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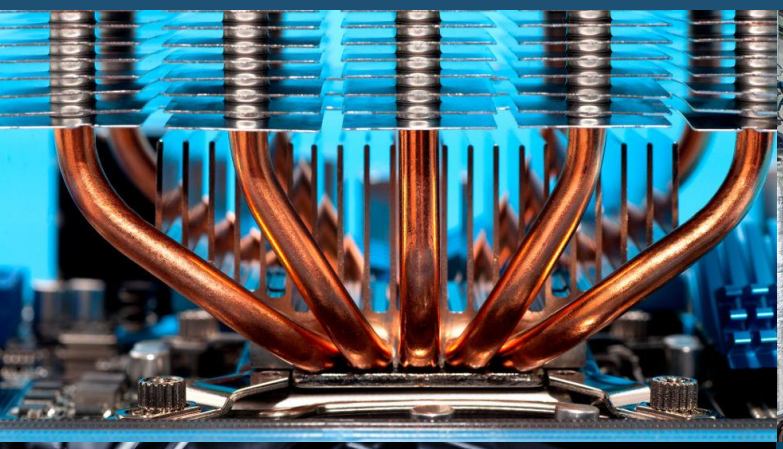
Working Group Reports

DELIVERABLE 3

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Title: Working Group Reports

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Contents

Deliverable 3

1. Introduction

A total of five Working Group (WG) meetings have been held in the frame of Nanouptake during the whole duration of the Action, with the following dates and places:

- 1st WG Meetings (October 2016) Castellon (Spain)
- 2nd WG Meetings (March 2017) Lisbon (Portugal)
- 3rd WG Meeting (October 2017) Lisbon (Portugal)
- 4th WG Meeting (May 2018) Naples (Italy)
- 5th WG Meeting (June 2019) Castellon (Spain)

A table summarizing the relevant data of the WG is presented below. A total of 366 participants have attended the Nanouptake WG meeting, with a high presence of ECI profiles (54,64%).

WORKING GROUP MEETINGS			Number of participants	Number of Countries	% ITC	% females	% ECI
1st Working Group Meetings	2016	Castellon (Spain)	83	23	25,3	13,25	53,01
2nd Working Group Meetings	2017	Lisbon (Portugal)	43	12	39,53	23,26	46,51
3rd Working Group Meeting	2017	Lisbon (Portugal)	85	17	37,65	27,06	55,29
4th Working Group Meeting	2018	Naples (Italy)	76	19	23,68	22,37	53,95
5th Working Group Meeting	2019	Castelló (Spain)	79	20	34,67	30,37	60,75
ALL NANOUPTAKE WG MEETINGS			**366**		**31,53**	**23,22**	**54,64**

The application rules for each event has been disseminated for all Nanouptake participants and also shared in the Nanouptake website: http://www.nanouptake.eu/documents/#meetings .

A report from each of the four WG (Heating, Cooling, Storage, Boiling-Solar-Modelling) in each WG meeting has been summarized by the corresponding WG Leaders and Vice-leaders:

WG 1 (Heating):
Leader: Prof. Oronzio Manca, ViceLeader Prof. Luis Lugo

WG 2 (Cooling):
Leader: Prof. S M Sohel Murshed, ViceLeader Prof. Bengt Sundén

WG 3 (Storage):
Leader: Prof. Yulong Ding, ViceLeader Prof. Carlos Nieto de Castro

WG 4 (Boiling, Solar Application, Modelling):
Leader: PD Dr.-Ing. habil M. H. Buschmann, ViceLeader Dra E. Sani

In the case of the Dissemination WG (number 5), the documentation is included in the Deliverable 1.

The compilation of the different presentations of the WG meetings have been shared in open access in different documents uploaded in the website (http://www.nanouptake.eu/documents/#reports), with these specific links:

1st WG Meetings:
http://repositori.uji.es/xmlui/handle/10234/189051

2nd WG Meetings:
http://repositori.uji.es/xmlui/handle/10234/189051

3rd WG Meeting:
http://www.nanouptake.eu/wp-content/uploads/2020/05/ESNf17-BoA-NanoUptake-version.pdf

4th WG Meeting:
http://www.nanouptake.eu/wp-content/uploads/2020/05/Book-of-Abstracts-WGNapoles.pdf

5th WG Meeting:
http://repositori.uji.es/xmlui/handle/10234/183448?locale-attribute=en

During the first three Working Groups Meeting, each of the four WG (Heating, Cooling, Storage, Boiling-Solar-Modelling) had different locations and timetables. In those meetings, each Nanouptake participant had to choose to select which WG to attend. However, there was an increasing interest from different members to attend all the different WG, as many participants work in more than one of these applications. Following this demand, the agendas of the last two WG meetings were arranged so that all participants could attended all the WG meetings.

Taking this into account, the first 3 WG meetings are split in this document in the different WG reports (sections 2 to 5 of this document) and the last 2 meetings have joint reports in section 6.

2. Working Group 1 (Heating) Reports

WG1: 1st WG meeting Castellon

The meeting started with a brief Tour de Table in which all the participants presented themselves and their interest in the NANOUPTAKE Working Group 1 (WG1): Heating.

After that, 6 participants presented their work. The title and affiliation of the presentations are as follows:

#	Title	Authors and Affiliation
1	Experimental heat transfer coefficients and pressure drop of functionalized graphene nanoplatelets/water nanofluids	R. Agromayor[1], J. P. Vallejo[1,2], D. Cabaleiro[2], A. A. Pardiñas[1], J. Fernandez-Seara[1], L. Lugo[2*] [1] Área de Máquinas y Motores Térmicos, Universidade de Vigo, 36310, Vigo, Spain [2] Departamento de Física Aplicada, Facultade de Ciencias, Universidade de Vigo, 36310, Vigo, Spain
2	Nanofluids characterization for HVACR and heat exchange applications	S. Barison[1], L. Fedele[2], F. Agresti[1], V. Zin[1], S. Rossi[2], S. Bobbo[2], M. Fabrizio[1] [1] Istituto di Chimica della Materia Condensata e di Tecnologie per l'Energia, Consiglio Nazionale delle Ricerche, 35127 Padova, Italy [2] Istituto per le Tecnologie della Costruzione, Consiglio Nazionale delle Ricerche, 35127 Padova, Italy
3	Hybrid nanofluids behavior in turbulent flow: numerical techniques applied to studied fluids	A. A. Minea [1], O. Manca[2], M. G. Moldoveanu[1], S. Bacaita[1], J. E. Julia[3] [1] Technical University "Gheorghe Asachi" from Iasi, Faculty of Materials Science and Engineering, 700050, Iasi, Romania [2]Seconda Universita degli Studi di Napoli, 81031 Aversa (CE), Italy [3]Universitat Jaume I, 12071 Castellon de la Plana, Spain
4	Mixed convection boundary layer flow past a vertical flat plate embedded in a porous medium saturated by a nanofluid: Darcy-Ergun model	N. C. Roşca[1], A. V. Roşca[2], T. Groşan[1], I. Pop[1*] [1]Department of Statistics–Forecasts–Mathematics, Babeş–Bolyai University, 400084 Cluj–Napoca, Romania [2]Department of Mathematics and Statistics, Sultan Qaboos University, P.O. Box 36, P.C. 123 Al-Khod, Muscat, Sultanate of Oman
5	Semi-analytical solution for the flow of a nanofluid over a permeable stretching/shrinking sheet with velocity slip using Buongiorno's mathematical model	N. C. Roşca[1*], I. Pop[1], E. H. Aly[2,3] [1]Department of Mathematics, Babeş–Bolyai University, 400084 Cluj–Napoca, Romania [2]Department of Mathematics, University of Jeddah, Jeddah 21589, Saudi Arabia [3]Department of Mathematics, Ain Shams University, Roxy 11757, Egypt
6	Modeling and 3 ω ωω ω hot wire measurement of effective thermophysical properties of inhomogeneous media	M. Chirtoc, J-F. Henry, N. Horny GRESPI Lab., Université de Reims Champagne Ardenne URCA, 51687, Reims, France

