DROP-IT

DELIVERABLE 6.5

Exploitation Plan

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EXECUTIVE SUMMARY

The deliverable D6.5 Exploitation Plan of the H2020 FET-Open project DROP-IT (GA 862656) is reported here as part of WP6, the work package related to Management, dissemination and exploitation of developed technology. The exploitation actions in DROP-IT aim to communicate and approach project results to key industrial stakeholders and technological companies.

The present exploitation plan is an elaboration of preliminary actions suggested at the time of DROP-IT application (see Part B of the Grant Agreement, page 11). The execution of this plan will be monitored and reported (eventually updated) along the project duration. The plan was planned on month 12 and a final report will be delivered on month 36.

The following actions will be pursued for the protection and exploitation of results:

(1) Intellectual Property Rights (IPR). The Coordinator and the Steering Board of DROP-IT will regularly have meetings and discussions about the project progress and will determine whether some actions regarding IPR need to be taken to protect generated results, eventually with the help of screening services at the partner's institution. Patents can be submitted initially at national level and along the following year can address the Patent Cooperation Treaty (PCT) for international protection (150 countries). The chemistry of some demonstrated utility of **lead-free perovskite materials** and/or **nano-ink developments** are expected to be patentable, as also the **architecture and inkjet fabrication procedures** of individual devices (**solar cells, LEDs, photonic devices**). In this sense, several materials will be developed within DROP-IT with a more or less specific use for a device and not for the others. We also foresee a high degree of innovation in the use of other device elements, as charge transport layers adapted for inkjet printing.

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(2) Exploitation by academic partners and research centers. The academic partners and research centers of the consortium are UVEG, UB, UJI, ETHZ, INSA and CRI. The protection of knowledge and technology transfer can take place at these institutions using their internal administration services and others recently available in Europe, and eventually creating a spin-off company within different application fields that could include lighting (displays, LEDs, etc.), optical chemosensors and IOT based on integrated photonics, X-ray detectors for medicine imaging, etc. Eventually, Avantama and Saule Technologies can participate in some of these spin-off initiatives.

(3) Exploitation by Industrial partner Saule Technologies and Avantama AG. There are a vast number of applications that would benefit from a low-cost and high-efficiency photovoltaic technology that offers the extra feature of enabling custom design. The successful development of promising LFP materials would potentially unlock a huge target market for Avantama AG and Saule Technologies. Particularly, Avantama can increase its portfolio of electronic/optoelectronic inks containing nanocrystals and Saule can reach a pioneering position in the worldwide commercialization of different kinds of flexible photovoltaic modules working efficiently in low- and indoor lighting conditions, for example to be used as power sources for sensors, smart textiles, telecommunications (for future IoT), etc.

1 INTRODUCTION

The overall objective of DROP-IT is the development of Lead-Free Perovskite (LFP) materials that will overcome two of the most important drawbacks associated to standard (but successful) hybrid organic-inorganic lead halide perovskites: (i) the presence of Pb as hazardous element and (ii) the long-term degradation of devices under ambient conditions.

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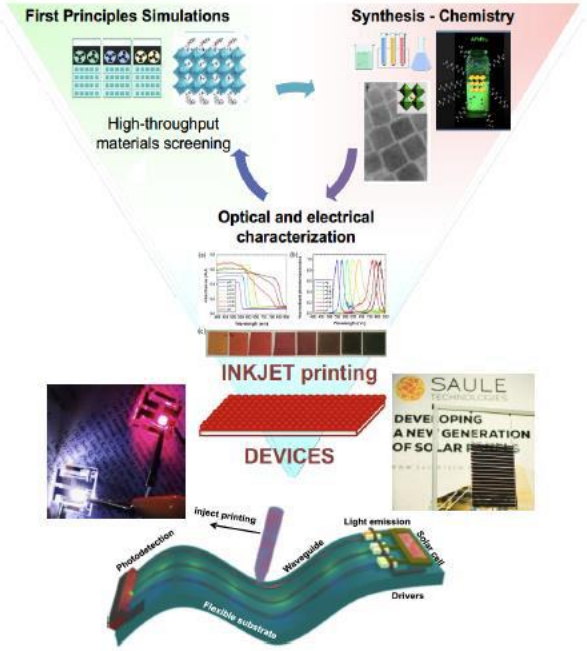

The strategy of DROP-IT to overcome these issues is illustrated in Fig. 1 and comprise four challenges:

1) the synthesis of novel LFPs, previously screened theoretically (see Deliverable D1.1 for present status),

2) formulation of inks,

3) inkjet printing of thin films with the desired functionality on flexible substrates,

4) demonstration of operative optoelectronic and photonic devices, as proofs of concept.

