, POREDOŠ, Alojz, GOVEKAR, Edvard. Optimization of heat pump weather dependant operation for residential buildings. V: BAN, Marko (ur.), ZIDANŠEK, Aleksander (ur.). *Book of abstracts*, 12th Conference on Sustainable Development of Energy, Water and

Environment Systems, October 4-8, 2017, Dubrovnik, Croatia, (Book of abstracts (Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems), ISSN 1847-7186). [Zagreb]: SDEWES. 2017, f. 260. [COBISS.SI-ID 15692315]

6. POREDOŠ, Alojz, LJUBENKO, Andrej, KITANOVSKI, Andrej, REMEC, Janko, BAJSIČ, Ivan. *Celovite meritve ter analiza toplotnih izgub v glavnem distribucijskem omrežju daljinskega ogrevanja Šaleške doline : zaključno poročilo*. Ljubljana: Fakulteta za strojništvo, Laboratorij za hladilno tehniko, 2010. 239 str., graf. prikazi. [COBISS.SI-ID 11446299]