A discussion occurred after each presentation and a very short group discussion was accomplished at the end of the meeting together with some conclusions. The main points appeared can be summarized as in the following:

a) There are two main research topics in WG1:
   - Preparation of nanofluids and evaluation of thermophysical properties (nanofluids preparation and properties activity, NPPA) that corresponds to presentations #1, 2 and 6.
   - Evaluation of thermal and fluid dynamic behaviors in convective heat transfer (thermofluid dynamic activity TDA) and fluid flow that corresponds to presentations #3, 4, and 5.

b) The main research activities of the presentations with reference to:
   - the first area, NPPA, are related to the stability of nanographene/water nanofluids, the evaluation of different nanofluids as refrigerants in HVAC applications and the experimental evaluation of thermophysical properties by 3ω hot wire technique;
   - the second area, TDA, are related to numerical investigation on turbulent forced convection of hybrid nanofluids, the application of Darcy-Ergun model in mixed convection in the study of boundary layer flow past a vertical flat plate embedded in a porous medium satured by a nanofluid and the evaluation of fluid dynamic fields on a permeable stretching/shrinking plate in a nanofluid employing the Boungiorno model.

c) The main conclusions of this WG1 meeting are that it is possible to observe there are several applications and a lot of data in the NPPA and TDA areas and this indicates that the convective heat transfer in nanofluids in single phase (without phase change) is the most mature topic in nanofluids. Now there are new experimental measurements and new solutions to understand the effect of nanofluids. This is a good way also to confirm and support the analytical and numerical models and simulations to expand the applications. However, it should be tried to find standards for the properties measurements but also for the preparation with some assigned rules for single step and two-steps preparation techniques such as sonication time, stability and so on. The convective single phase flow should have also some standards to measure the heat transfer coefficients. One of the main problem is the thermal boundary conditions also for the comparison with numerical models and simulations and their validation. New directions are to combine different nanoparticles to have hybrid mixtures and also to improve the heat transfer by magnetic fields.

In the next weeks the WG Leaders will specify the joint collaborations and will contact with the subgroups participants.

WG1: 2nd WG meeting Lisbon

The meeting started with a brief Tour de Table in which all the participants presented themselves and their interest in the NANOUPTAKE Working Group #1: Heating.

The discussion was focused on three main points: Open discussion about H2020 proposals,Round Robin Tests, and Joint Review Papers.

On the first point the following proposal was presented:

WG1 : Heating NFs based on water, ionic liquids and thermal oils for medium and high temperature transfer processes	Milan Timko (1,2,3) Estibaliz Aranzabe Angel Huminic (2,4,5) Sara Manzano (6,7,8) Stefan Van Vaerenberg	**1 - B** - FET-OPEN – NOVEL IDEAS FOR RADICALLY NEW TECHNOLOGIES - FETOPEN-01-2016-2017 - research and innovation actions **2 - B** - CALL: FCH2 JU CALL FOR PROPOSALS 2017 - EE-18-2017 - Energy efficiency of industrial parks through energy cooperation and mutualised energy services **3 - C** - CALL: ENERGY EFFICIENCY CALL 2016-2017 - EE-18-2017: Energy efficiency of industrial parks through energy cooperation and mutualised energy services 4 – **A** – EE-15-2017: Increasing capacities for implementation of energy efficiency measures in industry and services 5 – **A** – LCE-12-2017: Near-to-market solutions for the use of solar heat in industrial processes 6 – **A** - Nanotechnologies, Advanced Materials, Biotechnology, and Advanced Manufacturing and Processing (NMBP) 7 – **B** - Factories of the Future (FoF) 8 – **C** - Sustainable Process Industries (SPIRE)

The second and third points were examined and discussed. There was a proposal on the analysis of numerical simulations of forced convection in tubes. The geometry and the boundary conditions were assigned to compare the numerical results with the experimental paper “Laminar mixed convection of TiO_2/water nanofluid in horizontal uniformly heated pipe flow” by L. Colla, L. Fedele, M.H. Buschmann, International Journal of Thermal Sciences 97 (2015) 26-40. Different groups were interested and Professor Alina Minea took in charge the management of the work. Moreover, the discussion was also to underline the other possible work lines related mainly to:

- Preparation of nanofluids and nanosalts and evaluation of thermophysical properties
- Evaluation of properties by theoretical models
- Evaluation of thermal and fluid dynamic behaviors in convective heat transfer and fluid flow

In the meeting was underlined the need to find a standardization for the nanofluid preparation with some assigned rules for single and two-steps techniques and for the properties measurements. New promising research lines are to combine different nanoparticles to obtain hybrid mixtures also with ionic fluids and to employ magnetic fields to enhance the heat transfer.

WG1: 3rd WG meeting Lisbon

The WG meeting was in conjunction with the 1st European Symposium on Nanofluids (ESNf2017). The special session for WG1 meeting and open discussion was arranged at 17.00. It was closed at 18:30.
The meeting started with a brief Tour de Table in which all the participants presented themselves and their interest in the NANOUPTAKE Working Group #1: Heating.

The main points discussed have confirmed the interests appeared in the previous meetings and they have been reinforced in the activities developed during the period from March 2017 and September 2017. The main research topics in WG#1 can be summarized as in the following:

  - Measurements and evaluation of thermophysical properties
  - Preparation of nanolubrificant for automotive application and electrokinetic mobility.
  - Ferrofluids.

- The greater part of the work was on the measurements of thermophysical properties for new nanofluid mixtures and on the techniques for the evaluation of thermophysical properties. Water-based nanofluids with dispersion of graphene-oxide nanoparticles and eutectic mixture as base fluid with NiO particles and surfactants as well as TiN-EG nanofuids were presented and discussed. New model and review with comparisons for the evaluation of thermophysical properties were proposed and discussed. Some improvements in the measurement techniques were showed also to be able to evaluate the thermal proprieties of ferrofluids and nanolubrificants with Cu.
- The main conclusions of this WGM were that it is possible to observe there is a strong interest in the evaluation of thermophysical properties of new mixtures as well as of theoretical models. A new direction is the research on the effect of magnetic fields on ferrofluids.