The successful achievement of these four challenges will lead to clear impacts into future market, which is the base for the present exploitation planning along the project duration.

Exploitation indicates the use of project results for (see article 28 of the GA):

(i) research activities beyond those covered by the present action, or
(ii) developing, creating or marketing a product or process, or
(iii) creating and providing a service, or
(iv) standardization activities

In the framework of H2020, it is established the need to strengthen the links between basic research and application, as well as between applied research and industry and SMEs (including spin-off and start-up companies). For this reason, it is important for project consortia to enhance the impact of their research, as far as possible, and to plan activities for exploitation of project results, which is the objective of the present deliverable. Particularly, in the case of DROP-IT, we plan to achieve at least TRL3, because we leave from TRL1 (see definitions of TRL1-2-3 in Table I). Therefore, in the present plan, we should establish the conditions for further advancements regarding directions (i) and (ii) above, given the nature of DROP-IT (points iii and iv are mostly out of this nature).

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Table I: TRLs planned for DROP-IT

TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept

In this way, our Exploitation Plan, as expected for H2020 projects, will provide measures to:

(1) explain (to different audiences) and promote the impact of the project results,

(2) allow/promote the knowledge transfer (related to the project results) to industry/market, and

(3) promote exploitation beyond the project,

On the other side, as stated in Article 28 of the Grant Agreement (GA), each beneficiary in DROP-IT consortium must take measures aiming to ensure the **exploitation** of its results, and it holds up to four years after the finalization of the project. To this regard, the following major aspects should be considered:

1. **Confidentiality** (Article 36 of the GA): each Partner must keep confidential data, documents or other material (in any form) that is identified as confidential for third parties at the time it is disclosed;

2. **Ownership of results** (Article 26 of the GA): the knowledge is owned by the Partners who carried out the work generating such a knowledge;

3. **Protection of results** (Article 27 of the GA): each beneficiary that contributes to the development of a certain knowledge must examine the possibility of patenting its results and shall keep informed the Consortium;

4. **Access rights** [Article 25 and 31]: All partners of the consortium can be granted (royalty-free) to access background knowledge (results/methods/know-how previously developed) and new developments reached along the project duration by the different partners (different of the one asking for access).

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2 PRELIMINARY ANALYSIS FOR DROP-IT'S MARKET

In Photovoltaics (PV), the use of perovskites will target to increase the efficiency and lower the cost of solar energy. However, perovskite solar cell technology (MAINLY BASED ON "LEAD HALIDES") is NOT at advanced stages of commercialization, as compared with other technologies. In the case of lighting devices, (direct bandgap) lead halide perovskites also offer a large variety of materials (including nanocrystals) with emission wavelengths in the visible and with very high quantum yields, which make perovskites suitable for LEDs and photonic applications. In these two big market areas, DROP-IT will contribute by replacing toxic materials (Pb-free) and targeting applications based, but not only, on flexible substrates, which is possible by using the inkjet printing technology.

The PV market is very important and DROP-IT will strongly influence the creation of new markets and will permeate existing ones with technology solutions that will allow a reduction of price and a multiplication of functionalities. One of the new markets with expected strong social and economic demand is flexible-PV with free form factors that will make it possible to convert almost any surface into a solar cell producing energy. In addition, printed flexible solar cells can be integrated with other printed optoelectronic/photonic (OP/PH) components in autonomous systems. OP/PH are fast expanding Key Enabling Technologies (KETs) that provide multiple devices and systems that cover many applications. The market predictions of the OP/PH sector are projected to reach 745 M€ in 2022 with an average growth of about 8.4% per year [1]. Moreover, OP/PH is a sector in which Europe is leading thanks to sensing, fiber, lighting, optics, integrated photonics and other subsectors, as stated by Photonics 21 platform [2]. This is a consequence of the large number of European OP/PH SMEs and their capability of innovation. DROP-IT technology would allow to find new non-toxic materials, develop the appropriate inks for a flexible technology and demonstrate efficient OP/PH devices with this technology, which is expected to impact the subsectors of illumination, signaling, displays, telecom, optical sensors, etc. This market analysis will be updated along the

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project, especially for the deliverable D6.8 at month 36, where the patent portfolio and the report on exploitation activities will be reported. To complete this analysis, it is important to consider here the position and leadership of several key companies in Europe.

1. **Perovskite material providers:**

   1.1. **Valais Perovskite Solar (VPS)** (https://vps-suisse.com) is a Switzerland-based company with a focus on molecular engineering of functional materials for PV and light-emitting applications. The target of the company is to bring an abundant and renewable source of energy using low-cost solar cells.

