WG4
Spent fuel dissolution and chemistry in a high-level waste container

Lena Zetterström Evins

Agenda Tuesday 3rd November

WG 4 Spent fuel dissolution & chemistry in container		
03-Nov		Title
14:00	INTRO JA Leader: SKB (L.Z. Evins, J. Andersson)	Waste form and behaviour: Dissolution and chemistry in a high-level waste container
14:15	Studsvik (Olivia Roth)	Leaching of doped irradiated fuel under H2 conditions
14:35	JRC-ITU (Detlef Wegen)	Dissolution rate of MOX and Cr-doped UO2 fuel
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15:40	***COFFEE BREAK***	
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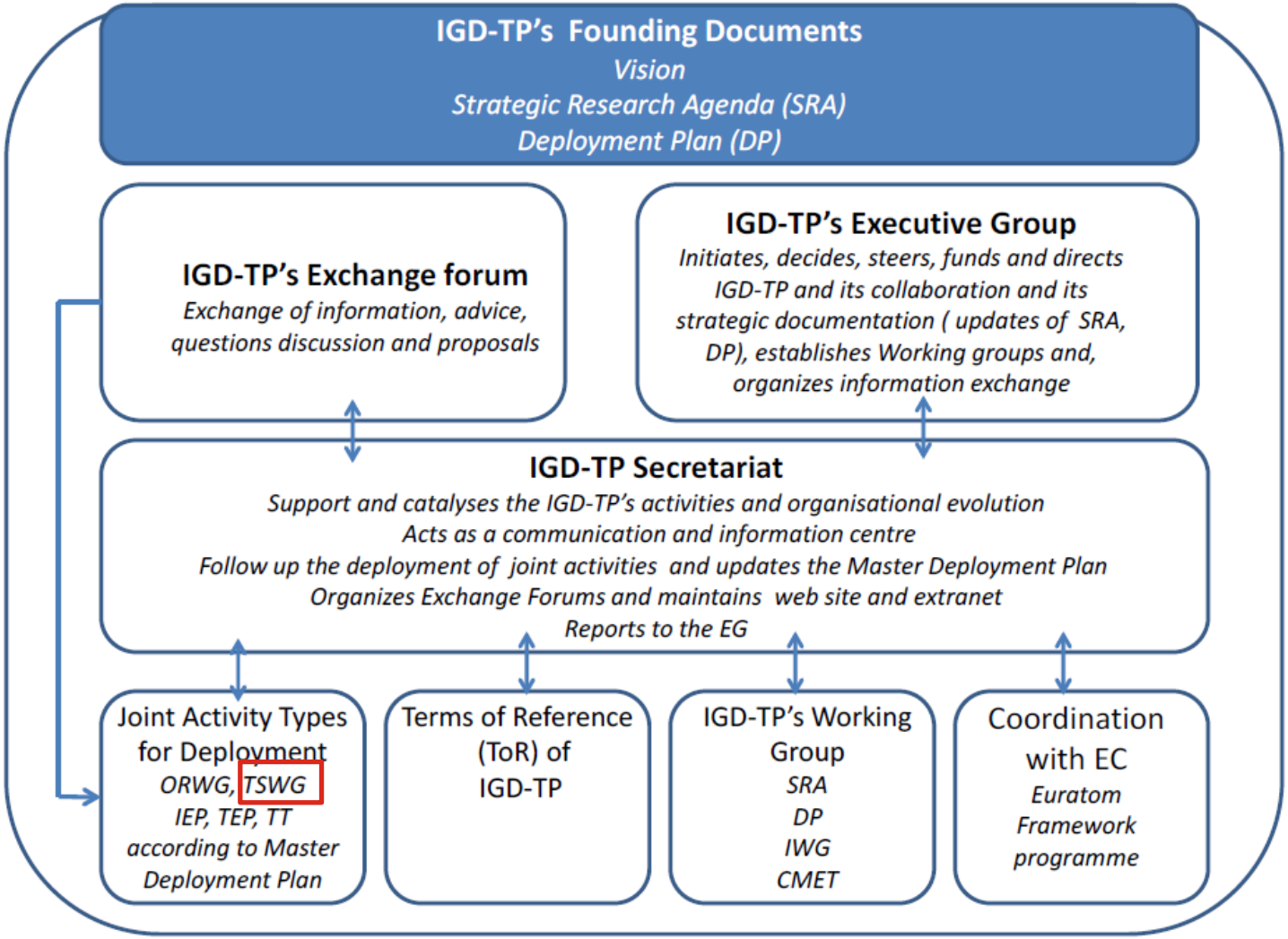
16:20	VTT (Kaija Ollila, E. Myllykylä)	UO2 interactions inside canister conditions
16:30	FZ Jülich (Dirk Bosbach)	Corrosion mechanisms of modern LWR-fuels using UO_2-based model systems
16:40	ANDRA (Christelle Martin)	Andra proposal for a future European project dealing with geochemical processes within a HLW/Spent fuel disposal cell
17:00	General Discussion (All)	
17:30	END day 1	