The following group have given their interest in the Round Robin Tests “Nanoround” as decided in the meeting in Lisbon on March 2017: 1) University of Maribor, Faculty of Mechanical Engineering Maribor, Slovenia; 2) Technical University ”Gheorghe Asachi” from Iasi, Faculty of materials Science and Engineering, Romania; 3) Transilvania University of Brasov, Faculty of Mechanical Engineering, Romania; 4) Faculté de génie, Université de Sherbrooke, Canada; 5) Universita degli Studi della Campania “Luigi Vanvitelli”, Aversa, Italy; 6) IMH - Institute of Modelling and High Performance Computing, Germany; 7) Università degli Studi di Roma La Sapienza, Roma, Italy; 8) Technische Universitat Dresden, Institut of Fluid Mechanics, Dresden, Germany; 9) Technological University Hyderabad, India; 10) Technical Faculty, University of Novi Sad, Serbia.

Professor Alina Minea is managing the activities and the following schedule was proposed and approved:

	Deliverable	**Reporting terms**
1	Adopted properties for water and governing equations	end of november 2017
2	First set of analysis on water simulations	end of january 2018
3	Discussion on water analysis results	end of february 2018 For discussion of results we can set up a skype conference call during february 2018.
4	Adopted nanofluid model and first set of analysis on nanofluid	end of march 2018
5	Discussion on nanofluids first results	end of april 2018
6	Developing the entire CFD analysis	end of june 2018
7	Discussion on final results	end of july 2018 For discussion of final results we can set up a skype conference call during july 2018.
8	Drafting the article on Nanoround	mid september 2018

3. Working Group 2 (Cooling) Reports

WG2: 1st WG meeting Castellon

The meeting started with a brief introduction about this working group (#2-Cooling) and presentation instruction by the group leader. The meeting was splitted up into two sessions. The first session (from 08:00 to 11:00) was for the presentation of the works and the second session (from 11:20 to 13:00) was for the open discussion. At the beginning of the presentation, each presenting author introduced themselves and work areas. Each presentation was followed by Q&A and short discussion on the topic of the presented work.
There were in total 6 pre-accepted presentations on nanofluids cooling related topics. The title and affiliation of the presentations are as follows:

#	Title	Authors and Affiliation
1	Application of Nanofluids in Heat Exchangers: Performance and Challenges	Bengt Sunden Department of Energy Sciences, Lund University, SE-22100, Lund, Sweden
2	Numerical study of the heat transfer characteristics in double tube helical heat exchangers using hybrid nanofluids	G. Huminic[1], A. Huminic[1], F. Dumitrache[2], C. Fleaca[2], I. Morjan[2] [1] Mechanical Engineering Department, Transilvania University of Brasov, 500036, Brasov, Romania [2] National Institute for Laser, Plasma and Radiation Physics, 077125 Magurele, Bucharest, Romania
3	Characterization of the wettability of complex nanofluids using 3D Laser Scanning Confocal Fluorescence Microscopy	V. Silvério[1], A. S. Moita[1], A. L. N. Moreira[1],*, R. Lima[2], N. Pereira1 [1] Instituto Superior Técnico, University of Lisbon, Center on Innovation, Technology and Policy Research, 1049 – 001 Lisboa, Portugal [2] University of Minho, Department of Mechanical Engineering, 4804 – 533 Guimarães, Portugal
4	Transformer oil based magnetic fluid for effective cooling medium in power transformers	M. Timko[1], P. Kopcansk[1], M. Rajnak[1], M. Molcan[1], B. Dolnik[2], J. Kurimsky[2] [1]Institute of Experimental Physics, Slovak Academy of Sciences, 040 01 Kosice, Slovakia [2]Faculty of Electrical Engineering and Informatics, TU in Košice, Letna 9, 040 01 Kosice, Slovakia
5	Thermophysical properties of ethylene glycol based yttrium aluminum garnet (Y3Al5O12–EG) nanofluids	Gaweł Żyła Department of Physics and Medical Engineering, Rzeszow University of Technology, Rzeszow, 35-905, Poland
6	Carbon nanotubes nanofluids: Thermophysical properties and applications to heat exchange	P. Estellé Laboratoire de Génie Civil et Génie Mécanique, Matériaux et Thermo-Rhéologie, Université Rennes 1, 35704 Rennes, France

From the open discussion, the following research issues/barriers were identified which need to be focused/worked out in the years ahead:

- Major drawbacks of nanofluids for cooling application are their long-term stability and high viscosity.
- Proper dispersion/homogenization of nanoparticles in the base fluids needs to be ensured in the preparation of sample nanofluids for their better stability and optimum properties.
- Nanofluids should be prepared with low concentration of nanoparticles in order to keep the viscosity low.
- Morphology (particularly size and shape) and purity of purchased nanoparticles should be verified by characterizing them in the lab.
- Inconsistency of results of thermophysical properties of nanofluids
- Results on heat exchanger-based cooling performance of nanofluids differ considerably (sometimes even opposite).
- Need for collaborated and systematic works for both the thermophysical properties characterization and application in heat exchange systems.
- Need to specify the participants in each group and build active collaboration among the participants.
- Simulations and experiments on cooling performance in heat exchangers should be performed using experimental values of thermophysical properties of nanofluids and should be verified/compared with experimental results of the same nanofluids and cooling systems.
- The possibility of mini round-robin exercises on properties characterization of some selected nanofluids among several laboratories before application in cooling systems.
- Possible contribution to a review article from this WG.

WG2: 2nd WG meeting Lisbon

This specific working group meeting was mostly dedicated to identify areas and possibilities for joint H2020 proposals, preparation and co-ordination under NanoUptake. All working groups (WG1, WG2, WG3 and WG4) participants meet together in this special meeting. The meeting started with a brief welcome speech by Prof. José Rebordão, Vice-director by a representative (Vice-director) from the FCUL on 27th March (10:30) followed by presentation on NanoUptake and H2020 strategic programme by the then Action Chair- Prof J.E. Julia (11:00). Later during the pre-lunch session on 27th March, there was a presentation from H2020 NCP Portugal representative (Drª Sofia Azevedo) on next NMP H2020 calls, types of calls and detailing the possibilities in H2020 followed by two sessions (pre-lunch and post-lunch) of presentations and open discussion from the participants on potential H2020 proposals based on all Working groups including cooling. On 28th March there was a meeting and discussion on possible Round Robin tests from different working group areas followed by the final session of presentations on H2020 proposals, ideas and open discussion. At the end, WG leaders presented the summary and tasks for the next meeting.