   1.2. **William Blythe** (https://www.williamblythe.com/home/) is a manufacturer based in UK specialized in inorganic chemicals and advanced materials, covering perovskite metal halide precursor salts (high purity lead iodide and stannous iodide), as well as iodine, Tin, Copper and Tungsten derivatives.

   1.3. Switzerland-based **Avantama AG** (https://avantama.com) is leader in high-tech materials for electronics. Their material innovations are used in optical and electronic coatings for fast proof-of-concepts and focused product developments, which ensures minimizing time-to-market. Their production capacity is at the multi-ton-scale. **Avantama AG** is a partner of DROP-IT.

   1.4. The **Merck Group** (https://www.merckgroup.com/en), branded and commonly known as Merck, is a German multinational science and technology company headquartered in Darmstadt. Among other services, they provide precursor materials for perovskites, as well as transport and blocking layer components for optoelectronic devices.

2. **Perovskite application developers:**

   2.1. **Helio Display Materials** (https://www.heliodisplaymaterials.com) is a UK company that develops materials for a new generation of more efficient and colourful display. It is a joint spin-off company from both Oxford University (Prof. Richard Friend) and the University of Cambridge (Prof. Henry Snaith) that aims to use the superior efficiency (quantum yield, narrow emission spectrum and high absorption) and lower costs of metal halide perovskites. They will be the basis for the next generation of display technology that use significantly less power.

   2.2. **Power Roll** (https://www.powerroll.solar) was established in UK to develop and commercialize its innovative proprietary energy storage (technology of flexible capacitors

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made on microgrooves) and energy generation (technology based on flexible perovskite solar modules) technologies.

2.3. **Oxford PV** company (https://www.oxfordpv.com) was founded in 2010 as a spin-out from the University of Oxford to commercialize a thin-film solar cell technology based in a highly efficient perovskite-on-silicon tandem architecture. It was amongst the first in the world to recognize the potential of perovskites to act as a low-cost, highly efficient solar cell absorber material to convert sunlight into electricity.

2.4. **Evolarab** (https://www.evolarab.se/) is a Sweden-based start-up targeting a rapid commercialization of tandem solar cells incorporating perovskite films thanks to the recent investment by the Norwegian renewables Magnora. Their technology is based on an unique method to mechanically stack perovskite and conventional solar cells to achieve the highest efficiency.

2.4. **Saule Technologies** (https://sauletech.com) is a start-up established in Poland that manufactures transparent perovskite solar cells fabricated on flexible substrates by using the inkjet printing deposition technique. The very recent production line of Saule will allow to supply first perovskite-powered products for the Internet of Things (IoT) and Building Integrated PV (BIPV) market. **Saule Technologies** is a partner of DROP-IT.

3. Industrial R&D players:

3.1. **Solliance** (https://www.solliance.eu/) was established in the Netherlands in 2010, and by now it is a large consortium of R&D and industrial partners, focusing on thin-film photovoltaic development, with a strong presence in perovskite-related R&D.

3.2. The **Fraunhofer Society** (https://www.fraunhofer.de/en.html) is a German research organization with 72 institutes spread throughout Germany, each focusing on different fields of applied science. Among them, Fraunhofer-ISE (https://www.ise.fraunhofer.de/en.html) is working on photovoltaics, Fraunhofer-IOF (https://www.iof.fraunhofer.de/en.html) on applied optics, and Fraunhofer-IIS (https://www.iis.fraunhofer.de/en) on IoT solutions, among many others.

4. Commercial end-users:

4.1. **STMicroelectronics** (https://www.st.com/content/st_com/en.html) is a Swiss-domiciled multinational electronics and semiconductor manufacturer headquartered in Geneva,

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Switzerland. It is commonly called ST, and it is Europe's largest semiconductor chip maker based on revenue. The company is actively developing hardware for IoT applications.

4.2. **Skanska** AB (https://group.skanska.com/) is a multinational construction and development company based in Sweden. Skanska is the fifth largest construction company in the world according to Construction Global magazine. Skanska is collaborating with Saule to develop Building Integrated PV (BIPV) modules based on perovskites.

4.3. **Signify** (https://www.signify.com/global) is a spin-off from Royal Philips, the world leader in connected LED lighting systems, software and services. The company has installed over 71 million connected lighting points, and is exceptionally active in investing into R&D to develop new products and applications.