TSWG Technical & Scientific WG



IGD-TP SRA:
Strategic Research Agenda

3.2 Key Topic 2: Waste forms and their behaviour

3.2.1 Definition, scope and rationale

Definition – This Key Topic deals in particular with understanding the behaviour of various wastes in geological repositories. The waste types include spent uranium oxide (UO_2) and mixed oxide (MOX) fuels, vitrified high level waste and long-lived intermediate level wastes. The various waste types represent the potential source terms for release of radionuclides after the waste canisters are breached.

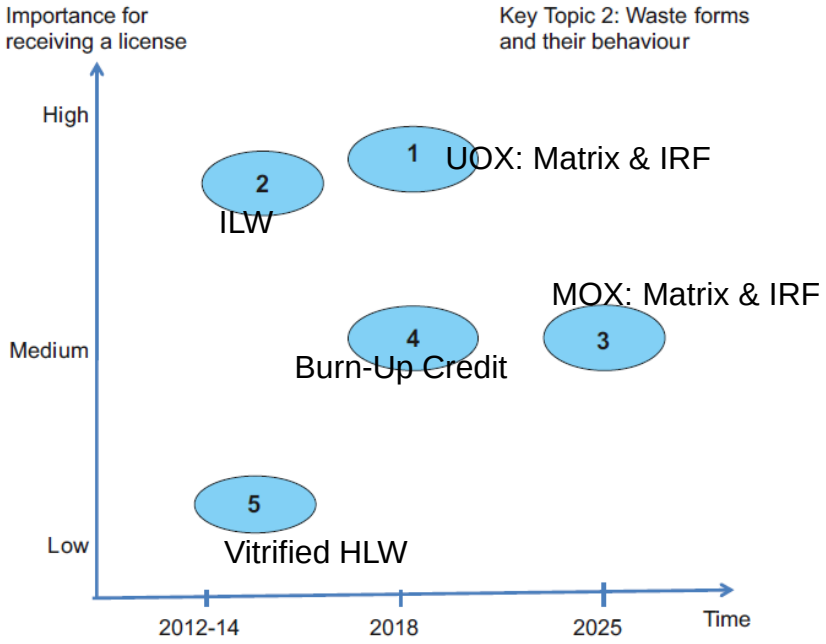
Objectives – The purpose of work is to understand safety-relevant processes, in particular the contribution of the waste form to radionuclide retention in the repository. It is important to define the total inventory of various radionuclides and their time-dependent release in mathematical models in order to assess radionuclide release from a repository.

Rationale and benefits – The studies will better quantify the processes controlling radionuclide, chemicals and gas release from waste forms, thus contributing to the quality of models used in safety assessment and adequately defining the types and magnitudes of uncertainties associated with various processes. It is expected that, because experimental facilities and specialised equipment for work with highly radioactive materials are available in only a few countries, benefits for other countries could become available through use of these facilities in such studies under international co-operation arrangements. All knowledge related to each of the waste forms is gathered in specific files for each waste form. WMOs that are at an earlier stage of implementation in their programmes would benefit through participating at the appropriate stage and having access to information from the studies performed.

