COST Action
Final Achievement Report

FP1303: Performance of bio-based building materials
(22/10/2013 to 21/10/2017)

The Action was approved by the Committee of Senior Officials (CSO) on 16-5-2013 and has the MoU reference COST 020/13.

This report was submitted on 04-12-2017 by the Action Chair on behalf of the Management Committee in fulfilment of the requirements of the rules for COST Action Management, Monitoring and Final Assessment.
## Action leadership and participants

### Leadership Positions

<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
<th>Contact details</th>
<th>Country of work affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair</td>
<td>Dr Dennis Jones</td>
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<td>DE</td>
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</tbody>
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### Working Groups

<table>
<thead>
<tr>
<th>#</th>
<th>WG Title</th>
<th># of participants</th>
<th>WG Leader</th>
<th>Country of nomination</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Material capability and enhancement</td>
<td>65</td>
<td>Dr Stig Bardage</td>
<td>SE</td>
</tr>
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</tr>
<tr>
<td>2</td>
<td>Functionality and performance</td>
<td>85</td>
<td>Dr Miha Humar</td>
<td>SI</td>
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<tr>
<td>3</td>
<td>Adaptation and application</td>
<td>50</td>
<td>Dr Ed Suttie</td>
<td>UK</td>
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### Participants

**COST Member Countries and Cooperating State having accepted the MoU**

<table>
<thead>
<tr>
<th>Country</th>
<th>Acceptance Date</th>
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<td>UK</td>
<td>30/05/2013</td>
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### Other Participants

<table>
<thead>
<tr>
<th>Institution Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>National University of Forestry &amp; Wood Technology</td>
<td>Ukraine</td>
</tr>
<tr>
<td>Scion</td>
<td>New Zealand</td>
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Summary

Main aim/objective
The main objective of the Action is to improve the knowledge on the performance of bio-based materials used as building products and the assessment of chemical and physical factors influencing these, with the aim of increasing their service life.

The Action addressed this as described below.

Over the four years of COST FP1303, the Action has addressed a variety of key issues:

Improve and disseminate knowledge about damage of materials caused by organisms – this has been achieved and reported in most meetings and joint conferences. The knowledge on design and avoiding moisture risks is of particular importance.

Guidelines for preventing decay - the state of the art book covers this subject, along with presentations from meetings.

Assessment protocols and procedures – this was achieved, through the round robin trial, and through the links with relevant CEN TCs. It was also covered in high detail during the training schools.

Novel protection methods – this was achieved in book and in presentations.

Involvement of young researchers – this was achieved by the high number of ECI participants in meetings (usually 30-40% of delegates at meetings were ECIs), trainings schools (90% of delegates), and through the 39 STSMs undertaken and 7 ITC grants awarded for ECIs to present at conferences.

National representation and gender balance - the Action ensured that delegates from all countries attended where possible, with an additional emphasis on gender balance (typically 30% female attendance for all meetings). Additional focus was placed on ITC attendance, particularly of Training Schools.

High publication rates - papers on subjects linked to the Action and those acknowledging the Action continue to be collected.

COST FP1303 over its four years contributed to the development and expansion of the use of bio-based building materials. Action members continue to develop new ideas, uses and documentation supporting the correct use of materials.

Action website
http://costfp1303.iam.upr.si/en/
**Achievement of MoU objectives, deliverables and additional outputs/ achievements**