The following proposal topics and categories were received from participants under WG2-cooling (some of the proposals fit into multiple WGs):

Participant	Title/H2020 call Info	WG
Sara Manzano, ADItech Corporation, Spain	1. H2020 calls including categories A, B and C: A. Nanotechnologies, Advanced Materials, Biotechnology, and Advanced Manufacturing and Processing (NMBP). B. Factories of the Future (FoF) C. Sustainable Process Industries (SPIRE)	1-2
Estibaliz Aranzabe, IK4-TEKNIKER, Spain	H2020 calls including categories A, B and C:	1-3
Angel Huminic, Transilvania University of Brasov, Romania	1.A EE-15-2017: Increasing capacities for actual implementation of energy efficiency measures in industry and services 2.A : LCE-12-2017 and FETOPEN-01-2016-2017: FET-Open research and innovation actions	1-4
Żyła Gaweł, Rzeszow University of Technology, Poland	1. H2020 calls including categories A andB: A: •Marie-Sklodowska-Curie Actions •Research Infrastructures B: •The European Institute of Innovation and Technology (EIT) •Leadership in enabling and industrial technologies (LEIT) (Nanotechnologies)	2
Stefan Van Vaerenbergh, Université Libre de Bruxelles, Belgium	1. H2020 calls including categories A, B and C:	1-4
Jesper Glückstad, Techn. Univ. Denmark	1. H2020 calls including categories A, B and C: To be informed	2

Although most of the participants identified potential calls (some of them already closed, some still open and a few forthcoming), only a couple of them gave their ideas and information. The cut off dates for open calls are mostly between June to Sep 2017. However, except 1-2 potential proposal applications, the preparation progress and efforts needed for strong and collaborated applications for any of those open calls neither initiated nor in well-planed/grouped to make it possible. Nevertheless, current initiation and preparation can lead successful project for next year.

However, there are some very potential proposals/ideas/H2020 experienced groups such as ILK Dresden, CIC Energigune, Wroclaw University of Science and Technology, Poland; University of Maribor, and Techn. Univ. Denmark. Co-coordinating strongly collaborated 2-3 of these projects and applying in forth-coming calls could give high chance of successes. Some of these proposals fall in multiple WGs of NanoUptake.

Regarding the Round Robin tests, several areas of nanofluids such as convection heat transfer, thermophysical properties particularly thermal conductivity, specific heat capacity were identified for conducting Round Robin tests under the NanoUptake. Various possibilities and challenges for such Round Robin test were also discussed.

WG2: 3rd WG meeting Lisbon

The WG meeting was in conjunction with the 1st European Symposium on Nanofluids (ESNf2017).

A special session (17.00 – 18.30) for WG2 meeting and open discussion was arranged. In total 21 participants attended the meeting and discussion which was chaired by the WG2 leader. The meeting started with a brief introduction about this working group (#2-Cooling) and earlier presentations by the group leader. From this meeting and open discussion, the following issues were highlighted for the future focus/work to be carried out within this working group:

- It was unanimously agreed that the literature data on the cooling feature such as convective heat transfer coefficient shows a large scatter.

-It was emphasized that nanofluids cooling related studies need to be intensified and carefully investigated.

-The need for round robin experiments for cooling (convection in heat exchange system) performance evaluation of nanofluids was also emphasized.

-Various possibilities of realizing such a round robin test were discussed and analyzed. It was decided that first all participating members will be asked for the facility in the lab/company and which specific area they are expertise of. Then in the 1st phase everybody/selected group will be requested to prepare some specific nanofluids and do the stabilization checking (UV-vis, DLS, TEM etc) and characterize the given properties of the fresh sample. For the 1st phase, a general protocol will be prepared and participants will be asked to follow that. Then all results will be analyzed and shared to find the best nanofluids in terms of properties, concentration, stability and cost. In the 2nd phase, the selected nanofluids will be re-prepared following the same previous protocol and used in available convectional heat transfer systems to evaluate the cooling performance.

-Nanofluids cooling applications based barriers such as high viscosity and stability were also discussed.

4. Working Group 3 (Storage) Reports

WG3: 1st WG meeting Castellon

The meeting started with a brief Tour de Table in which all the participants presented themselves and their interest in the NANOUPTAKE Working Group #3: Storage.

After that, 8 participants presented their work. The title and affiliation of the presentations is as follows:

#	Title	Authors and Affiliation
1	Innovative solutions for geothermal heat exchangers with nanofluids	L. R. Silviu[1,2], M. T. Dorin[1], P. G. Catalin[1,3], C. Ionela[1], B. A. Irina[1] [1] Department of Building Services Engineering, "Gheorghe Asachi" Technical University of Iasi, 700050, Iasi, Romania [2] Department of Research, SC AIR-PROJECTS SRL IASI, 700697, Iasi, ROMANIA [3] Department of Research, SC CLIMA THERM CENTER SRL IASI, 700545, Iasi, ROMANIA
2	Nano-PCMs characterization and modelling	P. Bison[1], S. Bobbo[1], L. Fedele[1,*], S. Rossi[1], S. Mancin[2], D. Ercole[3], O. Manca[3] [1] Istituto per le Tecnologie della Costruzione, Consiglio Nazionale delle Ricerche, 35127 Padova, Italy [2] Dept. of Management and Engineering, University of Padova, 36100, Vicenza, Italy [3] Dipartimento di Ingegneria Industriale e dell'Informazione, Seconda Università degli Studi di Napoli, 81031 Aversa, Italy
3	Graphene/PEG400 Nanostructured Materials for Thermal Energy Storage and Lubrication. Thermal Analysis and Thermophysical Profile	D. Cabaleiro[1*], M. A. Marcos[1], M. J. G. Guimarey[2], M. J.P. Comuñas[2], J. Fernández[2], L. Lugo[1] [1] Departamento de Física Aplicada, Universidade de Vigo, E-36310, Vigo, Spain [2] Laboratorio de Propiedades Termofísicas, Departamento de Física Aplicada, Universidade de Santiago de Compostela, E-15782, Santiago de Compostela, Spain
4	Specific Heat increment of nitrate salts	M. E. Navarro[1], G. Qiao[2], Y. Ding[1] [1] Birmingham Centre of Energy Storage (BCES), School of Chemical Engineering, University of Birmingham, B152TT, Birmingham, UK [2] Global Energy Interconnection Research Institute (GEIRI), 10117, Berlin, Germany
5	Investigation of specific heat capacity of solar salt-based nanofluids	Y. Hu [1, 2], Y. He [2], D. Wen[1,*] [1] School of Chemical and Process Engineering, University of Leeds, LS2 9JT, Leeds, United Kingdom [2] School of Energy Science and Engineering, Harbin Institute of Technology, 150001, Harbin, China