Setting the stage

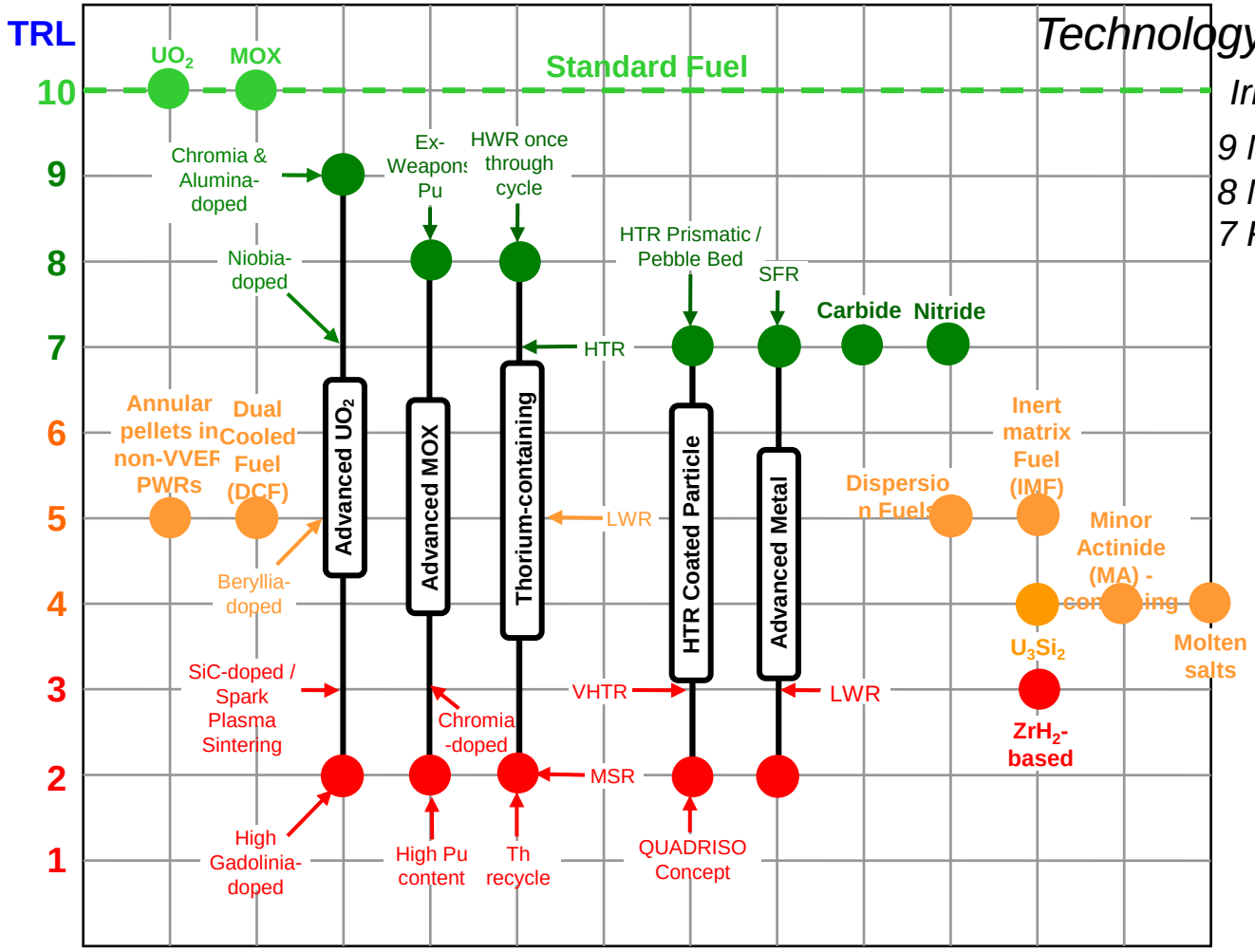
This introduction aims to highlight the needs identified in IGD-TP SRA, Euratom call as well as from research groups.

- Improved understanding of behaviour of the expected waste form in expected repository conditions.
- Test dissolution rate of the waste form in direct relation to expected chemistry inside a corroding waste container.



Expected fuel evolution in Sweden (pers. comm. Vattenfall 2011):
2011: doped pellets in one reactor
2016: doped pellets in 50% of reactors
2021: doped pellets in all reactors
NB: doped pellets, made by different manufacturers do not have uniform properties

Fuel evolution (Nugenia, 2014)



David Hambley, NNL, EF5 2014: Technology Readiness Level /

Irradiation Performance Maturity

9 Multiple assemblies/core loads
8 Multiple assemblies/core loads
7 Few assemblies

Availability of doped fuel pellets for dissolution experiments?