**MoU objectives**
The Action had the following specific objectives.

<table>
<thead>
<tr>
<th>MoU objective</th>
<th>Level of achievement</th>
<th>Further information (hyperlink or other)</th>
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<tr>
<td>Creating a platform for performance testing. The Action will link ongoing national and international activities looking at aspects of testing of the performance of a range of materials, and how these should be altered to account for changes in treatments, uses, micro and macro-climatic issues. Findings from this can then be fed into standardization committees (such as CEN).</td>
<td>76 - 100%</td>
<td>The Action has provided a forum for the presentation of ideas and ongoing projects and studies into the performance of materials. Based on initial discussions, it was decided at an early stage to undertake a round robin performance test. To do this a table comprising several different wood species/treatments was devised by the University of Ljubljana. In total, 49 tables were manufactured and sent to 28 participating sites across Europe, some of these tables were fitted with datalogging equipment and others used for visual performance only. Information on the table and some papers outlining results to date can be found on <a href="http://costfp1303.iam.upr.si/en/round-robin">http://costfp1303.iam.upr.si/en/round-robin</a>. The Action participants have taken information from this round robin and other projects and compiled state of art overviews, such as those given in the final meeting (<a href="http://costfp1303.iam.upr.si/en/past-events/zagreb-meeting">http://costfp1303.iam.upr.si/en/past-events/zagreb-meeting</a>). These overviews have been compiled into the COST Action book (<a href="http://costfp1303.iam.upr.si/en/book">http://costfp1303.iam.upr.si/en/book</a>), particularly chapters 7 (Test methods for bio-based building materials) and 8 (Modelling). Several Action members have been active within CEN TC38, with much of the outcomes discussed in recent meetings and being incorporated into new standardisation drafts. Much of the work undertaken by participants has been presented at international conferences such as the International Research Group on Wood Protection. The IRG48 conference, held in Belgium in 2017 had a special session on timber bridges, where their performance was detailed (<a href="http://irg48.be/wp-content/uploads/2017/05/IRGW_P-17-60415-IRG48_Programme_June-04-08th_05_062016_final_3.pdf">http://irg48.be/wp-content/uploads/2017/05/IRGW_P-17-60415-IRG48_Programme_June-04-08th_05_062016_final_3.pdf</a>). Further evidence of the performance of materials and products can be seen from the number of papers listed as relevant to this Action (<a href="http://costfp1303.iam.upr.si/en/publications">http://costfp1303.iam.upr.si/en/publications</a>), and it is expected that as further publications will emphasise ongoing studies and acknowledge the impact of COST FP1303.</td>
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<tr>
<td>Establish a critical appraisal of innovative materials. As more materials progress from laboratory development to commercial production, information gathered to their properties and how they perform in use will be created. This will help identify correct materials for specific uses.</td>
<td>76 - 100%</td>
<td>The Action has provided a platform for participants to present some of the latest developments in treatments and uses of materials. The use of non-wood materials was the main theme of one of the workshops, held in Tallinn (<a href="http://costfp1303.iam.upr.si/en/past-events/tallinn-meeting">http://costfp1303.iam.upr.si/en/past-events/tallinn-meeting</a>), whilst there have been several other presentations given at other Action meetings.</td>
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</table>
The development of modified wood has been an ongoing issue for nearly 20 years across Europe, and this Action has been active in participating with the European Conference on Wood Modification, having dedicated sessions in ECWM7 in Lisbon (http://costfp1303.iam.upr.si/en/past-events/ecwm7-conference-2014) and ECWM8 in Helsinki (http://costfp1303.iam.upr.si/en/past-events/ecwm8-conference-2015). Several of the Action participants have also presented at other conferences such as IRG and the Nordic-Baltic Wood Science and Engineering conferences.

The Action has also shown how historical methods of material use are beginning to have a renaissance, such as the use of sheepswool for insulation. This material has been shown by Action members to be especially good at absorbing airborne chemicals, thus helping improving indoor environment. Similarly the use of straw in composites is an area of increasing interest.

In many cases the use of Short Term Scientific Missions (STSMs) have helped young researchers to increase their knowledge of new materials, whilst building new collaborative links of importance for future careers (http://costfp1303.iam.upr.si/en/stsm).

The use of innovative materials was thoroughly reviewed in Chapters 2 and 3 of the COST Action book (http://costfp1303.iam.upr.si/en/book), where the non-wood materials flax, hemp, straw, bamboo, rattan, reed, wool, peat, grass and vegetable pith were reviewed.

Guidance for users æœ There appears to be considerable misunderstanding on how natural materials perform in use and protective maintenance schemes that should be followed to ensure they reach their expected service lives. The Action will determine best practice methods suited to both professional bodies and consumers (the general public).

76 - 100%

The Action has provided much of the technical information on how biobased building materials need to behave to meet consumer expectations. This is exemplified by the meeting "Designing with biobased building materials - challenges and opportunities" held in Madrid (http://costfp1303.iam.upr.si/en/past-events/madrid-meeting) and "Design, Application and Aesthetics of Biobased Building Materials" (http://costfp1303.iam.upr.si/en/past-events/sofia-meeting).

