11/03/2016

Project Overview:

Interfaces of Fluid Electrodes: New Conceptual Explorations

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*This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under **grant agreement No** **608621**.*

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Outline

- General information
- Motivation
- Project objectives and scientific approach
- WP structure and relation between WPs
- Main challenges, Go-No Go criteria
- Expected impact

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General information

- The FP7-project **InFluENCE** started on September 1, 2013
- The contract has a duration of **36 months**
- Grant agreement no.: 608621
- Total budget: ca. 3.3 M€; EC funding: ca. €2.6 M€

- Programme: FP7-Cooperation (collaborative project)
- Theme: ENERGY
- Subprogramme: ENERGY.2013.7.3.3 – Understanding interfaces in rechargeable batteries and super-capacitors through *in situ* methods.

- Call : FP7-ENERGY-2013-1

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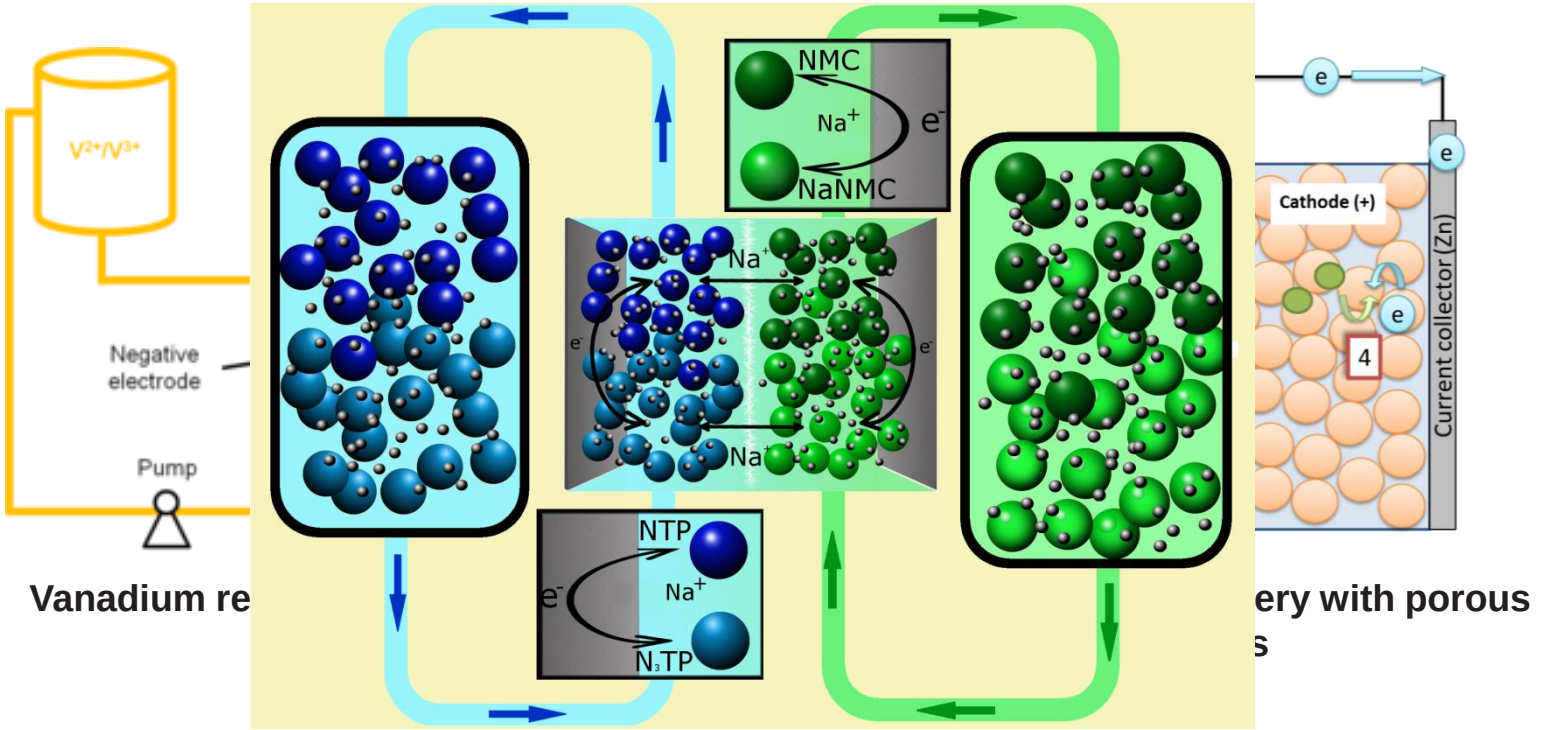
Semi Solid Flow Batteries (SSFB)

Energy conversion and storage system, "hybrid" between an aqueous redox flow battery and a solid state Li-ion or Na-ion battery



Vanadium re **ery with porous s**

- SSFB vs aq RFB: energy densities ca.10 times higher
- SSFB vs Li-ion: decoupling power and energy

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Why SSFBs?