Licensing facilities for existing SNF as well as future SNF, but so far based on standard fuel data…
Requirements to formulate clear waste acceptance criteria

Spent Fuel Workshop 2014*

Some issues highlighted from ITU summary

- https://ec.europa.eu/jrc/en/page/scientific-outcome-spent-fuel-workshop-2014-karlsruhe
- the consensus to **move from leaching of spent fuel in oxidising to reducing conditions** as these are more representative for conditions
- a relatively **small number of modelling attempts** to describe the spent fuel corrosion mechanism
- to **identify critical operational fuel characteristics** controlling the radionuclide release.
- **include spent (U,Pu)O_2 fuels and spent fuels with additives such as Cr or Al in the future experimental programmes**.
- Single-parameter experiment using **SIMFUEL** should be applied complementary

** Next SFW in Stockholm 3-4 May 2016! I will soon send more info…*

Background to this WG

From presentation by Johan A to IGD-TP EG, Spring 2015

- SRA Key Topic:
  - "Waste forms and their behaviour"
- Overarching goal:
  - improve understanding of fuel behaviour in realistic repository conditions
  - Handle development of modern fuel characteristics
- Specific goal – activities
  - Effect of dopants (Cr, Al, Si…) on matrix dissolution rate.
    - In First-Nuclides ADOPT fuel was studied for the Rapidly released fraction of the inventory. We also need data for the matrix dissolution and IRF for a wider range of fuels.
  - Influence of real groundwater chemistry inside waste package on matrix dissolution rate.
    - critique from reviewer of **Saferock**: "But a real "coupling" should take into account realistic time and space scales, and a pertinent description of the nearfield, with all its components, which is not the case. Degraded canisters and overpacks or engineered barriers will play an important role, as most RN, and especially actinides and highly charged fission product cations will react in the "degraded" nearfield."
      [interpreted as, in short] "*water chemistry inside waste container will depend on natural groundwater buffering with degradation products*"
  - "SIMFUEL" experiments: varying age and burnup,

Euratom Work Programme 2016-2017

This action will address key R&I issues in view of the construction and operation in the EU of the first DGRs, notably with respect to validating data and performance. The focus should be on topics of high priority and European added value that were raised in safety reviews and identified in the SRA of IGD-TP. These concern notably the disposal of **new and unconventional fuels**, the validation of the properties of engineered barrier materials and the confirmation of the integrated performance of engineered barrier systems. A further goal is to identify the aspects of these first EU DGR projects that could be amenable to the transfer of knowledge and technology to other countries or regions with less mature programmes, and therefore the action should also involve a mechanism of communicating results to these countries in the most effective way. The Commission considers that proposals requesting a contribution from Euratom of between EUR 2 and 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts. Proposals for topics NFRP 6 to 8 will be ranked in a single ranking list.

Time line according to EG Guidelines

Guidelines for selecting proposals

Purpose: limit the risk of unnecessary effort and rejection of proposals.

- At EG18, November 5, 2015
  Each coordinator asking for official support should provide to the EG a summary of the proposal for information
  (1 page/partner/indicative budget). *Is this doable? At least overall project budget…*
  A first selection of projects according the SRA priorities

- In EG19, February 24-25, 2016
  Each coordinator should submit two page project description and the estimated required budget,
  After presentation by an EG members of the final scope, participants and budget of the proposals, the formal decision for supporting or not supporting a project should be taken by EG.
- After EG19, March 2016
  The formal letters for IGD-TP support will be sent to the proposals' coordinators.
- October 2016
  Submission of the proposals.

Purpose and challenge of this meeting

Send required summary to EG 5th November!

Bulk of this discussion tomorrow morning. We should aim for:

- Defining the working group in terms of participating organisations
- Preliminary structure: work packages, background and motivation based on today's presentations
- List of beneficiaries, estimation of contribution in Person months
- List tasks connected to other direct costs
- Attach a very preliminary budget to each participant considering the 2-4 million Euro target.

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Wednesday 4th November- Discussion

Working group /participating organisations …

Coordinator: SKB - any thoughts/comments?