The understanding of performance of materials was promoted with two training schools dealing with durability in field studies, held in Hannover (http://costfp1303.iam.upr.si/en/past-events/training-school-2) and the evaluation of mould risk, held in Bangor (http://costfp1303.iam.upr.si/en/past-events/training-school-2-1). A further training school, held in Hoje Tasstrup on the use of fibres in new products increased knowledge on the potential of a range of wood and non-wood products (http://costfp1303.iam.upr.si/en/past-events/training-school-4).

Additional input into understanding biobased materials in modern society is also given within Chapter 5 of the Action book, where function,
durability, moisture performance, aesthetics, thermal performance and fire performance were reviewed (http://costfp1303.iam.upr.si/en/book). The Action also held joint activities with COST Action FP1404 (Fire safe use of biobased building products) and COST FP1407 (Understanding wood modification through an integrated scientific and environmental impact approach: Woodmodlife (http://www.costfp1407.iam.upr.si).

The majority of outputs on this objective have dealt with scientific approaches. Total achievement will be seen as achieved with the publication of general articles suited more to consumers. It is hoped these will be produced after the end of the Action, based on the strong collaboration of members formed as a result of the Action’s activities.

Networking as a group and among other groups - As this Action proceeds, it is anticipated that the majority of European countries will be represented, providing the pan-European dimension necessary for achieving close collaboration. The topics within this Action transcend several other Actions and research initiatives, and as such members will be encouraged to promote the Action and to engage in cross-theme development, not only with research peers but also the industrial community. This offers the potential of the Action having a global presence.

76 - 100% The Action has helped bring together more than 260 scientists from across a wide range of technical expertise - ranging from wood science, chemistry, material engineers, designers, architects, heritage conversation, and industrial manufacturers. It has helped in the career development of a group of early career investigators by providing opportunities to present their work, interact with scientific peers, and to learn new methods through Training Schools and Short Term Scientific Missions.

Through joint initiatives, this Action has promoted the performance of biobased materials with conferences such as IRG, ECWM, International Panel Products Symposium (http://costfp1303.iam.upr.si/en/past-events/ipps-conference-2015), whilst members have presented at a range of other conferences and COST Actions (particularly FP1407).

Deliverables
The Action reported the following deliverables:

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Timing of deliverable</th>
<th>Further information (hyperlink or other)</th>
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<tbody>
<tr>
<td>Dissemination of knowledge to alleviate consumer misconceptions and misunderstandings regarding the presence of mould growth, decay and other damage caused by organisms.</td>
<td>Delivered</td>
<td><a href="http://costfp1303.iam.upr.si/en/publications/2017">http://costfp1303.iam.upr.si/en/publications/2017</a> (e.g. refs 2,8,20) and <a href="http://costfp1303.iam.upr.si/en/publications/2016">http://costfp1303.iam.upr.si/en/publications/2016</a> (e.g. 4,6,16,21,23)</td>
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<thead>
<tr>
<th>Task</th>
<th>Delivery Status</th>
<th>Online Resources</th>
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<tbody>
<tr>
<td>Engaging Early Career Investigators in Action activities and assisting in their continued career development.</td>
<td>Delivered</td>
<td><a href="http://costfp1303.iam.upr.si/en/book">http://costfp1303.iam.upr.si/en/book</a> (e.g. chapter 4); <a href="http://costfp1303.iam.upr.si/en/past-events/ecwm7-conference-2014">http://costfp1303.iam.upr.si/en/past-events/ecwm7-conference-2014</a>; <a href="http://costfp1303.iam.upr.si/en/publications/2017">http://costfp1303.iam.upr.si/en/publications/2017</a> (e.g. 9, 10, 13-16)</td>
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<tr>
<td>Improved and harmonized assessment protocols and procedures for various bio-based building materials linking materials to building physics.</td>
<td>Delivered</td>
<td><a href="http://costfp1303.iam.upr.si/en/book">http://costfp1303.iam.upr.si/en/book</a> (e.g. chapter 10)</td>
</tr>
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</table>

**Additional outputs/ achievements**

The following outputs/ achievements also resulted from the Action.

The Action reported 71 publications on the topic of the Action, co-authored by at least two Action participants from two countries participating in the Action, and for which the Action networking was necessary.