These companies will be the most important ones that will be targeted by DROP-IT for communication and knowledge transfer, given that lead-halide perovskites are the central materials of their products, directly (group 1 companies above) or indirectly (group 2 companies above), through important applications/devices. Of course, DROP-IT will communicate for a broader audience of European (mainly) end-user big industries (group 3 above) and SMEs, because they can be the basis for establishing specific collaborations and/or joint ventures for developing new products and applications within prospective important markets in next future (BIPV and IoT, for example).

3 PLANNED ACTIONS

COMMUNICATION:

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In our opinion, the main output of a research project should be the transformation of the research objectives into future products that would reach the population. For this long-term goal, DROP-IT is planning here different exploitation actions, together with the correct communication of scientific results achieved along the project duration and their economical and societal impact. Our dissemination plan contemplates all channels and initiatives for the communication or DROP-IT scientific results, hence here we will specify with greater detail only the initiatives to appropriate socio-economical stakeholders and forums (innovation, market, business, policy, …), big industry and SME audiences. See table II for a summary of planned dissemination activities separated by target audience.

Table II. Dissemination tools and the corresponding targeted audiences for DROP-IT

Dissemination tool	**Target Audience**		
	Scientific Community	**Industry - SMEs**	**General Public**
Project Website including News - Achievements of partners within or related to DROP-IT objectives	✓	✓	✓
Leaflet/Brochure of DROP-IT	✓	✓	✓
Scientific Publications	✓	✓	✗
Participation in National/International scientific/technical Conferences, Exhibitions and Industrial fairs	✓	✓	✗
General audience news (press releases, radio-television, newspapers)	✗	✓	✓

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NETWORKING:

In our exploitation plan, the most important target will be the networking with industry and companies interested in our technology (see the most important ones listed in section 2), but it is also important to follow, monitor and contact the most important Related EU projects in the field of ours in order to look for future possible collaborations and/or synergies.

Particularly, we have identified three research projects leaving from higher TRL (all three were funded within the Low-Carbon Energy call 2016-17) as compared to DROP-IT:

- **PERTPV** (Perovskite Thin-film Photovoltaics, https://pertpv.web.ox.ac.uk/project) is a H2020 European project running until 31th March 2021. This project aims to advance the (lead halide) perovskite thin-film PV technology on both performance (efficiency and stability) and the development of scalable device and module fabrication methodologies, compatible with high volume manufacturing. This consortium has the ambitious target of reaching an efficiency as high as 30 % in a thin-film all-perovskite tandem solar cell architecture.

- **ESPResSo** (Efficient Structures and Processes for Reliable Perovskite-Solar Modules, https://www.espresso-h2020.eu/index.php) is a H2020 European project running until 31th March 2021. This project aims to reach solar cell efficiencies of more than 24% (on 1cm²) and less than 10% degradation in cell efficiency, on the basis of slot-die coating of lead halide perovskites. This project also envisions the integration of modules in building with a levelised cost of electricity (LCoE) of $\leq$ 0.05€/kWh. In this project it is involved as partner SAULE Technologies, hence we can have a very close contact along the duration of DROP-IT.

- **APOLO** (SmArt Designed Full Printed Flexible RObust Efficient Organic HaLide PerOvskite solar cells, https://project-apolo.eu/project/) is the H2020 European project closest to DROP-IT, which will be running until 31th March 2022. This project contemplates the printing of solar cell modules using flexible substrates, as in DROP-IT, based on **lead** halide perovskites, and their integration into buildings (BIPV-target).

- Other than these three projects, it is also interesting to follow some other initiatives, as the European Training Network **MAESTRO** (https://maestro-itn.eu), and the achievements of some individual researchers/groups through their ERC projects as: **PINNACLE** (Perovskite Nanocrystal-Nanoreactors for Enhanced Light Emission), **SHINING** (Stable and High-

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Efficiency Perovskite Light-Emitting Diodes), **HYPERION** (HYbrid PERovskites for Next GeneratION Solar Cells and Lighting), **NANOSOLID** (Chemically Engineered Nanocrystal Solids) and **NO-LIMIT** (Boosting Photovoltaic Performance by the Synergistic Interaction of Halide Perovskites and Semiconductor Quantum Dots). The last two projects are led by Profs. Maksym Kovalenko and Iván Mora-Seró, both participating in our consortium.

USE OF SPECIFIC COMMUNICATION PLATFORMS:

Other than the above listed (Table I) communication activities, it will be also important to take account of the services offered from EC (for the coordinator, but also for any of the partners):

1. https://www.fet2rin.com

Supporting FET Projects to reach out Investors and make a larger Impact on Society.

2. https://fetbriefing.eu

Supporting FET/EIC Pathfinder projects in identifying innovation opportunities and accessing respective markets.