Research performed by …
Studsvik, JRC-ITU, KIT-INE, PSI, Univ Cambrige, VTT, FZ Jülich, Andra *(?), CEA(?), CTM (?), Ciemat(?), Amphos 21(?), SCK*CEN (?)*
- *see next slide*

End-User Group, WMO organisations:
SKB, Posiva (?), Nagra, NDA/RWM, Andra, Enresa, *Nirond/Ondraf(?)*

=Sweden, Finland, Switzerland, UK, France, Spain, Germany, *Belgium(?)*

Other countries?? Hungary, Czech Republic, Netherlands?
*No response from Rawra (Cz), RHK (Hu) nor Covra (NL)

Participation – some notes

French Involvement: Andra particpate in End User Group rather than in Work packages?

CEA (Christophe Jégou): “with our partner EDF. It seems agreed that we participate in the project. Nevertheless we have not converged to date on the content of our participation. We are both involved on studies around the IRF of MOX fuel and the spent fuel matrix behavior under environmental conditions (container, corrosion products, argilite…). We will get back to you shortly to specify our contribution.”

German involvement: KIT-INE performs experiments, who in EUG?

Spanish Involvement, Enresa (Miguel C) ”our spent nuclear fuel research groups at Ciemat and at CTM (in collaboration with ITU in Germany) are interested”

- CTM (Albert Martinez):
  “perform matrix dissolution studies and also some IRF studies on high burn-up UO2, doped fuels and MOX fuels. …possible experiments at ITU or in a cold lab using analogues at CTM, or also modelling part of the experimental data coming from the project.” “we agree on most of the topics that ITU will propose”
- Ciemat (Joaquin Cobos): “the possibilities to participate in the new Working Group”
- Amphos21 (Jordi Bruno): help with coordination and dissemination and of course modelling

Finnish involvement: Posiva participation, yes/no ?

Belgian involvement: (SCK*CEN, Karel L) “sent our ideas to KIT”

Wednesday 4th

Name? : **DISCO**: Modern Spent Fuel DISsolution and Chemistry in COntainer

or **DisCERN** :Dissolution and Chemical Environment in Repository Near-Field

(discern = distinguish, percieve, detect, determine, discover …)

or **DiRRECt**: Dissolution of Spent Fuel in Realistic Repository Conditions

Preliminary structure: work packages…

- WP1 Management (pure Coordinator /EC contacts) (SKB?)
- WP2 Research coordination and dissemination (SKB+ *Amphos21?*)
- WP3 Sample preparation and characterisation (model/analogue materials: Jülich, Cambridge, fuel characterisation/irradiation history: Studsvik, JRC-ITU, KIT-INE)
- WP4 Analogue materials experiments (VTT, Cambridge, Jülich,)
- WP5 Fuel leaching experiments (Studsvik, JRC-ITU, KIT-INE, *CEA?, SCK*CEN?*)
- WP6 Modelling of the chemical systems (PSI, ANDRA/other?, *Amphos21?*)

CTM?
Ciemat?

Budget variables to consider

1	2	3	4	5		
Organisation	Main contribution	#PM	4400 /M SUM 1082400	Other Direct Costs	ODC SUM 990000	SUM EUR 2072400
SKB	Management, coordination	12	52800	Travels, conferences, EUG	60000	112800
Studsvik	Hot lab work	18	79200	Lab costs, materials, travels	120000	199200
JRC-ITU	Hot lab work	18	79200	Lab costs, materials, travels	120000	199200
KIT-INE	Hot lab work	18	79200	Lab costs, materials, travels	120000	199200
?CEA	?Hot lab work	18	79200	Lab costs, materials, travels	120000	199200
?CTM	?Lab work/modelling	18	79200	Lab costs, materials, travels	60000	139200
?Ciemat	?Lab work	18	79200	Lab costs, materials, travels	60000	139200
?Amphos21	?Dissemination/ ?modelling	18	79200	Travels + ?	10000	89200
?SCK*CEN	?Hot Lab work	18	79200	Lab costs, materials, travels	120000	199200
Cambridge	Lab work	18	79200	Lab costs, materials, travels	60000	139200
Jülich	Lab work	18	79200	Lab costs, materials, travels	60000	139200
VTT	Lab work	18	79200	Lab costs, materials, travels	60000	139200
PSI	Modelling	18	79200	Travels + ?	10000	89200
?Andra/other	?Modelling	18	79200	Travels + ?	10000	89200

Wednesday 4th

- New project (Disco?) Modern spent fuel DIssolution in degraded COntainer.
- Hypothesis: Modern fuel (advanced fuel and mox) dissolution differs only insignificantly from standard fuel.
- Approach:
  A, Spent fuel leaching of modern fuels: Adopt (Cr&Al), only Cr-doped, and two different MOX. Direct test through comparison with previous results.