**Co-authored Action publications - peer-reviewed**

1. Application of high-frequency densitometry to detect changes in early- and latewood density of oak (Quercus robur L.) due to thermal modification. R. Shchupakivskyy (UA), L. Clauder (DE), N. Linke (DE), A. Pfriem (DE).

   Eur. J. Wood Prod. 72 (2014) 5-10

   DOI 10.1007/s00107-013-0744-x

2. Testing the mechanical resistance of timber used for construction in the marine environment. C. Brischke (DE), N. Iseler (DE), L. Meyer (DE), G. Sawyer (UK).


   DOI: 10.1179/2042645313Y.00000

   Mechanical and physical properties of thermally modified Scots pine wood in high pressure reactor under saturated steam at 120, 150 and 180 oC. L. Rautkari (FI), J. Honkanen (FI), C.A.S. Hill (UK), D. Ridley-Ellis (UK), M. Hughes (FI).

   Eur. J. Wood Prod. 72 (2014) 33-41

3.


4. Effect of initial moisture content on the anti-swelling efficiency of thermally modified Scots pine

Biomass Bioeng. 67 (2014) 425-434
DOI: 10.1016/j.biombioe.2014.0

6. The use of FT-IR and computed tomography non-destructive technique for waterlogged wood characterisation.


7. Reducing the moisture sensitivity of linear friction-welded birch (Betula pendula L.) wood through thermal modification. J. Ruponen (FI), P. Cermak (FI, CZ), M. Rheme (CH), L. Rautkari (FI).

DOI: 10.1080/01694243.2015.1068045


Int. J. Polym. Sci., 2015, Article ID 383279, 14 p
DOI: 10.1155/2015/383279


DOI: 10.1007/s00107-015-0919-8


Indoor Built Environ. 26(1) (2015) 92-107
DOI: 10.1177/1420326X15605162

11. Analysis of dimensional stability of thermally modified wood affected by re-wetting cycles. P. Cermak (CZ), L. Rautkari (FI), P. Horacek (CZ), B. Saake (DE), P. Rademacher (CZ), P. Sablik (CZ).

12. Influence of welding time on tensile-shear strength of linear friction welded birch (Betula pendula L.) wood. J. Ruponen (FI), P. Cermak (CZ), M. Rheme (CH), A. Miettinen (FI), A. Rohumaa (FI), L. Rautkari (FI). BioRes. 10(2) (2015) 3481-3491

DOI: 10.15376/biores.10.2.3481


DOI: 10.1016/j.conbuildmat.201


DOI: 10.1179/2042645314Y.00000


15.


DOI: 10.1179/2042645314Y.00000


Int. Wood Prod. J. 7(2) (2016) 80-88

DOI: 10.1080/20426445.2016.116


DOI: 10.1016/j.indcrop.2016.01


Wood Res., 61(2) (2016) 205-214


Int. J. Adhes. Adhes., 68 (2016) 351-358

DOI:10.1016/j.ijadhadh.2016.04


Acta Facultatis Xylologiae Zvolen, 58(2) (2016) 65-72

DOI: 10.17423/afx.2016.58.2.07


DOI 10.1007/s00226-016-0835-z

25. Role of various nano-particles in prevention of fungal decay, mold growth and termite attack in wood, and their effect on weathering properties and water repellency. E. Terzi (TR), S.N. Kartal (TR), N. Yilgor (TR), L. Rautkari (FI), T. Yoshimura (JP).


DOI: 10.1016/j.ibiod.2015.11.0


Wood Sci. Technol. 50 (2016) 1103-1123

DOI: 10.1007/s00226-016-0861-x

27. Surface densification of acetylated wood. K. Laine (FI), K. Segerholm (SE), M. Walinder (SE), L. Rautkari (FI), M. Hughes (FI), C. Lankveld (NL).


DOI 10.1007/s00107-016-1077-3

Eur. J. Wood Prod., 74 (2016) 909-911
DOI: 10.1007/s00107-016-1093-3

29. Critical moisture conditions for fungal decay of modified wood by basidiomycetes as detected by pile tests. L. Meyer (DE), C. Brischke (DE), A. Treu (NO), P. Larsson-Brelid (SE).

