**PPS-jaarrapportage 2017**
De PPS-en die van start zijn gegaan onder aansturing van de topsectoren dienen jaarlijks te rapporteren over de inhoudelijke en financiële voortgang. Voor de inhoudelijke voortgang dient dit format gebruikt te worden. Voor PPS-en die in 2017 zijn afgerond is een apart format "PPS-eindrapportage" beschikbaar.
**De jaarrapportages worden integraal gepubliceerd op de websites van de TKI's/ topsector. Zorg er svp voor dat er geen vertrouwelijke zaken in de rapportage staat.**

| **Algemene gegevens** | |
|---|---|
| PPS-nummer | KV1604-037 |
| Titel | PPS Smart Materials |
| Thema | Energie & CO2 |
| Uitvoerende kennisinstelling(en) | WUR, Stichting Wageningen Research |
| Projectleider onderzoek (naam + emailadres) | Silke Hemming, silke.hemming@wur.nl |
| Penvoerder (namens private partijen) | Marcel van Haren, Vereniging FME-CWM |
| Contactpersoon overheid | Leo Oprel |
| Werkelijke startdatum | 1/1/2017 |
| Werkelijke einddatum | 31/12/2020 |

**Korte omschrijving inhoud/doel PPS**
Wat is er aan de hand? Wat doet het project daaraan?
Wat levert het project op? Wat is het effect hiervan?

The **demand for vegetables and fruits worldwide is increasing**. Vegetables and fruits for fresh consumptions are produced in protected cultivation. With increasing affluence, the area of protected cultivation in the world is increasing, leading to increased demand for fresh, high-quality vegetables, without chemical residues. Protected cultivation in greenhouses makes this possible by capturing the sun's energy to raise inside temperature. Several properties of the cover materials contribute to crop productivity, quality and even the content of healthy compounds. The amount of sun radiation entering the greenhouse determines its temperature; light in the PAR wavelength range drives photosynthesis, the fundamental motor of crop production; the wavelength composition of light has a "signalling effect" on crop development and on the content of nutraceuticals of food products and the geometrical distribution of light affects crop productivity. In addition, the properties of the cover (and additional screen) material(s) determine the energy that is lost at night, requiring replacement by heating.

There is a great need and a huge potential for the development and application of **"smart" or "adaptable"** cover **materials** that would make it possible to control the quantity, spectral composition and geometrical distribution of solar radiation entering the greenhouse. Next to light and temperature, a smart control of the growth factors $CO_2$ and humidity is very important to optimize crop production and nutritional food products. New selective membranes and other "smart" or "adaptable" materials are needed so that a microclimate and light environment is generated that maximizes food production and desired quality aspects and containing healthy components, while minimizing/nullifying the need for fossil energy. This program will benefit from a two pronged approach: the adaptation of existing knowledge and materials to solve horticultural challenges, but also new higher-risk/higher-reward research to solve these challenges.

The **long-term goal** is that new greenhouse production systems will utilize sunlight in a very efficient way since they will be covered with smart or adaptable materials. Solar light at any climate zone in the world will be converted into a form (quantity, quality, geometrical distribution) exactly needed by the crop to produce fresh products with high yield, good taste and high in healthy components. All growth factors (light, temperature, $CO_2$, humidity) will be controlled by smart or adaptable materials in order to reach a minimum input of resources during food production (energy, $CO_2$, water).

In this program we focus as well on **fundamental research** for new smart material development as **on industrial research** of modification of existing materials and implementing adapted materials in greenhouse production systems. Short-term product screening and testing is combined with mid-term material adaptation and long-term fundamental new smart material development.

The program is a **cross over of TKI TU and HTSM** (High-tech 2 Feed the World) and offers a unique collaboration of horticultural supply industry with high-tech industry, as well as a unique collaboration between academic researchers in the areas of horticulture and chemistry to design new greenhouse production concepts with smart materials for the horticultural industry that could be applied on a huge scale.