Large scale applications:

- Storage of excess energy from the grid → key contribution to low-carbon economy
- Continuous power supplies, balancing the grid.
- power and energy are decoupled → safety and reliability

Highly relevant in the framework of EU energy policy and SET plan:

- Increasing share of energy from RES
- Multiple power sources, wind, solar, hydro…
- Next-generation storage systems: adaptation to offer/demand (on-peak & off-peak kWh cost)

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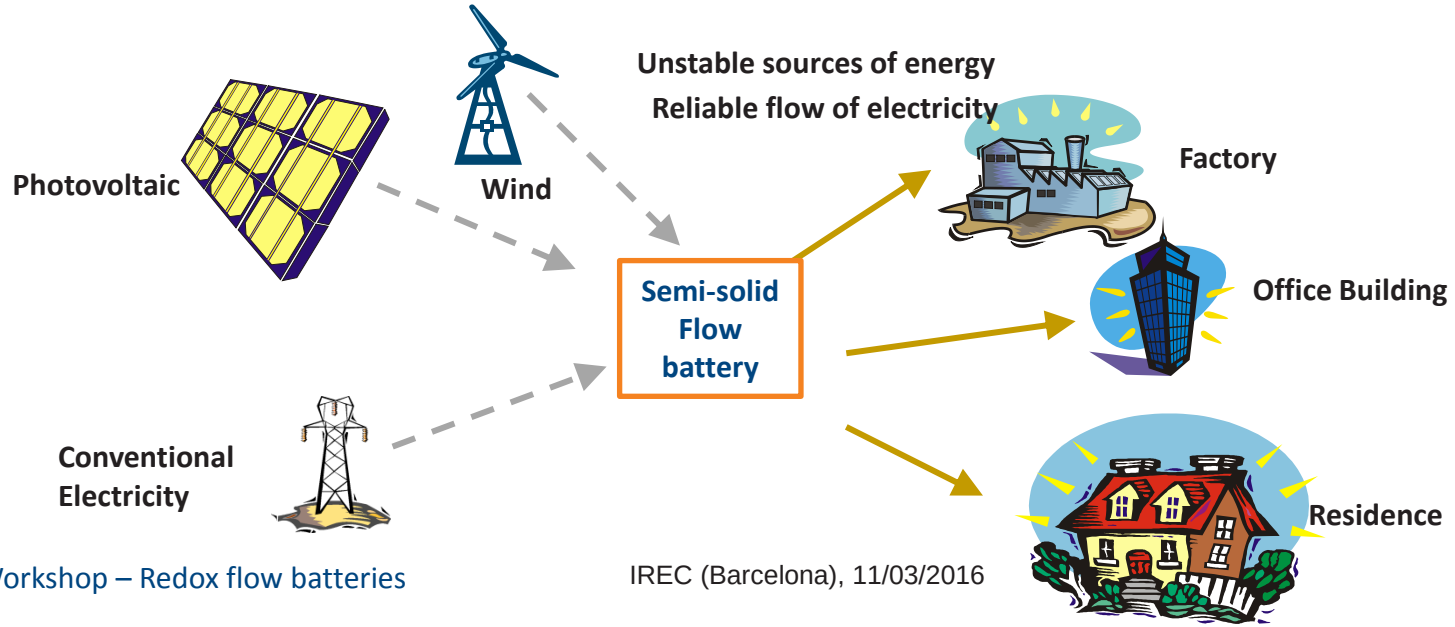
Why SSFBs?

Advantages of SSFBs versus conventional batteries:

- Possible to adjust the chemistry of the system during its operative life by adding the necessary chemical into the electrode flow.
- Potential for prolonging the operative life of the battery system.
- Simple (in-situ) measurements of conductivity, viscosity and density might supply crucial information to monitor the state of health of the system.



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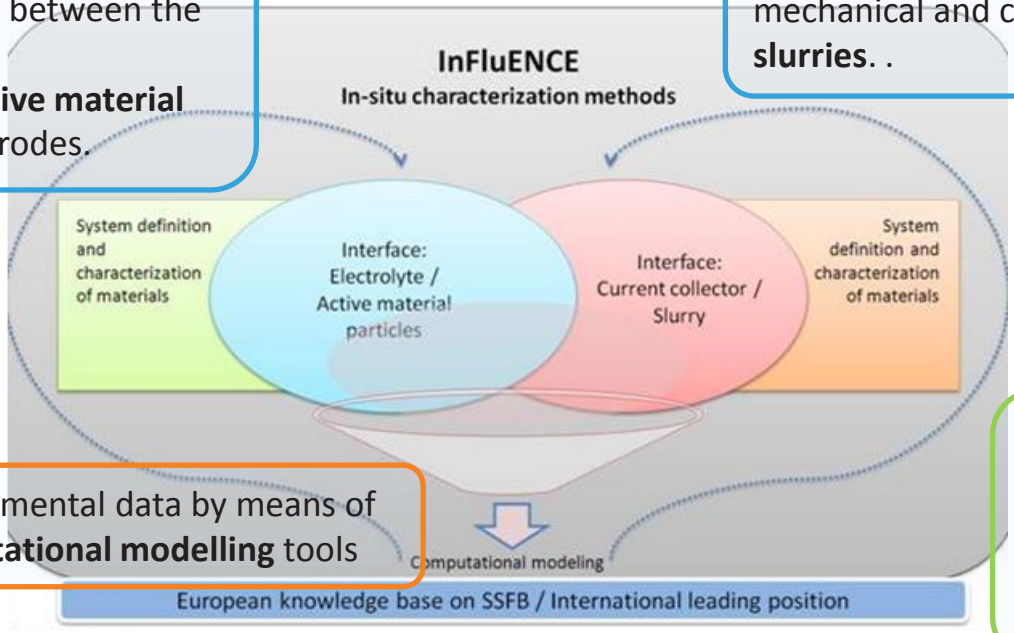
Project objectives

