

TRAJNOSTNE TEHNOLOGIJE V ENERGETIKI

UČNI NAČRT PREDMETA/COURSE SYLLABUS

Predmet:	Trajnostne tehnologije v energetiki
Course title:	SUSTAINABLE ENERGY TECHNOLOGIES
Članica nosilka/UL Member:	UL FS

Študijski programi in stopnja	Študijska smer	Letnik	Semestri	Izbirnost
Strojništvo - projektno aplikativni program, prva stopnja, visokošolski strokovni	Energetsko strojništvo (smer)	3. letnik	1. semester	obvezno

Univerzitetna koda predmeta/University course code:	0562727
Koda učne enote na članici/UL Member course code:	3028-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:	Mihael Sekavčnik, Mitja Mori
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Vrsta predmeta/Course type:	Izbirni strokovni predmet/Elective specialised course
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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.
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Vsebina:

<p>1. Uvod</p> <ul style="list-style-type: none"> - Definicije trajnosti in obnovljivosti (energijska, ekonomska in okoljska); - Kriteriji trajnosti; - Pogoji trajnosti; - Primeri iz vsakdanje prakse: opis, analiza in diskusija. <p>2. Tehnologije za izrabo energijo tekočih voda:</p> <ul style="list-style-type: none"> - Tehnološke sheme (praktični primeri); - Vprašanja izravnave energijskih tokov: tehnologije, stroški, vpliv na trajnost. <p>3. Tehnologije za izrabo sončne energije:</p> <ul style="list-style-type: none"> - Proizvodnja toplote in električne energije; - Tehnološke sheme (praktični primeri); - Vprašanja izravnave energijskih tokov: tehnologije, stroški, vpliv na trajnost. <p>4. Tehnologije za izrabo energije vetra:</p> <ul style="list-style-type: none"> - Profil proizvodnje električne moči (kronološki in urejeni diagram); - Tehnološke sheme (praktični primeri); - Vprašanja izravnave energijskih tokov: tehnologije, stroški, vpliv na trajnost. <p>5. Tehnologije za izrabo geotermalne energije:</p> <ul style="list-style-type: none"> - Proizvodnja toplote in električne energije; - Parni krožni proces z organsko delovno snovjo; - Tehnološke sheme (praktični primeri); - Vprašanja: infrastruktura, stroški, vpliv na trajnost. <p>6. Tehnologije za izrabo biomase:</p> <ul style="list-style-type: none"> - Termokemični procesi; - Ekstraktivni procesi; 	
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Content (Syllabus outline):