6	Effect of silica nanoparticles in the specific heat of Solar Salt	R. Mondragon[1], N. Navarrete[1], L. Hernandez[1], L. Cabedo[2], R. Martinez-Cuenca[1], S. Torro[1], J. E. Julia[1*] [1] Dept. de Ingenieria Mecanica y Construccion, Universitat Jaume I, Castellon, Spain [2] Dept. Ingenieria de Sistemas Industriales y Diseño. Universitat Jaume I. Castellon, Spain
7	Development of novel nanofluids based on solar salt and ceramic nanoparticles for sensible thermal storage applications	B. Muñoz-Sánchez[1,2], J. Nieto-Maestre[1,*], A. García-Romero[2] [1] Tecnalia Research and Innovation, 20009 - San Sebastián (Gipúzcoa). Spain.+34 671 729 012; [2]Department of Mining Engineering, Metallurgy and Materials Science, University of the Basque Country (UPV/EHU), 48013 - Bilbao (Vizcaya). Spain.
8	Overview of nano research for thermal energy storage at the University of Lleida	Aran Solé[1] , Camila Barreneche [1, 2], Luisa F. Cabeza[1] [1] GREA Investigació Concurrent. University of Lleida, Spain [2] Department of Materials Science and Physical Chemistry. University of Barcelona. Spain

There were several discussions after each presentation and from 17.30 to 19.00 it was a group discussion. The main conclusions are:

- There are two main research topics in WG#3:
    - Enhancement of Phase Change Materials properties (nanoPCM subgroup) that corresponds to presentations #2, 3 and 8.
    - Enhancement of Molten Salt properties (molten salt subgroup) that corresponds to presentations #4, 5, 6, 7 and 8.

- There are some common ideas to be developed by the participants during 2017 that can be starting point of future join research projects and publications:
    - Perform Round Robin Tests of molten salt with nanoparticles (heat capacity and viscosity; thermal conductivity if possible). Salt and NP's to be defined.
    - Perform Round Robin Test of nanoPCM (to be defined the PCM, NP's, thermal properties – using different methods of measurement).
    - Perform common simulations of systems using nanoPCMs and molten salts (with NP's if possible).

- To prepare short review presentations for the next WG Meeting.

After that the WG Leaders propose to form 2 subgroups related with the two main research topics of the Working Group. They ask for volunteers for both subgroups. It is expected that the subgroup participants will have active contributions to their subgroups.

In the next weeks the WG Leaders will specify the joint collaborations and will contact with the subgroups participants.

WG3: 2nd WG meeting Lisbon

The meeting was aimed to NANOUPTAKE participants who are willing to organize/coordinate H2020 proposals and they have already identified a call/topic in which the proposal can be allocated as well as participants actively involved in running joint research activities, and no group division was made. The meeting was open with a short presentation about NANOUPTAKE and H2020 Strategic Programme (Speaker: J. E. Julia), followed by a presentation about next NMP H2020 calls, types of calls, etc, (Speaker Drª Sofia Azevedo, NPM NCP Portugal). A preliminary work done by Carlos Nieto de Castro on H2020 Calls intentions - H2020 - Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing (NMP) – Type A – Nanotechnologies; B – Advanced Materials; C – Secure, clean and efficient energy was presented. This work was based on inquiry to all the NANOUPTAKE members. Several projects were identified, like NANOSALT – ITN (Enrique Juliá); NANO BOOSTER (Matthias Buschmann) and BLACK ENERGY (Matthias Bushmann). A very detailed discussion was held, and proposers were charged to prepare applications for the open calls.

In addition, a Round Robin Test meeting was held, namely on molten salt with nanoparticles (heat capacity and viscosity; thermal conductivity if possible). Organization of the tests postponed to 2018.

WG3: 3rd WG meeting Lisbon

The WG meeting was in conjunction with the 1st European Symposium on Nanofluids (ESNf2017).

A special session for WG3 meeting and open discussion was arranged. Several participants attended the meeting and discussion which was chaired by the WG3 leader. The meeting started with a brief introduction about this working group (#3-Storage) by the group leader. From this meeting and open discussion, some relevant issues were highlighted for the future focus/work to be carried out within this working group.

5. Working Group 4 (Boiling, Solar and Others) Reports

WG4: 1st WG meeting Castellon

The meeting started with a brief introduction of NANOUPTAKE Working Group #4: Boiling, Solar Application, Modelling.

After that, 11 participants presented their work. The title and affiliation of the presentations is as follows:

#	Title	Authors and Affiliation
1	Experimental Analysis of Nanofluid Pool Boiling in Plain and Nanostructured Surfaces	S. Mancin[1], L. Doretti[2] [1] Dept. of Management and Engineering, University of Padova, 36100, Vicenza, Italy. [2] Dipartimento Ingegneria Civile Edile ed Ambientale, Università degli Studi di Padova, 35131,Padova, Italy.
2	Pool Boiling Heat Transfer and Critical Heat Flux of Nanofluids	Z. Wu, B. Sunden Department of Energy Sciences, Lund University, SE-22100, Lund, Sweden
3	Nanofluids Influence on the Thermal Behaviour of Loop Heat Pipes and Pulsating Heat Pipes	R. Riehl Space Mechanics and Control Division – DMC, National Institute for Space Research - INPE São José dos Campos, SP, Brazil
4	Carbon nanohorn-based nanofluids for solar thermal harvesting applications	S. Barison[1], L. Fedele[2], F. Agresti[1], S. Rossi[2], S. Bobbo[2], C. Pagura[1] [1] Istituto di Chimica della Materia Condensata e di Tecnologie per l'Energia, Consiglio Nazionale delle Ricerche, 35127 Padova, Italy [2] Istituto per le Tecnologie della Costruzione, Consiglio Nazionale delle Ricerche, 35127 Padova, Italy
5	Optical properties of nanofluids for direct solar thermal harvesting	E. Sani, L. Mercatelli, M. Meucci Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, 50125 Firenze, Italy
6	High stable nanofluids produced by Pulsed Laser Ablation in Liquids	O. Torres-Mendieta[1*], R. Mondragón[2], E. Juliá[2], O. Mendoza-Yero[1], J. Lancis[1], and G. Mínguez-Vega[1], M. Meucci[3], E. Sani[3] [1] GROC, UJI, Institut de Noves Tecnologies de la Imatge (INIT), Universitat Jaume I., 12080, Castelló, Spain [2] Departmento de Ingeniería Mecánica y Construcción, Universitat Jaume I., 12071, Castelló, Spain [3] Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, Largo Fermi 6, 50125 Firenze, Italy
7	IoNanofluids for Thermal Applications	C. Nieto de Castro, S. M. Sohel Murshed, M. J. Lourenço, F. J. V. Santos, M. Matos Lopes, J. M. P. França, S. I. C. Vieira, F.