GOAL: Improve fundamental understanding and control of interfaces in **semi- solid flow batteries** (SSFB) based on Li-ion and Na-ion active materials

→ methods and techniques developed could also be implemented for conventional Li- and Na-ion systems

to investigate and optimize of **interfaces** developing between the **electrolyte** and the **electrochemically active material** particles in fluid electrodes.

to improve **understanding** and **control** the mechanical and conductive **behaviours** of the **slurries**. .



to complement experimental data by means of implementing **computational modelling** tools

to establish and maintain active exchange of information with research groups from third countries

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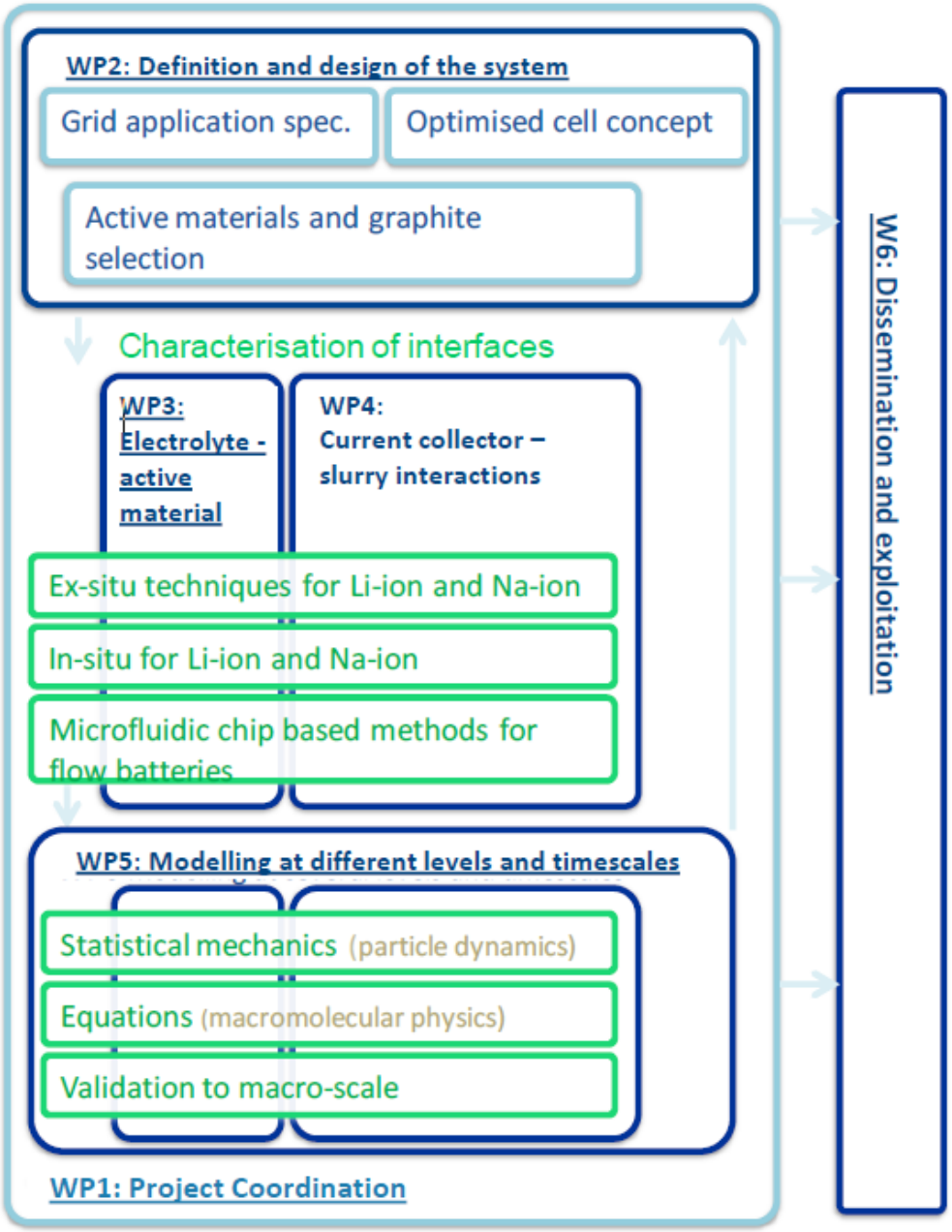
Approach