<p>1. Introduction</p> <ul style="list-style-type: none"> - Definitions of sustainability and renewability (based on energy, economy and environment) - Criteria of sustainability - Conditions for sustainability - Practical cases: description, analysis and discussion. <p>2. Technologies for utilization of running waters:</p> <ul style="list-style-type: none"> - Technology schematics (practical cases); - Grid balancing issues: technologies, costs, impact on sustainability. <p>3. Technologies for utilization solar energy:</p> <ul style="list-style-type: none"> - Heat and power production - Technology schematics (practical cases); - Grid balancing issues: technologies, costs, impact on sustainability. <p>4. Technologies for utilization of wind energy:</p> <ul style="list-style-type: none"> - Power production diagram (chronological load diagram and load duration curve) - Technology schematics (practical cases); - Grid balancing issues: technologies, costs, impact on sustainability. <p>5. Technologies for utilization geothermal energy:</p> <ul style="list-style-type: none"> - Heat and power production; - Organic Rankine Cycles; - Technology schematics (practical cases); - Issues: infrastructure, costs, impact on sustainability. <p>6. Technologies for utilization of biomass:</p> <ul style="list-style-type: none"> - Thermochemical processes; - Extractive processes; - Biological processes; - Combined heat and power production 	
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<ul style="list-style-type: none"> - Biološki procesi; - Proizvodnja toplote in električne energije; - Tehnološke sheme (praktični primeri). <p>7. Tehnologije za izrabo energije oceanov:</p> <ul style="list-style-type: none"> - Notranja energija, morski tokovi, valovanje gladine, bibavica; - Tehnološke sheme (praktični primeri); - Vprašanja: infrastruktura, stroški, vpliv na trajnost. <p>8. Tehnologije za izrabo jedrske energije – fizija:</p> <ul style="list-style-type: none"> - Osnove delovanja; - Tehnološke sheme (praktični primeri); - Vprašanja: infrastruktura, stroški, vpliv na trajnost. <p>9. Tehnologije za izrabo jedrske energije – fuzija:</p> <ul style="list-style-type: none"> - Osnove delovanja; - Projekt ITER; - Vprašanja: infrastruktura, stroški, vpliv na trajnost. <p>10. Trajnostna raba energije v proizvodnih procesih 1/2:</p> <ul style="list-style-type: none"> - Osnovni principi gospodarjenja z energijskimi tokovi; - Energetski pregled; - Tehnološke sheme (praktični primeri). <p>11. Trajnostna raba energije v proizvodnih procesih 2/2:</p> <ul style="list-style-type: none"> - Nadomeščanje fosilnih goriv za OVE; - Tehnološke sheme (praktični primeri); - Vprašanja: infrastruktura, stroški, vpliv na trajnost; <p>12. Trajnostna raba energije s sektorskim povezovanjem in aktivnim odjemom</p> <ul style="list-style-type: none"> - Tehnološke sheme (praktični primeri) - Analiza učinkov na trajnost. <p>13. Vodikove tehnologije</p> <ul style="list-style-type: none"> - Pridobivanje vodika (tehnologije) - Transport in shranjevanje vodika (tehnologije) - Uporaba vodika (gorivne celice, sektorsko sklapljanje - P2X) 	<ul style="list-style-type: none"> - Technological schematics (practical cases) <p>7. Technologies for utilization of energy of oceans</p> <ul style="list-style-type: none"> - Calorific internal energy, ocean streams, wave energy, tidal energy; - Technological schematics (practical cases); - Issues: infrastructure, costs, impact on sustainability <p>8. Technologies for utilization of nuclear energy – nuclear fission:</p> <ul style="list-style-type: none"> - Basic operation principles - Technological schematics (practical cases) - Issues: infrastructure, costs, safety, nuclear waste, sustainability <p>9. Technologies for utilization of nuclear energy - nuclear fusion:</p> <ul style="list-style-type: none"> - Basic operation principles - Project ITER - Issues: infrastructure, challenges, costs, perspectives, sustainability <p>10. Sustainable energy use in industrial processes</p> <ul style="list-style-type: none"> - Basic principles of energy flow management - Energy audits - Technological schematic (practical cases). - Issues: infrastructure, costs, impact on sustainability <p>11. Sustainable energy use in industrial processes</p> <ul style="list-style-type: none"> - Fossil fuel replacement with renewables - Technological schematics (practical cases) - Issues: infrastructure, costs, impact on sustainability <p>12. Sustainable energy use with sector coupling and demand side management</p> <ul style="list-style-type: none"> - Technological schematics (practical cases) - Analysis of impact on sustainability <p>13. Hydrogen technologies</p> <ul style="list-style-type: none"> - Hydrogen production (technologies) - Hydrogen transport and storage (technologies) - Hydrogen utilization (fuel cells, sector coupling P2X)
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<ul style="list-style-type: none"> - Sistemi gorivnih celic (stacionarna uporaba, transport in posebne aplikacije) <p>14. Tehnologije za 'shranjevanje' mehanskega dela (elektrike) in toplote</p> <ul style="list-style-type: none"> - Tehnološke sheme (praktični primeri) - Izračun energijskih izgub pri pretvorbah energije - Vprašanja: izkoristki, infrastruktura, vpliv na trajnost <p>15. Virtualne elektrarne in pametna energetska omrežja.</p> <ul style="list-style-type: none"> - Tehnološke sheme (izbrani primeri) - Izravnava sistemske moči - Vprašanja: infrastruktura, stroški in vpliv na trajnost. 	<ul style="list-style-type: none"> - Fuel cell systems (stationary, transport and special applications) <p>14. Energy storage technologies (mechanical work – electricity and heat)</p> <ul style="list-style-type: none"> - Technological schematics (practical cases) - Calculation of energy conversion losses - Issues: efficiency, infrastructure, impact on sustainability <p>15. Virtual power plants and smart grids</p> <ul style="list-style-type: none"> - Technological schematics (selected examples) - System load balancing - Issues: infrastructure, costs and impact on sustainability.
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Temeljna literatura in viri/Readings:

Strauß K.: Kraftwerkstechnik, zur Nutzung fossiler, nuklearer und regenerativer Energiequellen, Springer, 2009

Giesecke J., Mosonyi E.: Wasserkraftanlagen, Planung, Bau und Betrieb, Springer, 2009

Colombo E., Bologna S., Masera D.: Renewable Energy for Unleashing Sustainable Development, Springer 2013

Kaltschmitt M., Themelis N.J., Bronicki L.Y., Söder L., Vega L.A.: Renewable Energy Systems, Springer 2013

Cilji in kompetence:

Cilji:

Združiti uporabna znanja s področja strojništva pri presoji trajnostnih konceptov pri energijski oskrbi.

Na sistematični način analizirati tehnologije za pretvorbo alternativnih virov energije z vidika zagotavljanja kvalitete energijskih tokov in okoljske vzdržnosti.

Spoznati celostne karakteristike alternativnih tehnologij v energetiki ter način izbire optimalnih tehnoloških rešitev.

Kompetence:

Sposobnost povezovanja interdisciplinarnih znanj različnih

Objectives and competences:

Objectives:

Combine applied engineering knowledge in assessing sustainable concepts in energy supply.

Systematically analyze technologies for the conversion of alternative energy sources in terms of power quality assurance and environmental sustainability.

To learn about the holistic characteristics of alternative technologies in the energy sector and how to select the optimal technological solutions.

Competences:

Ability to integrate interdisciplinary

<p>področij strojništva (energijske pretvorbe, obratovanje in načrtovanje) (S1-PAP + S9-PAP + P1-PAP + P2-PAP)</p> <p>Sposobnost vrednotenja ustreznosti tehničnih izvedb energetskih strojev in naprav ter njihove vgradnje v sisteme (S9-PAP + P3-PAP + P8-PAP)...</p> <p>Sposobnost načrtovanja in vključevanja novih konceptov in tehnologij v praktično uporabo (S1-PAP + S9-PAP + P3-PAP + P5-PAP)</p>	<p>knowledge of various areas of mechanical engineering (energy conversion, operation and design) (S1-PAP + S9-PAP + P1-PAP + P2-PAP)</p> <p>Ability to evaluate the relevance of technical design of energy machines and appliances and their integration into energy systems (S9-PAP + P3-PAP + P8-PAP)</p> <p>Ability to plan and integrate new concepts and technologies into practical application (S1-PAP + S9-PAP + P3-PAP + P5-PAP)</p>
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Predvideni študijski rezultati:

Intended learning outcomes:

<p>Znanja:</p> <p>Z1: Poglobljeno strokovno teoretično in praktično znanje na določenem področju, podprto s širšo teoretično in metodološko osnovo.</p> <p>Spretnosti:</p> <p>S1.1 Izvajanje kompleksnih operativno-strokovnih opravil, ki vključujejo tudi uporabo metodoloških orodij.</p> <p>S1.2 Obvladovanje zahtevnih, kompleksnih delovnih procesov ob samostojni uporabi znanja v novih delovnih situacijah.</p> <p>S1.3 Diagnosticiranje in reševanje problemov v različnih specifičnih delovnih okoljih, povezanih s področjem izobraževanja in usposabljanja.</p> <p>S1.4 Osnova za izvirna dognanja/stvaritve in kritično refleksijo.</p>	<p>Knowledge:</p> <p>Z1: Thorough professional theoretical and practical knowledge in a selected field of expertise that is supported with a broad theoretical and methodological basis.</p> <p>Skills:</p> <p>S1.1 Executing complex operational-professional tasks that incorporate usage of methodological tools.</p> <p>S1.2 Mastering demanding and complex work processes by independent usage of knowledge in new working situations.</p> <p>S1.3 Problem diagnostics and solving in different and specific working environments that are linked to the teaching and training content.</p> <p>S1.4 Basis for unique innovations and critical reflections.</p>
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Metode poučevanja in učenja:

Learning and teaching methods:

<p>Klasične oblike poučevanja:</p> <p>P1 Avditorna predavanja z reševanjem izbranih - za področje značilnih - teoretičnih in praktično uporabnih primerov.</p> <p>P2 Obravnava snovi po urejeni in vnaprej razloženi sistematiki.</p> <p>P3 Avditorne vaje, kjer se teoretično</p>	<p>Conventional teaching methods:</p> <p>P1 Auditorial lectures with solving selected field-specific theoretical and applied use cases.</p> <p>P2 Presenting the content according to the explained system.</p> <p>P3 Auditorial exercises, in which theoretical content from the lectures is</p>
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<p>znanje s predavanj podkrepiti z računskimi primeri.</p> <p>P4 Laboratorijske vaje z namenskimi didaktičnimi pripomočki: Uporaba namenskega programskega orodja za simulacije naprednih rešitev v energetiki in LCA analize.</p> <p>P5 Uporaba študijskega gradiva v obliki skripte, tiskane in e- verzije predstavitve predavanj.</p> <p>Moderne in prožne oblike poučevanja:</p> <p>P7 Študij literature in razprava</p> <p>P8 Izdelava in predstavitev aplikativnih seminarskih nalog</p> <p>P9 Skupinsko delo: strukturirana diskusija, projektno delo.</p> <p>P10 Uporaba anket v realnem času</p> <p>P12 Individualizirane domače naloge v spletni učilnici</p> <p>P14 Virtualni eksperimenti</p> <p>P15 Uporaba video vsebin kot priprava na predavanja in vaje.</p>	<p>supplemented with practical examples.</p> <p>P4 Laboratory exercises with special-purpose didactic devices: use of dedicated software tool to simulate advanced energy solutions and LCA analysis.</p> <p>P5 Application of study material: textbook, printed and e-version of lecture presentations.</p> <p>Contemporary and flexible teaching methods:</p> <p>P7 Literature study and discussion.</p> <p>P8 Making and presenting applied seminar exercises.</p> <p>P9 Team work: structured discussion, project work.</p> <p>P10 Application of questionnaires in real time.</p> <p>P12 Individualised homeworks in a web classroom.</p> <p>P14 Virtual experiments.</p> <p>P15 Application of videos for preparations to the lectures and exercises.</p>
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Načini ocenjevanja:	Delež/ Weight	Assessment:
Teoretične vsebine (predavanja).	50,00 %	Theoretical contents (lectures).
Samostojno delo na vajah.	30,00 %	Coursework.
Delo na laboratorijskih vajah.	20,00 %	Laboratory exercises.

Reference nosilca/Lecturer's references:

Mihael Sekavčnik:

LOTRIČ, Andrej, STROPNIK, Rok, DROBNIČ, Boštjan, JURJEVČIČ, Boštjan, **SEKAVČNIK, Mihael**, MORI, Mitja. Assessment of critical materials and components in Fch technologies to improve Lcia in end of life strategy. V: KROPE, Jurij (ur.), et al. Environmental management and impact assessment : (conference proceedings). 10th International Conference on Sustainable Energy and Environmental Protection, (June 27th-30th, 2017, Bled, Slovenia). Maribor: University of Maribor Press: Faculty of Chemistry and Chemical Engineering, 2017. Str. [85]-97, ilustr. ISBN 978-961-286-053-0.

<http://press.um.si/index.php/ump/catalog/view/244/206/431-1>. [COBISS.SI-ID

[15550491](#)]

LOTRIČ, Andrej, **SEKAVČNIK, Mihael**, POHAR, Andrej, LIKOZAR, Blaž, HOČEVAR, Stanko. Concept of an integrated thermally self-sustained methanol steam reformer : high-temperature PEM fuel cell stack manportable system. V: KROPE, Jurij (ur.), et al. Hydrogen and fuel cells : (conference proceedings). Maribor: University of Maribor Press: Faculty of Chemistry and Chemical Engineering, 2017. Str. [75]-86, ilustr. ISBN 978-961-286-054-7. <http://press.um.si/index.php/ump/catalog/view/245/207/432-1>. [COBISS.SI-ID [15551515](#)]

