20. Diskussionsforum Ökobilanzen, 19. September 2003
ETH Zürich / Session „Nicht-erneuerbare Energieträger"

Schweizer Zentrum für Ökoinventare

Eine gemeinsame Initiative des ETH-Bereichs und Schweizerischer Bundesämter

Nuclear

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Summary

- Products & Boundaries of the nuclear chains
- Main differences with Ökoinventare 1996
- Key Assumptions
- Selected Results

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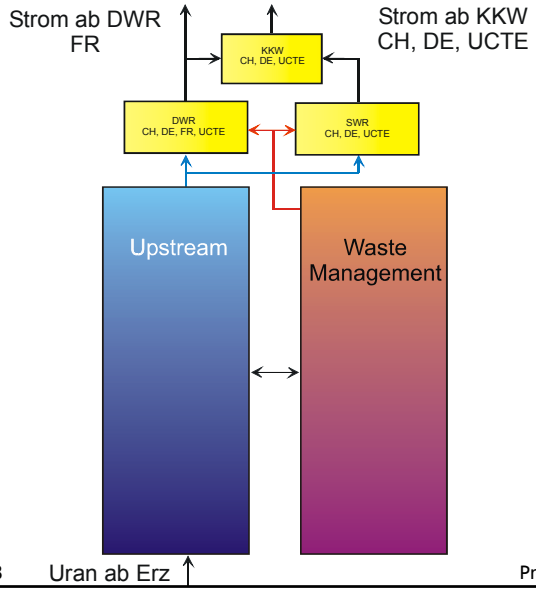
Products & Boundaries



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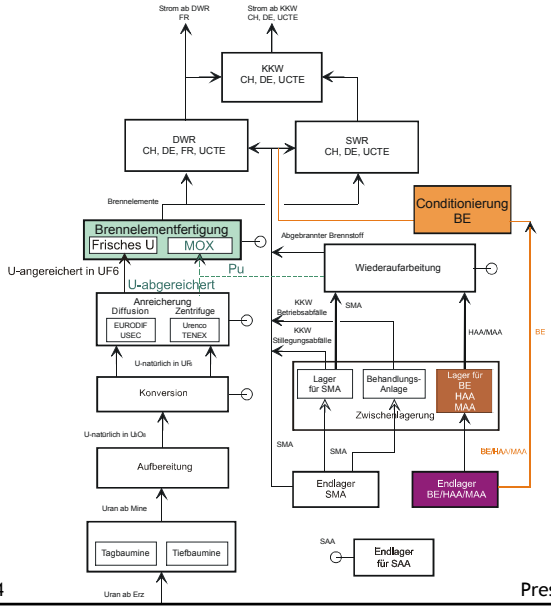
Presentation: Roberto Dones

Nuclear Chain: what's new in ecoinvent



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Progress from Ökoinventare 1996

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- Modelling of MOX fuels (Mixed Oxides of recycled Pu & depleted U): country and/or type (BWR/PWR) specific shares of MOX vs. fresh U fuel, estimated considering the entire lifetime of plants.
- Consideration of Conditioning of Spent Fuel (SF) (encapsulation w/o reprocessing) besides reprocessing; Assumed shares for the modeled chains:

CH	Reprocessed SF	40%	Conditioned SF	60%
DE		40%		60%
FR		100%		
UCTE		~80%		~20%

- New model for the Repository of Highly Radioactive Waste (Opalinus Clay Repository) for the Swiss nuclear energy scenario of 192 GWyear, using the new waste composition from Nagra (2002)

Other changes from Ökoinventare 1996

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- Updated long-term emissions of radon Rn-222 from U mill tailings, from recent literature (again integrated over 80'000 years).
- Increase of average U-enrichment for fuel elements; detailed data available for spent fuel elements discharged from CH power plants in 2000-2002, and current averages for DE and FR.
- Updated detailed radioactive emission species to air and water from West European nuclear power plants, averaged over 1995-1999.
- Higher net efficiency of power plants (from 31% to 32%-33%)
- Recent data for La Hague (FR) reprocessing plant used: Radioctive emissions to air and water (only classes available), requirement of chemicals, non-radioactive solid wastes.
- Higher (+ 60%) total volume of High Level radWaste and lower (- 50%) volumes of Low & Intermediate Level radWaste (including other origins) for the latest CH nuclear energy scenario.