		Bioucas Centro de Química Estrutural, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
8	The Rheological properties of silver nanofluids for enhancing thermal behaviour	T. Parametthanuwat Department of Agricultural Engineering for Industry, King Mongkut's University of Technology 129 Moo 21, Tambon Noenhom, Amphoe Mueang, Prachinburi 25230, Thailand
9	Overview of nanofluid research at MIT	R. Azizian Department of Nuclear Science & Engineering Massachusetts Institute of Technology, Cambridge, MA 02139, USA
10	Development of numerical methods for simulations of flow and heat transfer by nanofluids	J. Ravnik, J. Tibaut, L. Skerget Faculty of Mechanical Engineering, University of Maribor, SI-2000 Maribor, Slovenia
11	Laser pyrolysis synthesis of Fe-Si-C nanoparticles and their evaluation for water-based nanofluids	I. Morjan[1], F. Dumitrache[1], C. Fleaca[1], G. Huminic[2], A. Huminic[2] [1] National Institute for Laser, Plasma and Radiation Physics, PO Box MG-36, 077125, Magurele, Bucharest, Romania [2] Mechanical Engineering Department, Transilvania University of Brasov, 500036, Brasov, Romania

Each presentation was followed by a short discussion including several questions. From 17.30 to 19.00 the group had a general discussion. The main points were:

- how to organize overview or research papers which present the state of the art in the field,
- members of the group agreed to prepare a critical overview paper on nanofluid application in thermodynamical apparatus (plate heat exchanger, coil heat exchanger, counter flow heat exchanger etc.),
- at least two Short Term Scientific Missions were discussed (meanwhile the candidates applied for the according funding)

After the WG meeting a next smaller meeting of the group was discussed. Main subject of this meeting should be the investigation of possible joint projects with respect Horizon 2020 and / or based on binational funding schemes. So far, such a meeting is scheduled for May 4th 2017.

WG4: 2nd WG meeting Lisbon

The second WG-meeting took place at Universidade de Lisboa (Portugal). All working groups participants meet together in this special meeting.

The workgroup discussed general issues of heat transfer employing nanofluids for heat transfer based on phase change (heat pipes, thermosyphons etc.). Further emphasis was put on solar application and the thermophysical properties of according nanofluids.

Dr S. Barison (CNR-ICMATE Padua, Italy) and Dr M. H. Buschmann (ILK Dresden, Germany) presented the idea of a joined H2020 proposal coined BLACKENERGY. The BLACKENERGY project aims to utilize so-called black nanofluids (water-based suspensions with carbon nanoparticles) in volumetric solar absorbers. The work group discussed several options with respect to

- design and production of adequate black nanofluids,
- out coupling of thermal energy (thermo-electric, simple heat exchangers etc.),
- storage of harvested energy (PCM's storage employing nanoencapsulated particles), and
- combination with other renewables (mainly geothermal).

Potential partners of the project announced their interest. ILK Dresden (Germany) and Univ. Castellon (Spain) agreed to do some preliminary experiments using differently stabilized black nanofluids with nanohorn nanoparticles (produced by CNR-ICMATE Institute of Condensed Matter Chemistry and Technologies for Energy, Padova, Italy). Experiments should be carried out at ILK Dresden (Germany).

WG4: 3rd WG meeting Lisbon

The WG-meeting took place after the presentations related to the 1st European Symposium on Nanofluids (ESNf).

Prof. S. Mancin (Univ. Padua, Italy) presented the H2020-proposal "NANOBOOSTER". He explained goals and the anticipated strategy (FET-open call) of the project. Dr. M. H. Buschmann (ILK Dresden, Germany) presented first ideas for the H2020-proposal GEOAIR. The GEOAIR project aims to combine geothermal and solar energy resources to lower the net energy consumption of multi-family buildings.

The participants discussed several thermophysical properties related to nanofluids which are relevant for heat transfer with phase change. Contact angle and surface tension were given special attention. Both thermophysical properties seem to be underrepresented in the open literature. Options of a round robin test were discussed based on that finding. About five or six different institutions signaled their interest to join the project. The project was coined NANOTENSION and a first timeline for experimental work was scheduled.

6. Working Group 1, 2, 3 and 4 Joint Reports

As explained in the Section 1. Introduction of this document, the last two WG meetings (Naples 2018 and Castellón 2019) were attended by all Nanouptake participants, as many worked in different nanofluids applications (heating, cooling, storage and boiling-solar-modelling). Joint meeting including participants from all WGs were performed, and therefore, joint reports have been developed.

4th WG meeting Naples

The WG meeting was held on May 2018 in Naples. Due to the interest from different members in different WG and many shared problematics in all WGs, the agenda of the meetings was arranged so that all participants could attend to all the WG meetings. This allowed all the members to attend to:

- all presentations from different WGs
- two special key note lectures: "Modelling and experimental study of nanofluids" from Annalisa Cardellini (Politecnico di Torino) and "H2020 future calls for nanofluids" from Dr. Martina De Sole (APRE)
- strategic meeting with all WG members to present the different WG reports, present possible ideas for joint articles or H2020 proposals, identify objectives from the Action not deeply developed so far and identify ideas on how to keep Nanouptake network alive after COST funding.

A total 33 participants presented their works in the WG meeting: 6 from WG1, 7 from WG2, 9 from WG3 and 11 from WG4. At the end, each of the leaders of each WG summarized the presentations in this working group, highlighting the main advances of the field. The title and authors of the presentations are as follows:

Working Group 1

Effect of SiO2 nanoparticles on the internal structure of molten Solar Salt ***Argyrios Anagnostopoulos**, Anabel Palacios, Nuria Navarrete, Helena Navarro, Yulong Ding*
Wetting of Molten NaNO3 on MgO, Molten NaNO3- SiO2 nanofluid. Thermal energy storage through molecular dynamic simulations ***Argyrios Anagnostopoulos**, Alessio Alexiadis, Yulong Ding*
HNO3 oxidation of Single Wall Carbon Nanohorns for the production of surfactant free black nanofluids ***Filippo Agresti**, Simona Barison, Alessia Famengo, Cesare Pagura, Laura Fedele, Stefano Rossi, Sergio Bobbo, Marzio Rancan*
Thermal conductivity of aqueous iron oxides nanofluids ***Mihail Iacob**, Maria Cazacu, Leonor Hernandez*
Thermal Conductivity of Ionic Melts and Nanofluids - Where we are ***Carlos A. Nieto de Castro**, Maria José V. Lourenço*
Heat transfer enhancement by impinging slot jets with nanofluids in channels with and without metal foams *Bernardo Buonomo, Anna di Pasqua, Davide Ercole, **Oronzio Manca**, Sergio Nardini*

Working Group 2

Heat transfer enhancement in automotive cooling circuits by nanofluids *Bernardo Buonomo, Luca Cirillo,* ***Anna di Pasqua****, Davide Ercole, Oronzio Manca*
Heat transfer efficiency in a double pipe heat exchanger of functionalized graphene nanoplatelets/glycolated water nanofluids ***Javier P. Vallejo,*** *Julián Pérez-Tavernier, David Cabaleiro, José Fernández-Seara, Luis Lugo*
Isothermal analysis of Nanofluid Flow inside HyperVapotrons using Particle Image Velocimetry ***Antonis Sergis*** *, Yannis Hardalupas, Thomas Barrett*
Analysis of the Thermal Signature of Wind-turbine Generators: implications for their main Operative Parameters and future application of nanofluids ***Fran García****, Federico Argenio, Jorge Asensio, Luis M. Varela, Luis Lugo. Josefa Fernández*
Gr-Al2O3 Hybrid Nanoparticles based Multi-Functional Drilling Fluid ***Mortatha Al-Yasiri*** *, Dongsheng Wen*
A Benchmark Study on Heat Capacity of Nanofluids and Nanosalts ***S M Sohel Murshed***
Thermomagnetic properties of magnetic nanofluids and hybrid nanofluids ***M. Timko****, M. Rajnak, T. Tobias, K. Paulovicová, Z. Mitroova, Z. Wu, B. Sundén, P. Kopcansky*