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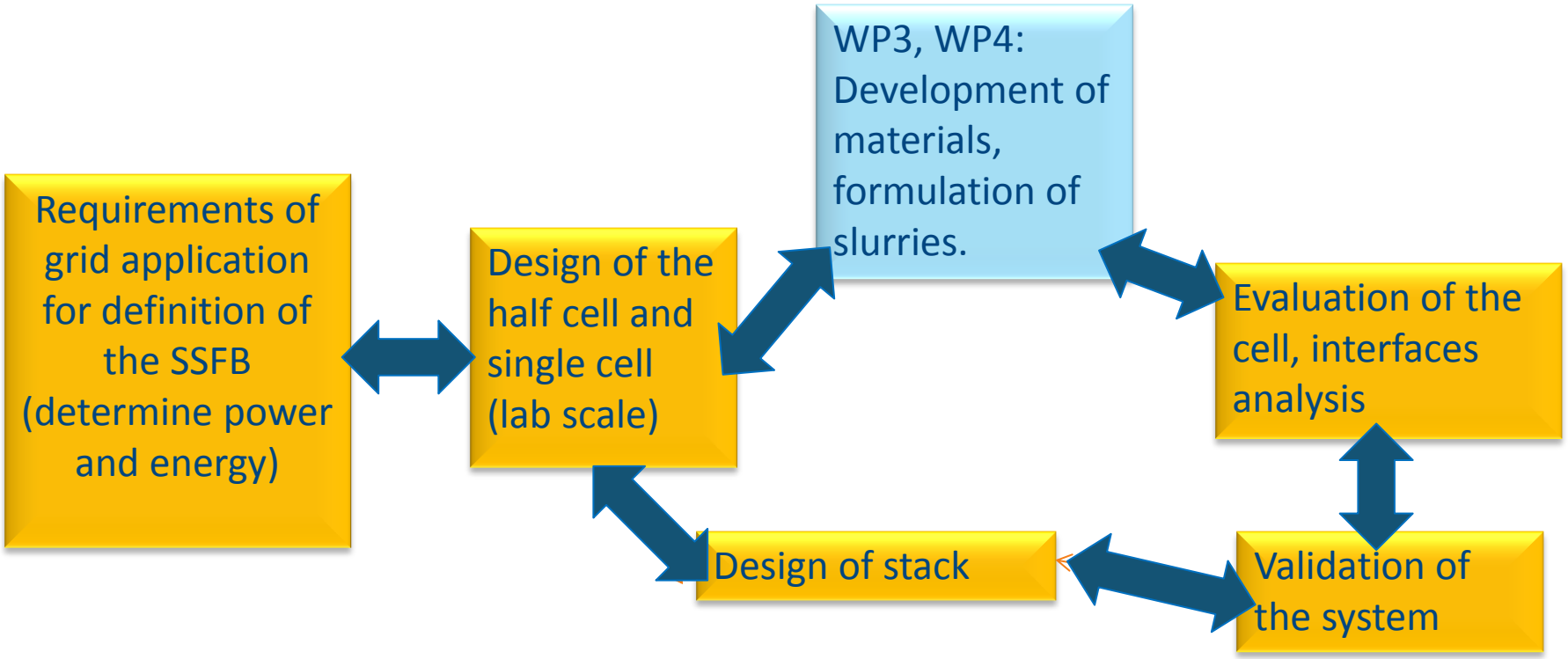
WP2: definition and design of the system



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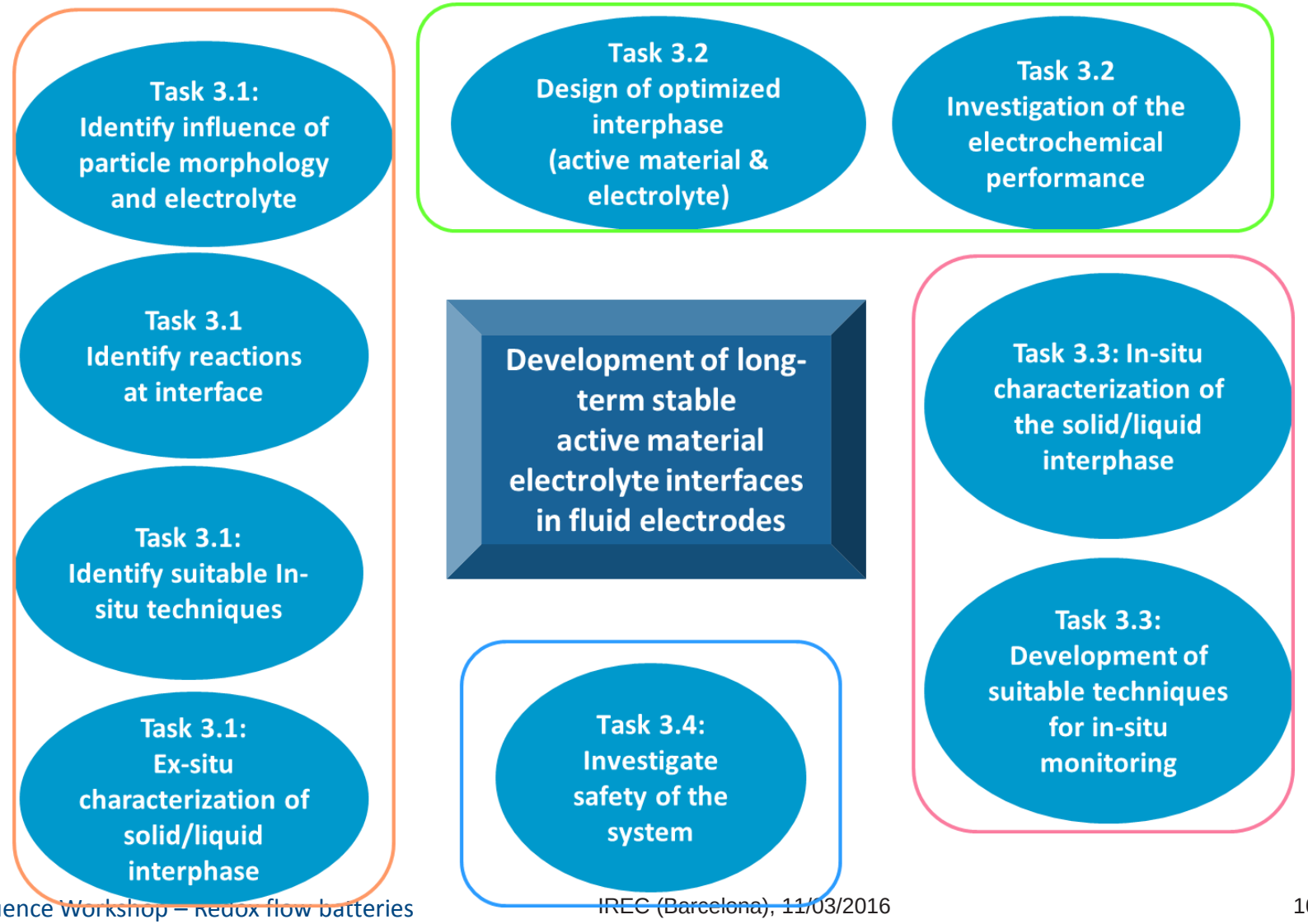
WP3: Interface Electrolyte / Active Particles



