



**Studsvik**



## ***Proposed SMILE scope***

### ***Proposal of Technical Scope for SMILE: Project Schedule and Budget***

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## ***PURPOSE OF PRESENTATION***

- Draft Technical Project Description presented
  - Participating members asked to prioritize among the tasks proposed
  - Feedback requested by the 10<sup>th</sup> of Feb. at the latest



**FINAL version of Project Description – 5 year project**

- Reflecting the priorities of the participating members
- Availability of materials and timing as a prerequisite
- **Now:** Proposal of Scope for 5 year project
  - Includes selected sub-tasks – Task 1 is Fundamental
  - Studsvik example selection based on gap analysis (presented) and availability and timing of materials. Balance PWR/ BWR considered.
  - To be revised based on the feedback obtained in the interest survey – availability of materials as a prerequisite

# MATERIALS FROM BWR

	Component	Material	Tentative harvesting time schedule											
			2019	2020	2021				2022				2023	2024
					Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
Internals	O2	Core shroud plate, vertical & horizontal weld various positions	304/308											
		Steam dryer w. defect	304											
		CRGT upper segment	CASS/304/X-750											
		Nuts	X-750											
	O1	Bracket for surveillance capsule incl. crack	304											
		Bracket with cracks –thermal shield	304											
		CRGT upper part incl. restrictor & weld	304, CASS, X-750											
	Risers for core cooling	316L incl. Weld												
	Bolt for CS/CS-support (low dose)	XM-19, X-750												
RPV & connections	O2	Bottom nozzles	LAS/182/304											
		Safe-end	LAS/182/600											
		Belt line region	LAS/HAZ/Weld											
		Core Shroud support	LAS/182/304											
	O1	Bottom nozzles	LAS/182/304											
		Safe-end	LAS/182/600											
	Belt line region	LAS/HAZ/Weld												
Other component	O2	T joints Mix of hot and cold water	304/Weld/CASS											
		Pipe weld Subjected to MSIP	304											
	O1	T-joints Mix of hot and cold water	304/Weld/CASS											
		Pipe weld Subjected to MSIP	304											

# MATERIALS FROM PWR

Component	Comment	Tentative harvesting time schedule												2024-2027				
		2019	2020		2021				2022				2023					
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3		Q4			
Internals	Baffle plate and bolt (various doses)	304/316 CW																
	Core barrel (various doses)	304/308																
	Flow mixing device	CASS, Irradiated.																
	Fuel alignment pins	304 surf. treatment																
	Upper and lower support	CASS, 2 temp.																
	Guide tube support pins	x-750, 316																
RPV and nozzles	RPV-head penetration	Alloy 690/52/LAS																
	Surveillance specimens	LAS/HAZ/Weld																
	Beltline	LAS, irradiated																
	BMI nozzle	LAS/304																
	Thermal Sleeve (thermal fatigue)	304																
	Hot leg RPV-nozzle	LAS/304																
PRZ	PV, wrought & plate	LAS forging and plate																
	CASS spray head	CASS																
	Heater penetration PRZ	LAS/182/304																
	Lower penetration PRZ	LAS/182/304																
SG	J-groove, repaired drainage nozzle	LAS/Alloy 182/304																
	Steam generator tubes	Alloy 690																
	SG-tube + support plate	Alloy 690, SS																
Primary side	Reactor coolant pump	CASS/weld																
	Pipe T mixing hot/cold	304																
	PWR Top Nozzle of Shield-FA	SS 316/Alloy 718																