Holzforschung, 70(4) (2016) 331-339
DOI: 10.1515/hf-2015-0046

30. The effect of wetting cycles on moisture behaviour of thermally modified Scots pine (Pinus sylvestris L.) wood. P. Cermak (CZ), K. Vahtikari (FI), L. Rautkari (FI), K. Laine (FI), P. Horacek (CZ), J. Baar (CZ).

DOI 10.1007/s10853-015-9471-5

DOI: 10.1255/jnirs.1255

DOI: 10.1255/jnirs.1253 All

33. Effects of air relative humidity and temperature on photodegradation processes in beech and spruce Wood. L. Tolvaj (HU), C.-M. Popescu (RO), Z. Molnar (HU), E. Preklet (HU).

BioRes. 11(1) (2016) 296-305
DOI: 10.15376/biores.11.1.296-

34. The environmental impact of wood compared to other building materials. C.A.S. Hill (UK, NO), J. Dibdiakova (NO).

DOI: 10.1080/20426445.2016.119

DOI: 10.1080/20426445.2016.116
36. The combined effect of wetting ability and durability on outdoor performance of wood: development and verification of a new prediction approach. L. Meyer-Veltrup (DE), C. Brischke (DE), G. Alfredsen (NO), M. Humar (SE), P.-O. Flaete (NO), To. Isaksson (SE), P. Larsson Brelid (SE), M. Westin (SE), J. Jermer (SE).

DOI: 10.1007/s00226-017-0893-x

37. Improvement of fire reaction and mould growth resistance of a new bio-based thermal insulation material. M. Palumbo (ES,BR), A.M. Lacasta (ES), A. Navarro (ES), M.P. Giraldo (ES), B. Lesar (SI).

DOI: 10.1016/j.conbuildmat.201


DOI: 10.1016/j.engfracmech.201

DOI: 10.1007/s10853-017-1278-0

DOI: 10.1080/17480272.2016.115

41. Cellular level distributions of Scots pine heartwood and knot heartwood extractives revealed by Raman spectroscopy imaging. T. Belta (FI), T. Keplinger (CH), T. Hanninen (FI), L. Rautkari (FI). Ind. Crop Prod. 108 (2017) 327-335
DOI: 10.1016/j.indcrop.2017.06

42. Testing the durability of timber above ground: evaluation of different test methods. L. Meyer-Veltrup (DE), C. Brischke (DE), B. Kallander (SE).

DOI:10.1007/s00107-016-1137-8
43. Tannin-caprolactam and Tannin-PEG formulations as outdoor wood preservatives: biological properties. J. Hu (PRC, FR), M.-F. Thevenon (FR), S. Palanti (IT), G. Tondi (AT).
Annals Forest Sci. 74(1) (2017) Art. no. 18
DOI: 10.1007/s13595-016-0606-x

44. Tannin-caprolactam and Tannin-PEG formulations as outdoor wood preservatives: weathering properties. G. Tondi (AT), J. Hu (PRC, FR), F. Rizzo (AT), J. Buh (SI), S. Medved (SI), A. Petutschnigg (AT), M.-F. Thevenon (FR).
Annals Forest Sci. 74(1) (2017) Art. no. 19
DOI: 10.1007/s13595-016-0605-y

45. Formaldehyde, phenol and ammonia emissions from wood/recycled polyethylene composites. P. Lyutyy (UA), P. Bekhta (UA), G. Ortynska (UA), J. Sedliacik (SK).
DOI: 10.17423/Afx.2017.59.1.10

DOI:10.1080/00218464.2015.1118

47. Shear strength of furfurylated, N-methylol melamine and thermally modified wood bonded with three conventional adhesives. A. Bastani (DE), S. Adamopoulos (SE), H. Militz (DE).
DOI: 10.1080/17480272.2016.116

DOI: 10.15376/biores.12.4.9198

DOI: 10.1007/s00107-016-1052-z

51. Machinability of Minor Wooden Species before and after Modification with Thermo-Vacuum Technology. J. Sandak (IT, SI), G. Goli (IT), P. Cetera (IT), A. Sandak (IT), A. Cavalli (IT), L. Todaro (IT).