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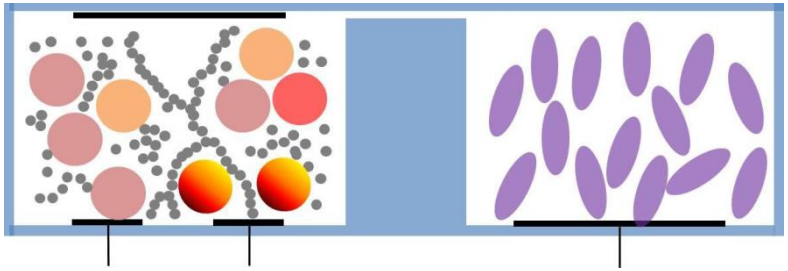
WP4: Interface current collector/slurry

- **high density** of Electro-Active Particles, **but still 'flowable'** electrodes
- additional **condutive network of nanoparticles**
- **cell walls** influence charge-transfer and suspension-flow
- **changes in morphology, surface chemistry** due to electrochemical cycling



Pre-investigate formulations

- Investigate particle interactions → key parameters for stable slurries

Ex-situ

- Study electric percolation in microfluidic chips
- Study flow behaviour

In-situ (electrochemistry in chip)

- Determine influence of electrochemical cycling
- Investigate diffusion effects

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WP5: Modelling the processes

molecular level

- Interface using MPCD and LB methods
- Rheology and colloidal stability of suspensions using MPCD
- Transport in membrane and electrolyte by EC techniques
- Electron transfer by electrochemical (EC) techniques

cell scale

- cell in static conditions with COMSOL
- cell in dynamic conditions: coupling of kinetics and hydrodynamics
- tentative optimisation by electrochemical engineering methodology

overall process scale

- Battery design
- Simulation of battery performance (capacity, current, power, voltage, time of discharge, lifetime, etc.) in "real conditions"
- Influence of thermal behaviour
- Energetic performance of the overall system

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Consortium

Participant no.	Participant legal Name	Country	Organisation type*
1 (Coordinator)	Flemish Institute for Technological Research (VITO)	Belgium	RTD
2	Karlsruhe Institute of Technology	Germany	RTD
3	Universiteit Twente	The Netherlands	RTD
4	IREC	Spain	RTD
5	Eckart	Germany	LE
6	Solvionic	France	SME
7	6T-MIC	France	SME
8	Imperial College London	United Kingdom	RTD

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Consortium: partner roles

- **VITO:** Coordinator. Expertise in batteries, battery testing and system integration for smart grids. Experience in electrochemical modelling and in characterisation of cell components.

- **KIT** (prev. WWUM): Expertise in synthesis and characterization of Na-ion and Li-ion materials. Expertise in the investigation and optimization of the interfaces and interfaces between active materials and electrolytes, and full cells (batteries). WPL for WP3. TL in WP2. Partner in tasks for WP2, WP4 and WP6.

- **U Twente:** Expertise in colloids, rheology and microfluidics. Equipment and experience in microscopy (AFM and CSLM), rheometry, contact angle goniometry, microchip fabrication

- **IREC:** Expertise and skills in electrochemical characterization of battery components. Experience in redox flow batteries..

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Consortium: partner roles

- **ECKART:** Expertise in metal particles and interface analysis of non-spherical particles.
- **Solvionic:** Expertise in ionic liquids .
- **6TMIC:** Expertise in computational modelling and electrochemical engineering.
- **Imperial College:** Expertise in molecular modelling.