WP Leader: TBD Studsvik /KIT, Contributors: Studsvik, KIT, ITU, CTM, SCK*CEN, Rez, CEA, (Hungarian contribution?) Doped fuel or MOX, two participants UO2 to close issues from First Nuclides

Rez res reactor fuels, more info coming. Reducing and oxidating conditions. Characterisation of samples, sample prep: limitations in labs. Try to be similar but difficult. Techniques for solid characerisation, sample size inside or outside of cells, solutions one similar to first nuclides. Bur additional solutions should be discussed.

- B, Effect of doping tested through model systems experiments, including model materials preparation and characterization.
  Test through compare to previous resuts, as well as illumination of important parameters, for a theoretical understanding

WP Leader Cambridge/Julich , Contributors: Julich, Cambridge, Sheffield, VTT, Ciemat
Structure Mox, & instant release, Mattrix release from doped fuel.? Model systems need to connected to

Next meeting of Working Group

Before EG19, February 24-25, 2016 ,
Each coordinator should submit two page project description and the estimated required budget

End of January? SEND doodle and question about 2nd may

And again 2nd of May ? Day before Spent fuel workshop.

WG 4 - Background, motivation

Spent fuel dissolution and chemistry in a high-level waste container
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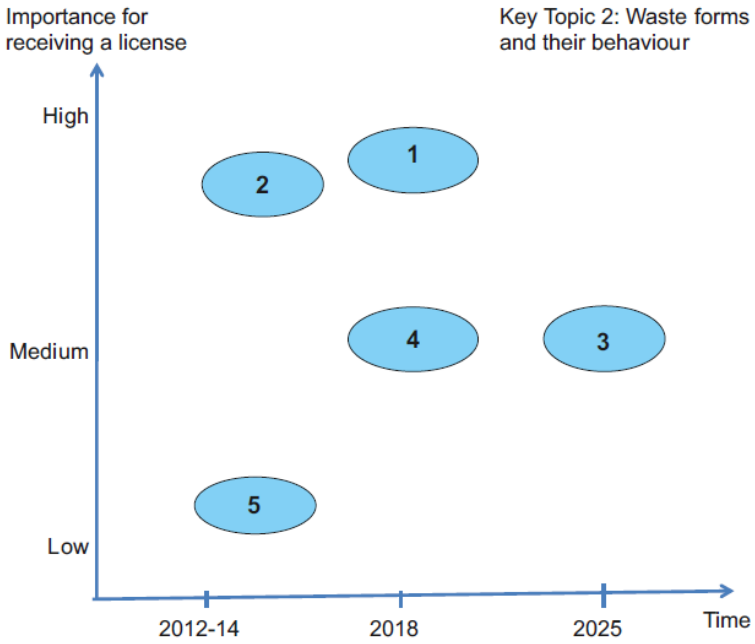