# SMILE - SCOPE & PROJECT SCHEDULE

## Task 1 Materials Library

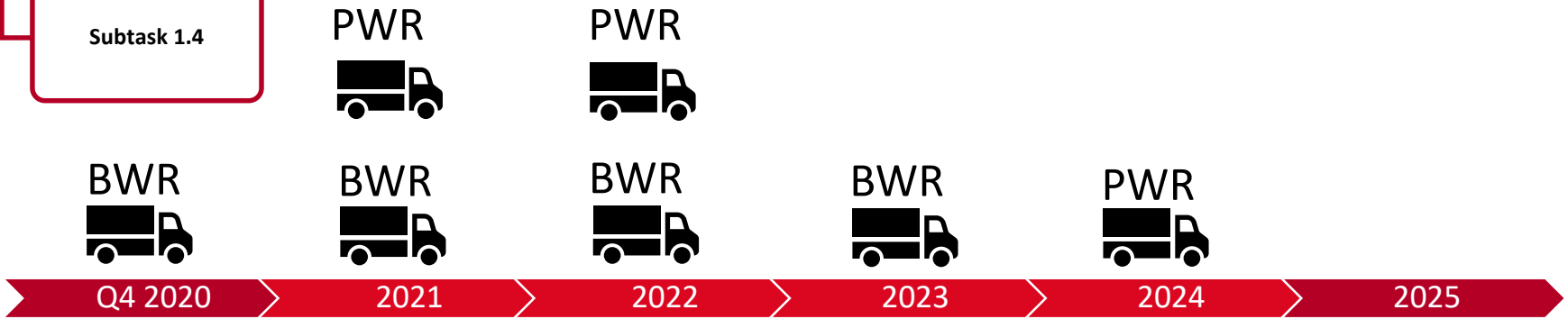
Subtask 1.1  
Acquisition of materials

Subtask 1.2

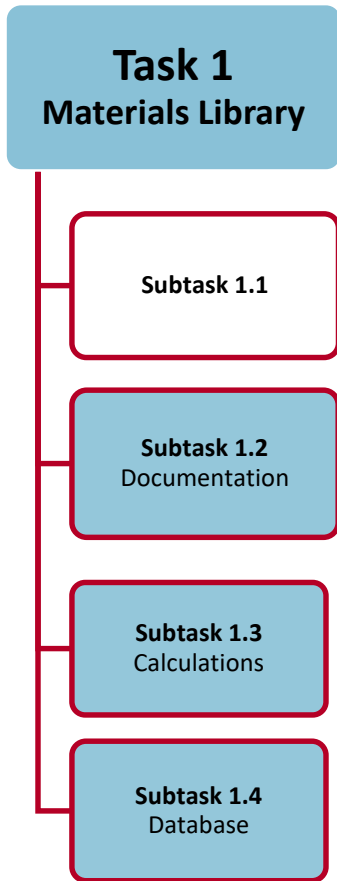
Subtask 1.3

Subtask 1.4

- **Subtask 1.1 – Acquisition of Materials**
  - Establishment of Materials Library
  - Transport/ Storage/ Equipment



# SMILE - SCOPE & PROJECT SCHEDULE



- **Subtask 1.2 – Documentation**
- **Subtask 1.3 – Calculations**
- **Subtask 1.4 – Database**



# SMILE- PROPOSED SCOPE

**Task 2**  
RPV LAS irradiation & thermal embrittlement

**Subtask 2.1**  
Irradiation embrittlement

**Subtask 2.2**

**Subtask 2.3**

**Subtask 2.4**

## • Subtask 2.1 – Irradiation Embrittlement

- Study mechanical behaviour and metallurgical reasons for embrittlement to contribute to development of predictive models
  - Hardness, Charpy, tensile and FT tests on steels & welds
  - Comparison to existing plant evaluations using current extrapolation models
  - Detailed characterization: LOM, SEM, TEM, APT

Material	# of conditions	# of tests or specimens				Characterization
		$\gamma$ -meas.	Tensile	Charpy	FT-test	
A	2	2	4	30	2	Hardness, LOM, SEM, TEM, APT
B	3	2	6	45	3	Hardness, LOM, SEM, TEM, APT
C	3	2	6	30	2	Hardness, LOM, SEM, TEM, APT



O2 RPV  
O1 RPV

R2 RPV

# SMILE- WORK SCOPE

**Task 3**  
SS core support structures and internals

**Subtask 3.1**  
Irradiation embrittlement including SS welds

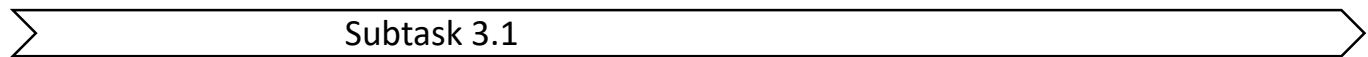
**Subtask 3.2**  
IASCC and corrosion fatigue susceptibility


**Subtask 3.3**  
CASS and weld thermal ageing with irradiation effects

## • Subtask 3.1

- To characterize metallurgical and mechanical properties, including extent of void swelling, if any, of irradiated SS and Ni-base alloys, incl. high-strength
  - Gamma spectroscopy & compare N-doses to calculations
  - Microscopy, H/He & hardness vs. N-dose & irr. temp.
  - Tensile & FT testing as a function of neutron dose, irradiation temp., H-content and reactor type, BWR or PWR

Material	# of conditions	# of tests or specimens							Characterization
		$\gamma$ -meas.	Tensile	FT-test	endurance	Fatigue Res. Stress	H/He-meas.	Density	
<b>A</b>	2	2	4	12	8				Hardness, LOM, SEM, TEM, APT
<b>B</b>	2	2	4	2					Hardness, LOM, SEM, TEM, APT
<b>C</b>	3	2	6	18	20	4			Hardness, LOM, SEM, TEM, APT
<b>D</b>	3	2	6	8			3	3	Hardness, LOM, SEM, TEM, APT
<b>E</b>	2	2	4	2			2		Hardness, LOM, SEM, TEM, APT