Materials 2017, 10, 121; 1-12
doi:10.3390/ma10020121

52. Selection of optimal conversion path for willow biomass assisted by near infrared spectroscopy. A. Sandak (IT, SI), J. Sandak (IT, SI), B. Waliszewska (PL), M. Zborowska (PL), M. Mleczek (PL).

iForest, 10 (2017) 506-514
DOI: 10.3832/ifor1987-010


Wood Mat. Sci. Eng., 2016, in press
10.1080/17480272.2016.1257651

doi: 10.1007/s00107-017-1233-4


56. Chemical, water vapour sorption and ultrastructural analysis of Scots pine wood thermally modified in high-pressure reactor under saturated steam. M. Kymalainen (FI), S.B. Mlouka (FI), T. Belt (FI), V. Merk (CH), V. Liljestrom (FI), T. Hanninen (FI), T. Uimonen (FI), M. Kosttainen (FI), L. Rautkari (FI).

J. Mater. Sci., 2017, in press
DOI 10.1007/s10853-017-1714-1


doi: 10.1016/j.polymdegradstab

DOI: 10.1080/20426445.2017.134


doi.org/10.1007/s00107-015-094


DOI: 10.1002/bate.201500102


doi.org/10.1179/2042645314Y.00


doi.org/10.1080/17480272.2014.

Co-authored Action publications - other


IRG/WP 15-40703.

6. Expert versus multi-sensor evaluation of wood samples after short term weathering; Anna Sandak, Jakub Sandak, Ingunn Burud, Lone Ross Gobakken, Marion Noel; Paper prepared for the 47th IRG Annual Meeting
Lisbon, Portugal 15-19 May 2016

Projects
The Action reported 11 project(s) and 5 proposal(s) resulting from the Action networking.

Key details of the projects are shown below

1. WINdow based on THERmally modified wood with high performance WAX coating (WINThERWAX)
   (H2020)
2. Renewable materials and healthy environments research and innovation centre of excellence (InnoRenew CoE)
   (H2020)
3. WINSMART - Sets New Standards for Windows! (FP7)
4. Performance standards for wood in construction - delivering customer service life needs (Performwood)
   (FP7)
5. Utilization of renewable biomass and residual materials for the production of environmentally friendly bio-based composites (National)
6. Cascading Recovered Wood (CaReWood) (Trans-national - Wood Wisdom Network)
7. European Hardwoods for the building sector (EU Hardwoods) (Trans-national - Wood Wisdom Net)
8. Enhancing wood durability and physical properties through innovative bio-based sustainable treatments (BioCoPol)
   (Trans-national - Wood Wisdom Network)
9. Competitive wood based interior materials and systems for modern wood construction (Wood2 New)
   (Trans-national - Wood Wisdom Network)
10. FiberTies – The use of fibrous materials from biomass
    (Trans-national - Nordic Joint Committee for Agricultural and Food Research (NKJ) and Nordic Forest Research (SNS))
11. FiberTies - The use of fibrous materials from biomass
    (Trans-national - Nordic Joint Committee for Agricultural and Food Research (NKJ) and Nordic Forest Research (SNS))

Other outputs / achievements

The following other outputs/ achievements contributing to the COST mission resulted from the Action:

1. As part of the planning during the running of the Action, it was agreed to undertake a state of the art book on the performance of bio-based materials. The book, entitled "Performance of bio-based building materials" was published by Woodhead publishing (part of Elsevier). Involving 67 contributors from the Action, the 646 page book is hoped to act as a reference material for senior and young researchers hoping to learn more about how bio-based materials behave in service. Due to copyright reasons the pdf of the book cannot be provided as part of the review process. More details about the book can be found on the web page within the Action site (http://costfp1303.iam.upr.si/en/book).