WHITE PAPER:

An interesting activity to be developed along the project, as complementary for the market approach and analysis made above, will be the cost estimation of devices developed in DROP-IT, in the line of the very nice studies made in Refs. 3 and 4. The materials, the technology basis of devices and applications, together with a cost estimation and market study, will be written as a white paper for next future exploitation of the materials and optoelectronic/photonic devices implemented in DROP-IT.

LEAFLET AND PROJECT SHORT VIDEO:

For month 18 we had proposed, as milestone MS8, a 4-pages leaflet and a video. The leaflet will be prepared and printed for distribution in certain conferences/meetings and uploaded as images to the web page of the project, eventually downloadable in pdf. The 3-4 minutes Layman's Guide video (and longer version, probably) will be prepared for uploading to our YouTube channel and linked in the web page of the project. Both kinds

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of materials will present the project objectives, the introduction of the partners involved, a summary of the technology and the most relevant results attained until month 18. The video will be produced by a professional filmmaker to make it sufficiently sound.

DROP-IT WORKSHOP:

A workshop will be organized by DROP-IT for month 30 (Milestone MS14), related to lead-free perovskites for optoelectronic (solar cells, photodetectors, LEDs) and photonic (lasers, optical amplifiers, modulators two-photon generation, …) devices fabricated by inkjet printing and other techniques. The workshop will be announced in the web page of the project, in conferences where researchers of the consortium will participate and mailing to selected researchers (from the consortiums in H2020 and ERC projects listed above, mainly).

4 KNOWLEDGE TRANSFER AND INTELECTUAL PROPERTY RIGTHS

We expect that the exploitation plan and strategy of DROP-IT will be continuously updated with time along the project duration, following the steps:

- definition of target groups for the generated knowledge (see companies listed in section 2 and others not working with perovskites that will be identified along the project duration);
- definition of generated IP/knowledge;
- identification of the needs by the target groups;
- validation and feedback by the target groups;
- funding schemes, other application areas, collaboration with other projects, commercialization through start-ups.

INTELLECTUAL PROPERTY RIGHTS (IPR):

The management of IPR is specifically regulated in the Consortium Agreement (CA) of DROP-IT (Section 8), where each partner of the project has also reported their

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particular background knowledge (see Attachment 1 of the CA). The CA includes all aspects of IPR: ownership, protection and publication, access rights to knowledge and pre-existing know-how, as well as confidentiality, liability and dispute settlement. Every outcome of the project is owned by the partner that has generated it, and hence, this partner can use and license the access right to the other contributors without royalty compensation. In the case that several partners had participated in the generation of the results/outcome, they should agree how obtaining the relevant access right and reach appropriate agreements.

The CA also rules the transfer of results (Section 8.3). Each partner may transfer ownership of its own outcome following the procedures of the Grant Agreement Article 30. Each partner may identify specific third parties it intends to transfer the ownership of its outcome. The other Signatory Parties hereby waive their right to prior notice and their right to object a transfer to listed third parties according to the Grant Agreement Article 30.1. The transferring partner shall, however, at the time of the transfer, inform the other partners of such transfer and shall ensure that the rights of the other partners will not be affected by such transfer.

DROP-IT results described in many of the deliverables are expected to generate significant intellectual property to be exploited by the SMEs in our consortium. The responsible of these particular deliverables and ultimately the steering committee of DROP-IT will monitor and identify sensitive data worthy to being protected, and/or propose to the partner/s the preparation of appropriate IP protection.

In month 36 we will prepare a report (deliverable D6.8) including the patent portfolio and exploitation activities (at least those proposed in section 3) developed until the end of the project, even if more activities will be developed thereafter. This deliverable will be the measure of the effectiveness of the present exploitation plan and the impact of results achieved within DROP-IT, as the basis for further exploitation efforts (new projects to reach higher TRLs and market approaches).

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It is also interesting to take account of the recently launched service: Intellectual Property Booster or IP Booster (http://ipbooster.meta-group.com), which is a new specialized professional IP service for public research organizations that are looking to valorize their research results/outcomes. The experts from IP Booster will examine the application and guide the researcher towards the best intellectual property strategy, at no cost and fully supported by the European Commission. The call is continuously open and assessments of applications will be carried out at regular intervals.

5 CONCLUSIONS

DROP-IT has the appropriate plan for the efficient communication and exploitation of the results obtained along project and a good understanding of the ecosystem that could benefit from it.

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6 REFERENCES:

[1] See http://www.optech-consulting.com/html/photonicsreports.html

[2] See www.photonics21.org

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