**Studsvik** O1 internals  
O2 internals  R2 internals



# SMILE- WORK SCOPE

## Task 3 SS core support structures and internals

**Subtask 3.1**  
Irradiation embrittlement including SS welds

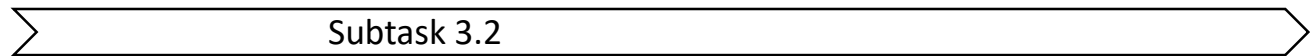
**Subtask 3.2**  
IASCC and corrosion fatigue susceptibility

**Subtask 3.3**  
CASS and weld thermal ageing with irradiation effects

### • Subtask 3.2

- To determine combination of factors important to IASCC
- Gamma spectroscopy characterizations to compare actual neutron doses to those estimated from plant calculations
- Dye penetrant, polymer replica and macroscopic metallurgical examinations to detect any IASCC if present
- Microscopy, H/He of any service induced IASCC
- IASCC susceptibility and CGR testing vs. N-dose. Where possible, end each test with a FT test.

Material	# of conditions	γ-meas.	# of tests or specimens				Characterization
			CGR-tests incl. Fatigue and FT	Initiation testing	H/He	NDT	
A	2	2	2	30	1	2	Hardness, LOM, SEM
C	3		2		1	3	
D	3		3			3	
E	2		1			2	



# SMILE- WORK SCOPE

## Task 4 Austenitic pressure boundary alloys

**Subtask 4.1**  
DMW and SS welds;  
SCC resistance in BWRs and PWRs

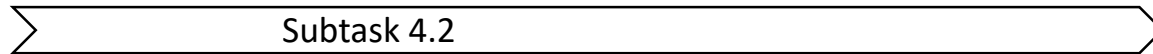
**Subtask 4.2**  
Alloy 690/152/52  
PWSCC resistance and thermal stability in PWRs

**Subtask 4.3**  
Fatigue in BWR and PWR reactor coolants

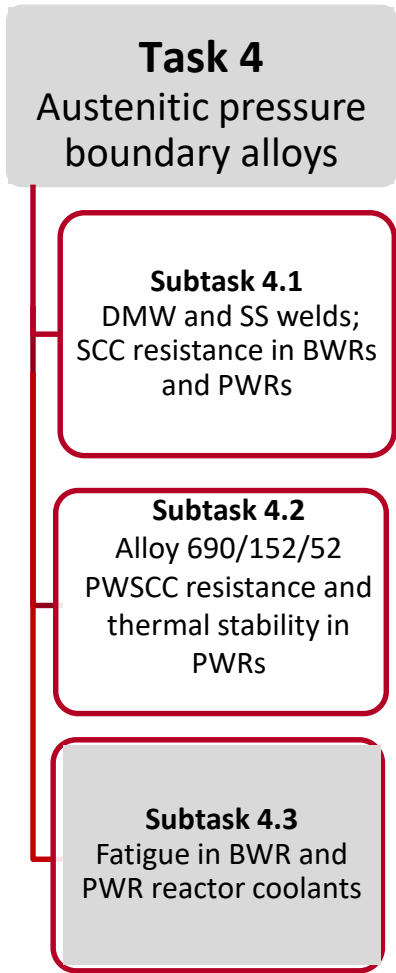
### • Subtask 4.2

- To examine Alloy 690 SG tubes and Alloy 52/152 welds for evidence of PWSCC and LRO
- Same range of tests as task 4.1 + XRD for intermetallic phases associated with LRO during thermal ageing.
- If evidence of PWSCC or LRO is found, conduct tensile, FT and PWSCC CGR tests, end CGR tests with FT, compare to fracture toughness test results in air.

Material	# of conditions	Tensile	FT-test	CGR-test incl. Fatigue & FT	# of tests/series			XRD
					Residual stress	NDT	Characterization	
A	2	4	2	4		2	Hardness, LOM, SEM, TEM, APT	2
B	3	6	2	2	2	3	Hardness, LOM, SEM, TEM, APT	3
C	2	4	2	2		2	Hardness, LOM, SEM, TEM, APT	2