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Scientific output

Title, d.o.i.	Author(s)	Title of the journal	Vol./Issue	Date of publication	Pages	Open access ?
Water sensitivity of layered P2/P3-Na; 10.1039/C4TA02627F	Daniel Buchholz , Luciana Gomes Chagas , Christoph Vaalma , Liming Wu , Stefano Passerini	Journal of Materials Chemistry A	2/33	06/2014	13415-13421	
Unfolding the Mechanism of Sodium Insertion in Anatase TiO; 10.1002/aenm.201401142	Liming Wu , Dominic Bresser , Daniel Buchholz , Guinevere Giffin , Claudia Ramirez Castro , Anders Ochel , Stefano Passerini	Advanced Energy Materials	5	08/2014	1401142-1401153	
P-type Na x Ni 0.22 Co 0.11 Mn 0.66 O 2 materials: linking synthesis with structure and electrochemical performance; 10.1039/C4TA03946G	L. G. Chagas , D. Buchholz , C. Vaalma , L. Wu , S. Passerini	Journal of Materials Chemistry A	2/I47	10/2014	20263-20270	Yes
Non-aqueous semi-solid flow battery based on Na-ion chemistry. P2-type Na; 10.1039/C4CC09597A	Edgar Ventosa , Daniel Buchholz , Stefan Klink , Cristina Flox , Luciana Gomes Chagas , Christoph Vaalma , Wolfgang Schuhmann , Stefano Passerini , Joan Ramon Morante	Chemical Communications	51	12/2014	7298-7301	Yes
Nanocrystalline TiO2(B) as Anode Material for Sodium-Ion Batteries; 10.1149/2.0091502jes	L. Wu , D. Bresser , D. Buchholz , S. Passerini	Journal of the Electrochemical Society	162/2	01/2015	A3052-A3058	Yes

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Scientific output

Title, d.o.i.	Author(s)	Title of the journal	Vol./Issue	Date of publication	Pages	Open access ?
Electron Bottleneck in the Charge/Discharge Mechanism of Lithium Titanates for Batteries; 10.1002/cssc.201500349	Edgar Ventosa , Marcel Skoumal , Francisco Javier Vazquez , Cristina Flox , Jordi Arbiol , Joan Ramon Morante	ChemSusChem	8/10	04/2015	1737–1744	Yes
Charge inversion and colloidal stability of carbon black in battery electrolyte solutions;	Yan Zhang , Aditya Narayanan , Frieder Mugele , Martien A. Cohen Stuart , Michel H.G. Duits	Colloids and Surfaces A: Physicochemical and Engineering Aspects	489	08/2015	461–468	No
Solid electrolyte interphase in semi-solid flow batteries: a wolf in sheep's clothing; 10.1039/C5CC04767F	E. Ventosa , G. Zampardi , C. Flox , F. La Mantia , W. Schuhmann , J. R. Morante	Chemical Communications	Vol. 51/Issue 81	10/2015	14973-14976	Yes
Extraordinary Performance of Carbon-Coated Anatase TiO 2 as Sodium-Ion Anode; 10.1002/aenm.201501489	Muhammad Nawaz Tahir , Bernd Oschmann , Daniel Buchholz , Xinwei Dou , Ingo Lieberwirth , Martin Panthöfer , Wolfgang Tremel , Rudolf Zentel , Stefano Passerini	Advanced Energy Materials	n/a-n/a	12/2015	n/a-n/a	Yes
Layered Na-Ion Cathodes with Outstanding Performance Resulting from the Synergetic Effect of Mixed P- and O-Type Phases; 10.1002/aenm.201501555	Marlou Keller , Daniel Buchholz , Stefano Passerini	Advanced Energy Materials	n/a-n/a	11/2015	n/a-n/a	Yes

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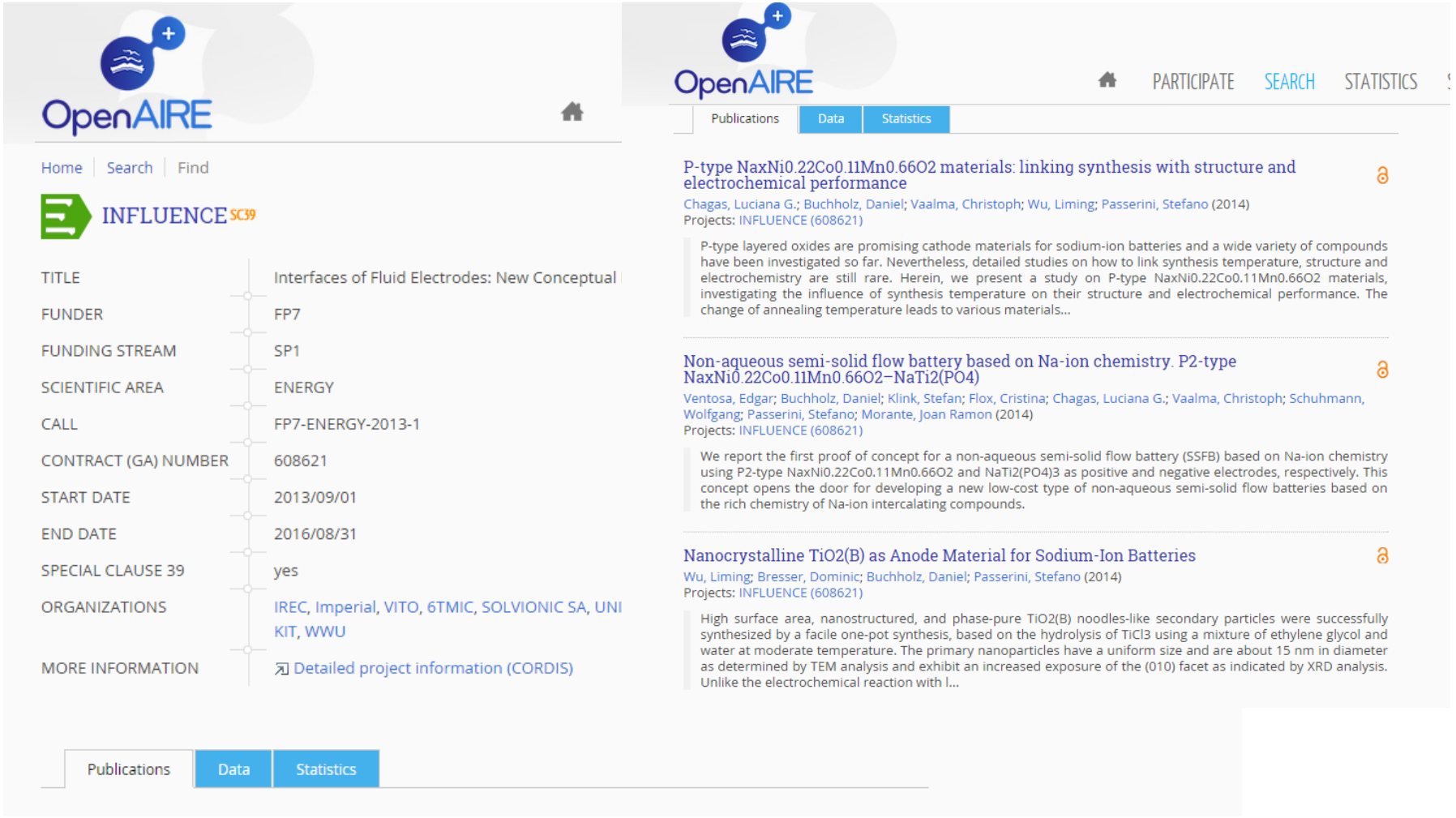
Scientific output – open access