2. Special issue of the International Wood Products Journal linked to the 7th European Conference on Wood Modification. The Action covered the participation costs (travel and subsistence of several persons to take part in ECWM7. In total, 14 persons were provided funding to attend the meeting in Lisbon, Portugal. Of these, 6 were ECIs and 3 were from ITC countries. Details of the presentations given in the dedicated session to the Action can be found on http://costfp1303.iam.upr.si/en/past-events/ecwm7-conference-2014. Arrangements were made with the International Wood Products Journal for several papers to be published, these being:


3. Special Issue of the Eighth European Conference on Wood Modification (ECWM8). Following on from the successful publication of the special issue from ECWM, the International Wood Products Journal once again agreed to publish selected papers. In total COST FP1303 funded 27 persons to attend ECWM8, of which 14 were ECIs and 7 were from ITC countries. The following papers were published in IWPJ:


4. Special Issue of the International Wood Panels Symposium 2015. The IPPS2015 conference provided an excellent opportunity for participants of COST FP1303 to take part in a major conference linked to composite materials manufactured from wood and non-wood fibres. IPPS represents one of the most industrially pro-active conferences, with several international companies present. Once again the International Wood Products Journal agreed to produce a special issue comprising several papers presented at the conference:


J. Grinins, I. Irie, B. Andersons, I. Andersone, A. Meija-Feldmane, A. Janberga, G. Pavlovics & E. Sansonetti. Thermo-hydro treated (THT) birch plywood with improved service properties. INt. Wood


5. The Action had strong links with both the European Conference on Wood Modification and the International Panel Products Symposium, as was demonstrated by the programmes for these events:


6. There have been a lot of publications in scientific journals and conference proceedings emanating from one Action country. Many of these are listed in the annual breakdown of publications. It is anticipated that these lists (http://costfp1303.iam.upr.si/en/publications) will continue to grow as more information is received from Action members.

7. Development of nationally funded projects through interaction with FP1303 members. By sharing information and collaborating, members were able to develop stand-alone nationally funded projects
(only one country participating). Whilst these are not listed as outputs from the Action, they have helped provide a wide range of data and ongoing research. The overlap between individual countries' projects allows partners to generate collaborative scientific papers and presentations.
Impacts

The Action reported the following impact(s):

<table>
<thead>
<tr>
<th>Description of the impact, i.e. what will change, and for whom, as a result of what the Action achieved</th>
<th>Type of impact</th>
<th>Timing of impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>There will be a better understanding on how bio-based building materials should be used. This will be aided through the Action book (<a href="http://costfp1303.iam.upr.si/en/book">http://costfp1303.iam.upr.si/en/book</a>). This will act as a core subject book for future students studying aspects of biobased building materials</td>
<td>Scientific / Technological</td>
<td>Achieved</td>
</tr>
<tr>
<td>Students to use technical documents created from the Training Schools to increase their knowledge and to get more involved in specific aspects of biobased material performance. This is best exemplified through the excellent instructional document created for the Training School on decay in performance by Leibniz University of Hannover and the invited trainers (<a href="http://costfp1303.iam.upr.si/en/resources/files/publications/handout-cost-fp-1303-training-school-hannover.pdf">http://costfp1303.iam.upr.si/en/resources/files/publications/handout-cost-fp-1303-training-school-hannover.pdf</a>).</td>
<td>Scientific / Technological, Societal</td>
<td>Foreseen within 2 years</td>
</tr>
<tr>
<td>Increased manufacturing with bio-based materials to meet environmental needs and provide energy efficient buildings. The Action has laid the foundation to increase opportunities for advanced building materials to be created and employed in new build and refurbishment projects. The knowledge built up on correct design, particularly over the avoidance of moisture traps, is being adapted by many architects across Europe, and ongoing activities by Action members in groups such as the International Research Group on Wood Protection will help to further ongoing performance studies which in turn will be adopted by standardisation committees.</td>
<td>Scientific / Technological, Economic, Societal</td>
<td>Foreseen 2-5 years</td>
</tr>
</tbody>
</table>
Dissemination and exploitation of Action results

Dissemination and exploitation approach of the Action

The Action’s dissemination and exploitation approach as well as all activities undertaken to ensure dissemination and exploitation of Action results and the outcomes of these activities are described below.

The outcomes of the Action will continue to be maintained on the Action website, with more information added in line with new publications, future meetings of interest etc. In addition, the Action members, and in particular the Steering Committee will continue to promote the activities undertaken to generate ongoing and new interest from ECIs starting their postgraduate studies.

Dissemination meetings funded by the Action

The Action did not fund any Dissemination Meetings

Other dissemination activities

The Action also undertook the following dissemination activities.