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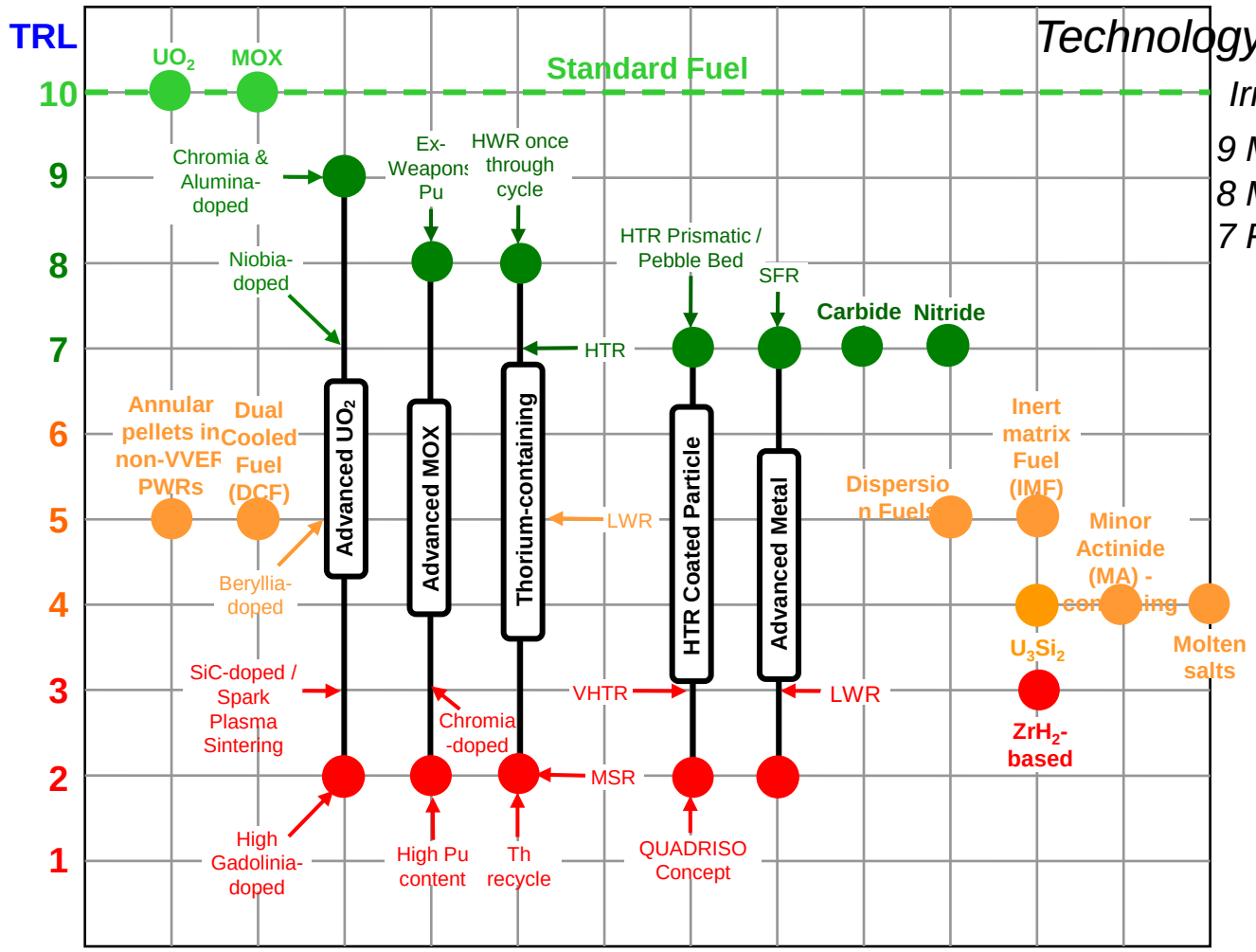
WG 4 – Fuel evolution



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WG 4 - presentations

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WG 4 – Real spent fuel

WG 4 - Model systems

WG 4 – Chemical modelling

WG 4 Summary

DISCO: Modern Spent Fuel DISsolution and Chemistry in Container
Hypothesis: Modern fuel (advanced fuel and mox) dissolution differs only insignificantly from standard fuel.

General Hypothesis: Modern fuel (advanced fuel and mox) dissolution in real repository condiitions differs only insignificantly from standard fuel. (zero-hypothesis)

Motivation: there are knowledge gaps and need for extended data base for the modern fuels and for the chemical system in a degraded HLW waste canister

3-4 year project. Preliminary work package structure

- WP1 Management, Coordination and Dissemination/Knowledge Management
  SKB (Coord) , Amphos21
- WP2 Sample preparation and characterisation of the chemical systems (All)
- WP3 Fuel leaching experiments WP Leader: (Studsvik /KIT-INE)
  Contributors: Studsvik, KIT, ITU, CTM, SCK*CEN, Rez, CEA, (Hungarian contribution?)
- WP4 Model materials experiments WP Leader: (Univ. Cambridge/FZ Jülich), Contributors: FZ Julich, Univ. Cambridge, Univ. Sheffield, VTT, Ciemat
- WP5 Chemical modelling WP Leader Amphos21/PSI, Contributors: Amphos PSI, NNL, Andra, Quintessa