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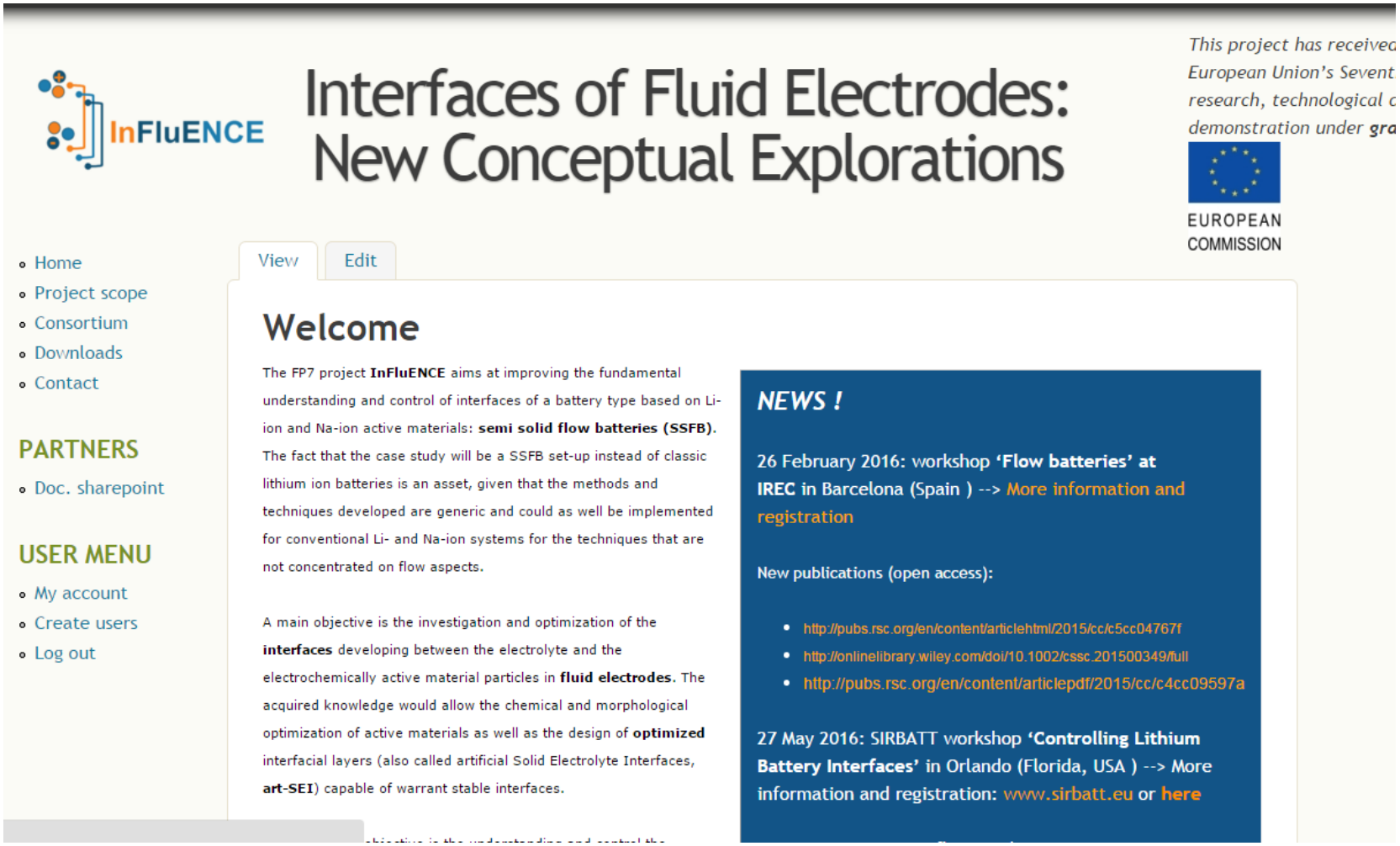
Project website: www.fp7-influence.eu