The Dutch horticultural sector will profit from knowledge brought in from the international high-tech industry and will benefit from the knowledge and new products developed in this program. At the same time the visibility of the Dutch greenhouse horticulture as a high-tech production sector is directly enlarged.

**Highlights: geef een korte beschrijving van de belangrijkste resultaten tot nu toe**

During the various workshops and meeting the results of projectpartners were presented. A study was presented by WUR exploring the opportunities of smart greenhouse covering materials with switchable filters allowing for the instantaneous modification of relevant optical properties of the cover. Greenhouse simulation models have been modified and used in the study to explore the potential effect on microclimate, use of resources and crop growth and development. Until recently, the only possibility to modify the amount and quality of the light reaching the crop in a greenhouse was the use of temporary coatings (i.e. whitewash) or screens/netting (fixed or mobile, internal or external). Nowadays and in the near future, new filters are being developed that allow for almost instantaneous change of relevant optical properties directly in the cover where the filter is added. This allows an optimization of the amount and quality of the light entering the greenhouse instantaneous induced by different triggers and can be applied for different crops and regions in the world. Different switchable filters were compared in the study, different climate regions and greenhouse types were analysed to analyse the potentials of smart materials compared with existing solutions.

Next to that, first switchable materials have been produced by TU/e. Materials were either switchable on an electric voltage or on temperature change. Again, a very creative brainstorm session has been held with the group resulting in new ideas and solutions for smart materials for greenhouses. This lead until now to two scientific publications.

During the first year many existing materials have been screened by WUR in the laboratory and several new materials are currently under development by company partners for horticultural application. Topics for material development are e.g. light transmittance, light diffusion, high insulation with new technologies, new polymers, new insect and shading netting technologies, heat reflection, humidity control by foils, membranes and coatings, materials with switchable properties triggered by temperature or electrical. Application fields are greenhouse systems world-wide depending on the innovation. Targeting crops are high-value food crops and ornamental. Networking of different partners plays an important role in the project.
First ideas for co-creation have already been developed between partners. Growers might expect new ways of controlling the crop environment in the future.

**Aantal opgeleverde producten in 2017** (geef in een bijlage de titels en/of omschrijving van de producten of een link naar de producten op openbare websites)

| Wetenschappelijke artikelen | Rapporten | Artikelen in vakbladen | Inleidingen/ workshops |
|---|---|---|---|
| 2 | 2 (not yet public) | 0 | 1 website<br>3 nieuwsitems<br>5 workshops/meetings |

**Bijlage: Titels van producten en links naar informatie op openbare websites (w.o. Kennisonline)**

Website:
www.ppssmartmaterials.nl

Nieuwsitems:
https://www.wur.nl/nl/project/TU-16029-Ht2ftw-Smart-materials-for-greenhouses.htm
https://www.fme.nl/nl/nieuws/smart-materials-greenhouses-0
https://www.dutchfoodsystems.nl/kick-off-van-het-pps-project-smart-materials-for-greenhouses/2992/

KennisOnline:
https://www.wur.nl/nl/Onderzoek-Resultaten/Topsectoren/Topsector-Tuinbouw-uitgangsmaterialen/Voedselveiligheid/TU-16029-Ht2ftw-Smart-materials-for-greenhouses.htm

Wetenschappelijke publicaties:

- Sol, J.A.H.P., Timmermans, G.H., Van Breugel, A., Schenning, A.P.H.J. & Debije, M.G. (2017). Multistate luminescent solar concentrator 'smart' windows. *Advanced Energy Materials*, 1702922.
- Sol, J.A.H.P., Dehm, V., Hecht, R., Würthner, F., Schenning, A.P.H.J. & Debije, M.G. (2017). Temperature-responsive luminescent solar concentrators: tuning energy transfer in a liquid crystalline matrix. *Angewandte Chemie - International Edition.* DOI: 10.1002/anie.201710487