<table>
<thead>
<tr>
<th>Activity</th>
<th>To help promote the activities of COST FP1303, the Action Chair attended the wood Science and Engineering Conference in Edinburgh in 2014. WSE is a northern European initiative funded by the SNS Nordic Research Council. It is aimed at all aspects of wood technology across Scandinavia, Baltic countries, Poland, North Germany, Northern UK and Russia and provides researchers, and in particular Early Career Investigators the chance to participate in an annual conference and present their work. The Action Chair the concept of COST and outlined three ongoing Actions (COST FP1205, COST FP1303 and COST FP1404) and how these Actions could benefit students / ECIs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Young scientists from northern European conference, with particular emphasis on those from ITC countries (Latvia, Lithuania, Estonia, Poland).</td>
</tr>
<tr>
<td>Outcome</td>
<td>Increased interest from ITC participants in future activities within the Action, with several ECIs attending meetings and training schools. Towards the end of the Action, seven ITC grants were given to ECIs to assist in their presentation at conferences (namely WSE 2017 conference in Copenhagen and IPPS 2017 conference in Llandudno, UK).</td>
</tr>
</tbody>
</table>

Exploitation activities

The Action undertook the following activities to ensure exploitation (use, in particular in a commercial context) of the Action’s achievements.

<table>
<thead>
<tr>
<th>Activity</th>
<th>One of the projects undertaken during COST FP1303 has helped increase sales of a high quality window system. The Wintherwax project, which linked Slovenia SMEs with research groups in Sweden, Germany and Spain, has helped provide performance data for the window systems, which in turn has helped marketing of products.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Technical presentations at FP1303 meetings and IRG have targeted researchers and industry contacts, whilst a range of non-technical presentations have promoted the performance of the windows to the general public.</td>
</tr>
<tr>
<td>Outcome</td>
<td>A successful product on the market and increasing sales.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Promotion of the Action through conferences such as ECWM, IPPS and WSE. Introductory presentations help people better understand the aims and goals of the Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>Young researchers and new contacts, particularly from industry (e.g. with high number of companies taking part at IPPS conference)</td>
</tr>
<tr>
<td>Outcome</td>
<td>Increased awareness and more participants wishing to take part in future events</td>
</tr>
</tbody>
</table>
Action Success(es)

The Action’s two most significant successes were the following:

- Collaboration of members in compiling the Action state of the art book "Performance of Biobased Building Materials", comprising 67 authors. Published through Woodhead Publishing (part of Elsevier group). Within this book, chapter 10 emphasised the work of members of the Action who have been actively promoting biobased building materials within CEN committees and standardisation.

- The development of an active group investigating biobased building materials across Europe. This is evident from the 260+ persons that have taken part in the Action activities over the 4 years. These activities have allowed active participation in a large number of students and Early Career Investigators that have taken part in the 4 Training Schools, undertaken STSMs and the several applicants to ITC grants for researchers from inclusiveness countries. This is in addition to the high number of presentations made by younger researchers during meetings over 4 years.
## Action Expenditure

The table below shows the budget allocated to the Action for each Grant Period.

<table>
<thead>
<tr>
<th>#</th>
<th>Grant Period</th>
<th>Start Date</th>
<th>End Date</th>
<th>Budget allocated to Action (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FP1303-20131031</td>
<td>1-11-2013</td>
<td>30-11-2014</td>
<td>165,174.00 (EUR)</td>
</tr>
<tr>
<td>2</td>
<td>CGA-FP1303-2</td>
<td>2-12-2014</td>
<td>30-9-2015</td>
<td>91,097.48 (EUR)</td>
</tr>
<tr>
<td>3</td>
<td>CGA-FP1303-2B</td>
<td>1-10-2015</td>
<td>30-4-2016</td>
<td>129,542.27 (EUR)</td>
</tr>
<tr>
<td>4</td>
<td>AGA-FP1303-4</td>
<td>1-5-2016</td>
<td>31-7-2016</td>
<td>2,415.00 (EUR)</td>
</tr>
<tr>
<td>5</td>
<td>AGA-FP1303-5</td>
<td>1-8-2016</td>
<td>30-4-2017</td>
<td>138,575.00 (EUR)</td>
</tr>
<tr>
<td>6</td>
<td>AGA-FP1303-6</td>
<td>1-5-2017</td>
<td>21-10-2017</td>
<td>80,000.01 (EUR)</td>
</tr>
</tbody>
</table>