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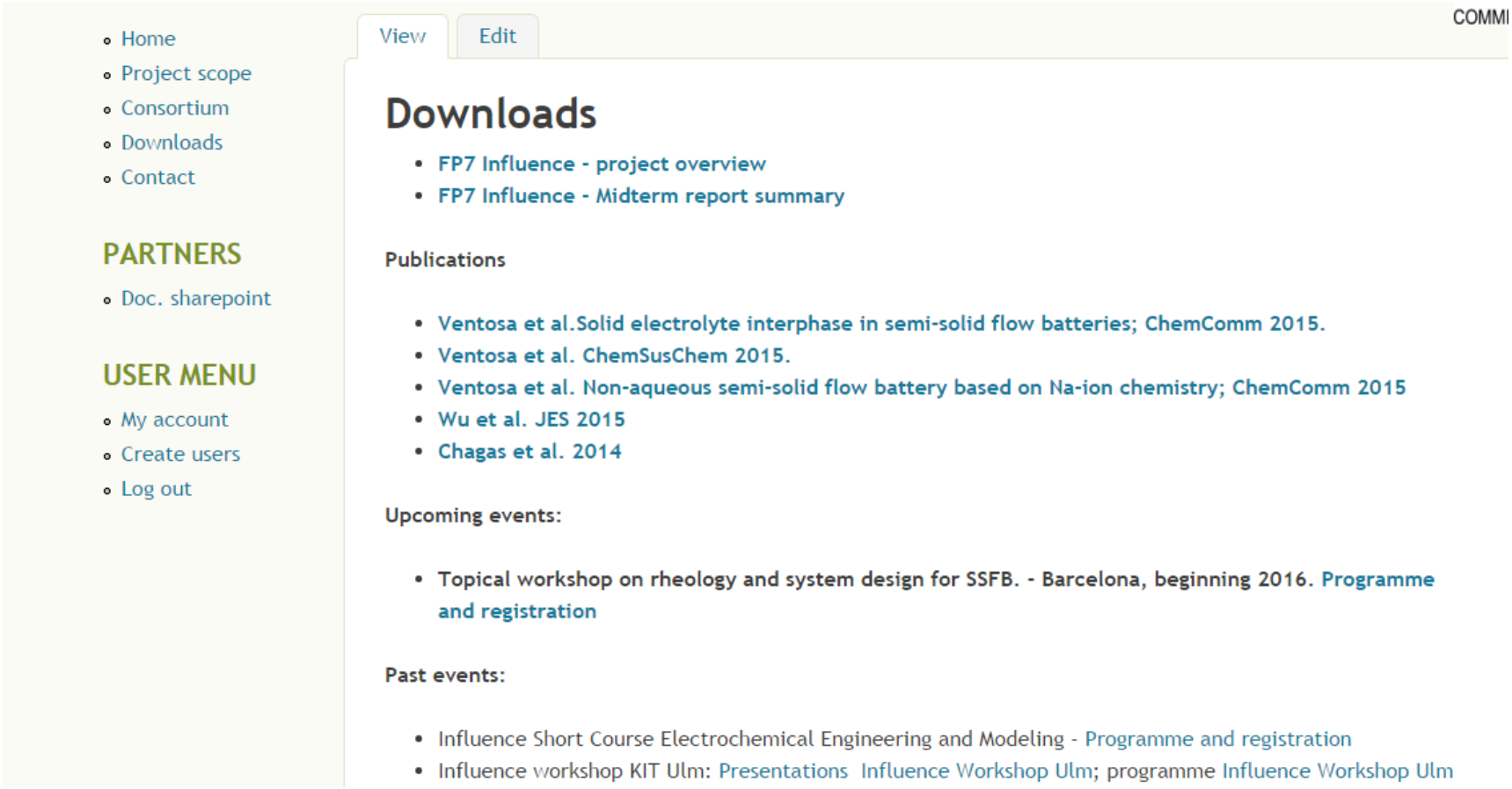

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Downloads

- FP7 Influence - project overview
- FP7 Influence - Midterm report summary

Publications

- Ventosa et al.Solid electrolyte interphase in semi-solid flow batteries; ChemComm 2015.
- Ventosa et al. ChemSusChem 2015.
- Ventosa et al. Non-aqueous semi-solid flow battery based on Na-ion chemistry; ChemComm 2015
- Wu et al. JES 2015
- Chagas et al. 2014

Upcoming events:

- Topical workshop on rheology and system design for SSFB. - Barcelona, beginning 2016. Programme and registration

Past events:

- Influence Short Course Electrochemical Engineering and Modeling - Programme and registration
- Influence workshop KIT Ulm: Presentations Influence Workshop Ulm; programme Influence Workshop Ulm

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Thank you!

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