PIRC, Andrej, DROBNIČ, Boštjan, MORI, Mitja, **SEKAVČNIK, Mihael**. Operating strategies of internal combustion engine in self-sufficient energy supply. V: GOLOBIČ, Iztok (ur.), CIMERMAN, Franc (ur.). Development and implementation of enhanced technologies 2011 : proceedings of the 3rd AMES International Conference, Ljubljana, Slovenia, November 29th-30th, 2011. 1st ed. Ljubljana: Association of Mechanical Engineers of Slovenia - AMES, 2011. Str. 105-112. ISBN 978-961-91393-7-0. [COBISS.SI-ID [12103451](#)]

SEKAVČNIK, Mihael, MORI, Mitja, NOVAK, Lovrenc, SMREKAR, Jure, TUMA, Matija. Heat transfer evaluation method in complex rotating environments employing IR thermography and CFD. Experimental heat transfer. 2008, letn. 21, št. 2, str. 155-168. <http://dx.doi.org/10.1080/08916150701815770>. [COBISS.SI-ID [10427163](#)]

NOVAK, Lovrenc, MORI, Mitja, **SEKAVČNIK, Mihael**. Heat transfer study in rotating cascade using IR thermography and CFD analyses. Heat and mass transfer. 2008, vol. 44, no. 5, str. 559-567. ISSN 0947-7411. <http://dx.doi.org/10.1007/s00231-007-0269-0>. [COBISS.SI-ID [10122011](#)]

Mitja Mori:

MORI, Mitja, STROPNIK, Rok. Comparing environmental impacts of three typical Slovenian electricity providers with hydroelectricity. Elektrotehniški vestnik. [Slovenska tiskana izd.]. 2019, vol. 83, no. 6, str. 97-104, ilustr. ISSN 0013-5852. <https://ev.fe.uni-lj.si/3-2019/Mori.pdf>. [COBISS.SI-ID [16699931](#)]

STROPNIK, Rok, LOTRIČ, Andrej, MONTENEGRO, Alfonso Bernad, **SEKAVČNIK, Mihael**, **MORI, Mitja**. Critical materials in PEMFC systems and a LCA analysis for the potential reduction of environmental impacts with EoL strategies. Energy science & engineering. Dec. 2019, vol. 7, iss. 6, f. 2519-2539, ilustr. ISSN 2050-0505. <https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.441>, DOI: [10.1002/ese3.441](#). [COBISS.SI-ID [16811803](#)]

FÉRRIZ, Ana María, BERNAD, Alfonso, **MORI, Mitja**, FIOROT, Sabina. End-of-life of fuel cell and hydrogen products : a state of the art. International journal of hydrogen energy. [Print ed.]. 2019, vol. 44, iss. 25, str. 12872-12879, ilustr. ISSN 0360-3199. <https://www.sciencedirect.com/science/article/pii/S0360319918330969?via%3Dihub#!>, DOI: [10.1016/j.ijhydene.2018.09.176](#). [COBISS.SI-ID [16334875](#)]

MORI, Mitja, JENSTERLE, Miha, MRŽLJAK, Tilen, DROBNIČ, Boštjan. Life-cycle assessment of a hydrogen-based uninterruptible power supply system using renewable energy. The international journal of life cycle assessment. Nov. 2014, vol. 19, iss. 11, str. 1810-1822, ilustr. ISSN 0948-3349. DOI: [10.1007/s11367-014-0790-6](#). [COBISS.SI-ID [13665307](#)]

MORI, Mitja, MRŽLJAK, Tilen, DROBNIČ, Boštjan, SEKAVČNIK, Mihael. Integral characteristics of hydrogen production in alkaline electrolyzers. *Strojniški vestnik*. Oct. 2013, vol. 59, no. 10, str. 585-594, si 116, ilustr. ISSN 0039-2480. DOI: [10.5545/sv-jme.2012.858](https://doi.org/10.5545/sv-jme.2012.858). [COBISS.SI-ID [13158683](#)]