Working Group 3

Characterization of nano-encapsulated metal alloy phase change materials for a molten salt-based nanofluid ***Nuria Navarrete****, Rosa Mondragón, Dongsheng Wen, Maria E. Navarro, Yulong Ding, J. Enrique Julia*
Corrosion properties of nanofluids based on molten nitrate salts for thermal energy storage applications ***Nithiyanantham Udayashankar****, Yaroslav Grosu, Luis González, Abdessamad Faik*
Design and Characterization of Phase Change Material Nanoemulsions as Thermal Energy Storage and Transport Media *Filippo Agresti, David Cabaleiro,* ***Simona Barison****, Laura Fedele , Stefano Rossi , M. A. Marcos , Luis Lugo , Sergio Bobbo*
Gold-silica core-shell nanoparticle dispersions in PEG400 as stable phase change materials for thermal energy storage ***Marco A. Marcos****, Martín Testa-Anta, David Cabaleiro, Verónica Salgueiriño, Luis Lugo*
Heat transfer study of nanosalt for solar energy storage ***Afrah Awad*** *, Dongsheng Wen*
Progress Report about Two-phase CFD Simulations of a Heat Storage Device with Nanofluid ***Peter Farber*** *, Christian Maraun, Peer Ueberholz*
Thermal performance of organic phase change material in the presence of graphene nanoplatelets ***Jose I. Prado****, M. Tomás Alonso, José Fernández-Seara, Luis Lugo*
Morphologies and thermal characterization on nanoparticle-seeded salt enhanced by metal foam ***Xin Xiao****, Dongsheng Wen*
Tailoring the properties of Nanoparticles by ALD Nanocoatings ***D. Valdesueiro****, A. Goulas , B. van Limpt*

Working Group 4

Characterization of graphene oxide nanofluids ***Agnieszka Wlaźlak** , Bartosz Zajaczkowski, Matthias H. Bushmann*
A Proposal for Thermal Conductivity Measurements of Magnetic Nanofluids Under the Influence of External Magnetic Field *Serkan Doğanay **, Levent Çetin**, Alpaslan Turgut*
Wettability Behaviour of Nanofluids ***Nur Çobanoğlu**, Ziya Haktan Karadeniz, Alpaslan Turgut*

The effect of oxidized carbon nanohorn nanofluid pool boiling on an aluminium surface *Alexandra Gimeno-Furio, Leonor Hernandez, Simona Barison, Filippo Agresti, Luca Doretti, **Simone Mancin***
Numerical simulation of a nanofluid in a pipe flow ***Jan Tibaut** , Tilen Tibaut , Jure Ravnik*
CFD modelling of volumetric vapour generation and its applications to the receiver design ***Raúl Martínez-Cuenca,** Alexandra Gimeno-Furió, Nuria Navarrete, Salvador Torró, Sergio Chiva, Leonor Hernández*
Plasmonic Nanofluids for Solar Cells Applications ***S. Kassavetis,** C. Kapnopoulos, P. Patsalas, and S. Logothetidis*
Performance evaluation of a solar cooling system with nanofluids *Furio Cascetta, Bernardo Buonomo, Luca Cirillo, **Sergio Nardini***
Towards highly stable nanofluids for Concentrating Solar Power ***Javier Navas,** Teresa Aguilar, Paloma Martínez-Merino, Ivan Carrillo-Berdugo, Antonio Sánchez-Coronilla, Elisa I. Martín, Roberto Gómez-Villarejo, Juan Jesús Gallardo, Rodrigo Alcántara, Concha Fernández-Lorenzo*
Round robin test for surface tension and contact angle of nanofluids ***Matthias H. Buschmann***
Experiment Investigation of Nanoparticle-assisted Enhanced Oil Recovery and Oil Reservoir Characterization **Zhonlgiang Hu**, Dongsheng Wen, Hui Gao, Ehsan Nourafkan

The summary of the presentations can be found in http://nanouptake.uji.es/wp-content/uploads/2018/06/Book-of-Abstracts-Nanouptake.pdf

A joint debate among all WG participants is held to identify nanofluids problems that Nanouptake network should be addressing in future papers or projects:

- Advance in agreement between different experimental data (inconsistent, unreliable, etc) and reliable universal experimental techniques and procedures
- Increase the agreement between the experimental findings and the theoretical model predictions
- Develop nanofluids theoretical models that can be generally accepted
- Improve long term stability at rest and during system operation
- Improve characterisation of the nanofluids under industrial applications conditions
- Develop tests in specific industrial applications including long term performance evaluations
- Develop nanofluids Life Cycle Analysis issues
- Clarify legislation and health, safety and environmental issues

The identified possible issues together with the meeting networking and the key note lecture in the meeting ("H2020 future calls for nanofluids" from Dr. Martina De Sole (APRE)) is expected to improve the number of nanofluids proposals from the Nanouptake network.

The joint meeting with all the WGs participants also identified that two Nanouptake objectives were poorly developed during the first half of the Action:

- Fostering the development of a joint research agenda in order to assess the economic and performance viability of using nanofluids in thermal systems.
- Promoting the development of a joint research agenda in order to evaluate health and safety of nanofluids and their potential impact on the environment and on selected industrial applications.

In this WG meeting different strategies to meet these goals were agreed to be developed during the second half of the Action:

- Stablish a strategic meeting with the industry to identify alternatives to promote the development of a joint agenda to bring nanofluids closer to the industry/market
- Stablish a strategic meeting with the industry to promote the development of a joint agenda to analyse health, safety and environmental impacts of nanofluids
- Perform a survey among Nanouptake participants to obtain key information regarding possible industrial implementation of nanofluids
- Perform a survey among Nanouptake participants regarding health, safety and environmental regulations for handling nanofluids
- Perform a collaborative compendium of resources about health, safety and environmental issued of nanofluids
- Promote new section in further Nanouptake meetings about nanofluids industrial applications and health, safety and environmental issues
- Compile contributions from Nanouptake participants in a handbook about industrial applications of nanofluids