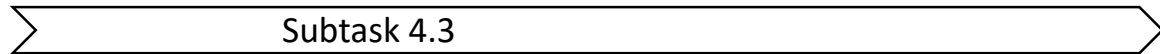
# SMILE- WORK SCOPE



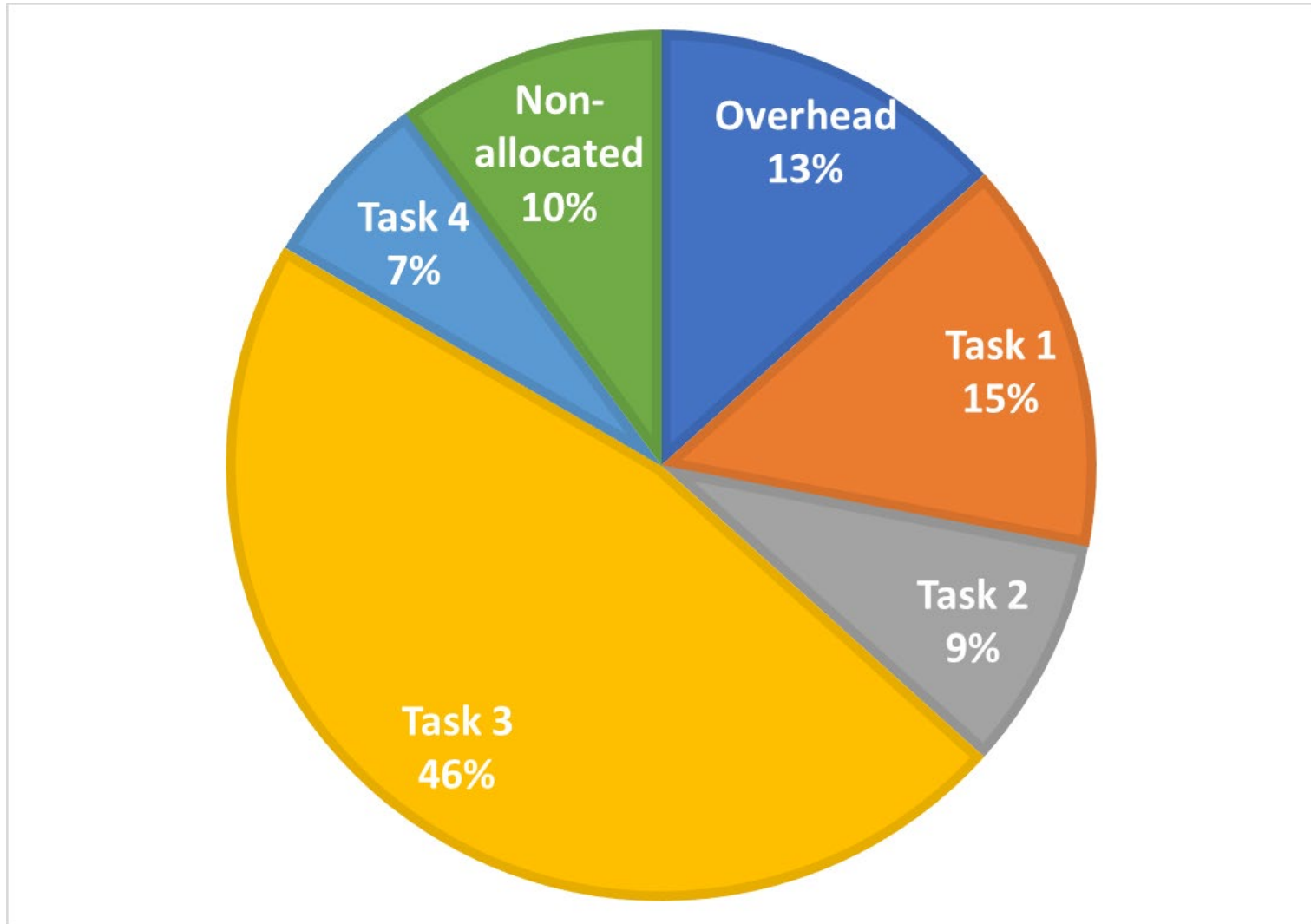
## • Subtask 4.3

- Examine in detail LCF sensitive components for evidence of corrosion fatigue
- Dye penetrant, polymer replica and microscopy detect any cracks and/or wear damage
- Fatigue life calculations for the harvested components use environmental corrections like  $F_{en}$  where applicable, and compare with the original plant design calculations

Material	# of conditions	# of tests or specimens		
		NDT	CUF-calc.	Characterization
A	1	1	1	Hardness, LOM, SEM,
B	2	2	2	Hardness, LOM, SEM,
C	1	1	1	Hardness, LOM, SEM,
D	1	1	1	Hardness, LOM, SEM,



# ***COST SHARE - PROPOSED SMILE SCOPE***



## ***SUMMARY***

- **Proposal of Scope for 5 year project presented**
  - Including selected sub-tasks
  - Studsvik example selection based on gap analysis (presented) and availability and timing of materials
  - To be revised based on feedback obtained in the interest survey – availability of materials as a prerequisite
- **Now: Participating members to prioritize**
  - At the latest 10<sup>th</sup> Feb



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