5th WG meeting Castellon

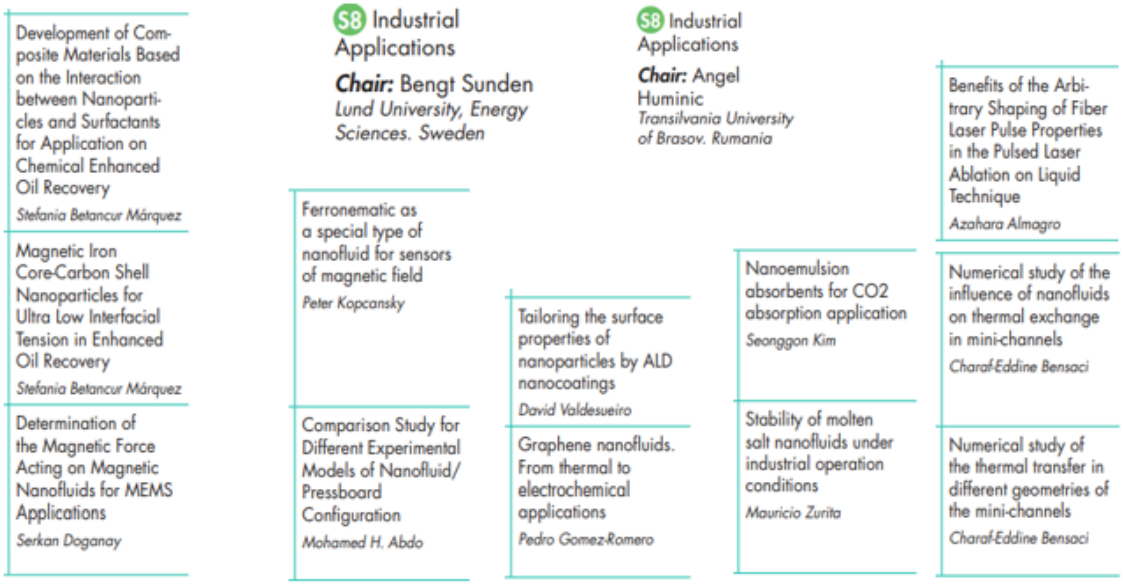
These WG meetings were held in conjunction with the 1st International Conference on Nanofluids (www.icnf2019.com) also organized by Nanouptake, and joining together all the 4 WGs with different nanofluids applications (heating, cooling, storage and boiling-solar-modelling). Two different sessions were organized, each of them with a specific thematic subjects, aligned with two of the Nanouptake goals:

a) promoting nanofluids industrial applications within the Nanouptake network

b) promoting nanofluids health, safety and environmental issues within the Nanouptake network

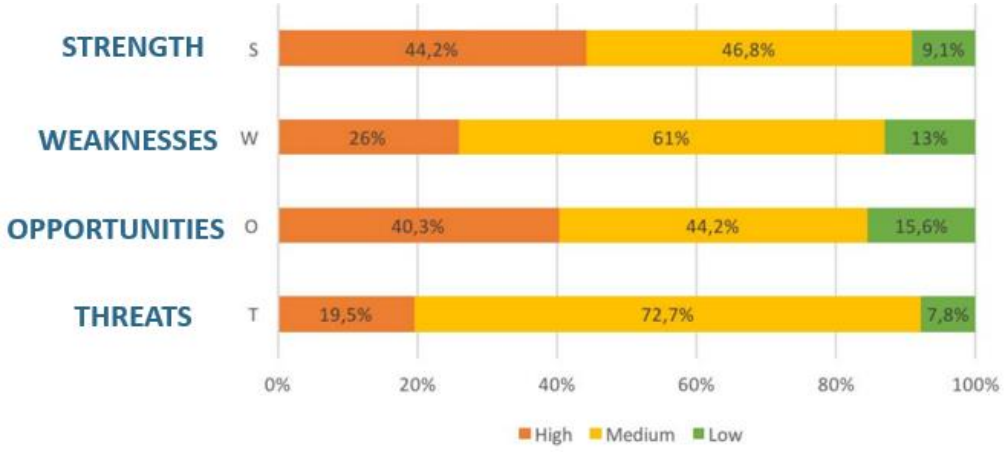
The information provided in the first session of "Promoting nanofluids industrial applications" was the following:

1) A specific session (session 8) of Nanofluids Industrial Applications was held in the ICNf2019 conference with the 12 oral papers + 4 posters. The detailed presentations can be found in http://repositori.uji.es/xmlui/handle/10234/183448 (pages 485 to 546)



2) The conclusions of the Strategic Meeting with industry (held in February 2019), were presented. More information can be found in http://repositori.uji.es/xmlui/handle/10234/182628 (Section 3)

3) The results of the survey of SWOT analysis about nanofluids industrial applications among Nanouptake participants were presented. More information can be found in http://repositori.uji.es/xmlui/handle/10234/182628 (Section 4)



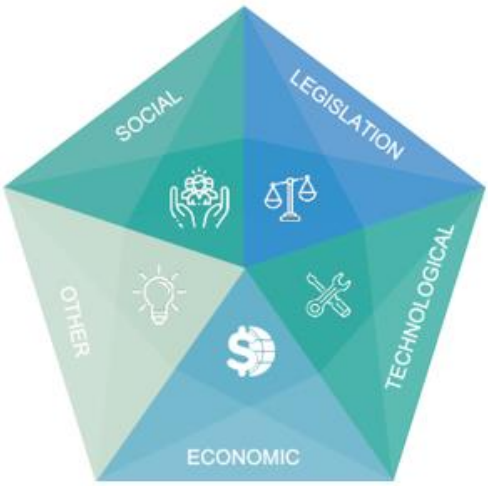
4) The results obtained so far about the open access publication "Handbook about industrial applications of nanofluids in energy sector" is presented. At that moment, 23 contributions were received and an invitation for new contributions from Nanouptake participants was shared.

5) An open discussion with the WG attendees was held, mainly based on these open questions: Which are the most promising nanofluids applications? What can be done from Nanouptake to identify those applications? What do the industry needs from nanofluids researchers?

The information provided in the second session of "Promoting nanofluids health, safety and environmental issues" was the following:

1) A specific session (session 9) of Nanofluids Industrial Applications was held in the ICNf2019 conference with 4 oral papers. The detailed presentations can be found in http://repositori.uji.es/xmlui/handle/10234/183448 (pages 547 to 565)

2) The conclusions of the Strategic Meeting with industry (held in February 2019), were presented. In the meeting, a collaborative PENTAGONAL ANALYSIS with problems & possible solutions of nanofluid's H&S&E was developed with the contributions from the participants. More information can be found in http://repositori.uji.es/xmlui/handle/10234/182629 (Section 3)



3) The results of the survey about nanofluids health, safety and environmental issue among Nanouptake participants were presented. More information can be found in http://repositori.uji.es/xmlui/handle/10234/182629 (section 4) and in http://www.nanouptake.eu/wp-content/uploads/2019/07/NanoSafety_presentation.pdf

4) The compendium with nanofluids health, safety and environmental resources is presented. More than 50 resources in these fields are gathered and grouped in: documents of interest, networks, projects and lab resources. More information can be found in http://repositori.uji.es/xmlui/handle/10234/182629 (Section 5)

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