Key Assumptions - I

Key Parameters		PWR				BWR		
Nuclear Power Plant		CH	DE	FR	UCTE	CH	DE	UCTE
Average enrichment fresh U fuel	%	4.2	4.0	3.8	3.9	3.8	4.0	4.0
Average Burn-up	$MW_{th}d$ / kgU	53	50	42.8	45	48.6	48	48
Net efficiency		0.32	0.33	0.33	0.33	0.32	0.33	0.33
Assumed share energy from MOX	%	8	15	10	13	0	10	8

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Key Assumptions - II

- Long term emissions to groundwater from U mill tailings not included (model/information not available);
- Chemical U mining not included.
- Two different commercial technologies (diffusion and centrifuge) with four different facilities modelled for Enrichment; country specific relative shares of enrichment services derived from the literature.
- Current burn-up of fuel assumed representative for the entire lifetime of the facilities (past: lower values; future: possible further increase).
- - For the definition of the CED of U fuel, the herewith modelled best performing chain has been considered as reference;
  - MOX fuel assumed free of upstream burdens, but reprocessing's;
  - Fuel from Highly Enriched Uranium from dismantled warheads & depleted U from enrichment considered as fresh U enriched to suitable grade (< 5%), i.e. no bonus.

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Selected Inventory Results
Example for PWR CH

		Name		electricity, nuclear, at power plant boiling water reactor	electricity, nuclear, at power plant pressure water reactor	electricity, nuclear, at power plant	electricity, nuclear, at power plant	electricity, nuclear, at power plant pressure water reactor	electricity, nuclear, at power plant
		Location		CH	CH	CH	DE	FR	UCTE
		Unit	Unit	kWh	kWh	kWh	kWh	kWh	kWh
resource	Land occupation	total	m2a	6.39E-03	5.77E-03	6.04E-03	5.53E-03	6.20E-03	5.89E-03
air	Carbon dioxide, fossil	total	kg	1.09E-02	5.14E-03	7.75E-03	9.99E-03	5.89E-03	7.65E-03
air	NMVOC	total	kg	8.54E-06	7.78E-06	8.12E-06	7.60E-06	8.77E-06	8.33E-06
air	Nitrogen oxides	total	kg	4.65E-05	3.34E-05	3.93E-05	4.04E-05	3.88E-05	3.97E-05
air	Sulphur dioxide	total	kg	6.09E-05	2.25E-05	3.97E-05	5.03E-05	2.62E-05	3.71E-05
air	Particulates, < 2.5 um	total	kg	7.19E-06	5.38E-06	6.20E-06	6.33E-06	6.24E-06	6.34E-06
water	BOD	total	kg	1.46E-05	1.35E-05	1.40E-05	1.32E-05	1.60E-05	1.52E-05
soil	Cadmium	total	kg	2.15E-11	2.02E-11	2.08E-11	1.89E-11	2.21E-11	2.07E-11
Further LCI results									
air	Radon-222	low population density	kBq	1.79E+01	1.69E+01	1.74E+01	1.56E+01	1.81E+01	1.70E+01
air	Radon-222	low population density, long-term	kBq	7.52E+02	7.10E+02	7.29E+02	6.53E+02	7.58E+02	7.12E+02
air	Carbon-14	low population density	kBq	6.62E-02	2.51E-02	4.36E-02	1.75E-02	5.09E-02	3.74E-02
air	Particulates, > 2.5 um, and < 10um	total	kg	7.17E-06	6.16E-06	6.61E-06	6.46E-06	7.37E-06	6.99E-06
air	Particulates, > 10 um	total	kg	2.00E-05	1.28E-05	1.60E-05	1.76E-05	1.46E-05	1.57E-05
air	Ammonia	total	kg	6.30E-06	5.92E-06	6.09E-06	5.50E-06	6.40E-06	6.01E-06
air	Chromium	total	kg	1.04E-07	1.10E-07	1.07E-07	1.03E-07	1.23E-07	1.14E-07
water	Arsenic, ion	river, ocean, unspecified	kg	3.75E-08	1.80E-08	2.68E-08	3.16E-08	1.95E-08	2.40E-08
water	Arsenic, ion	ground-, long-term	kg	9.72E-11	7.53E-11	8.52E-11	8.51E-11	8.48E-11	8.51E-11
water	Zinc, ion	river, ocean, unspecified	kg	9.12E-06	1.34E-06	4.84E-06	7.65E-06	1.54E-06	3.81E-06
water	Zinc, ion	ground-, long-term	kg	3.72E-08	3.10E-08	3.38E-08	3.56E-08	3.84E-08	3.89E-08
resource	Volume occupied, final repository for low-active radioactive waste	in ground	m3	6.20E-08	3.49E-08	4.71E-08	4.36E-08	4.95E-08	4.50E-08
resource	Volume occupied, final repository for radioactive waste	in ground	m3	8.75E-09	8.10E-09	8.39E-09	8.18E-09	1.37E-08	1.15E-08

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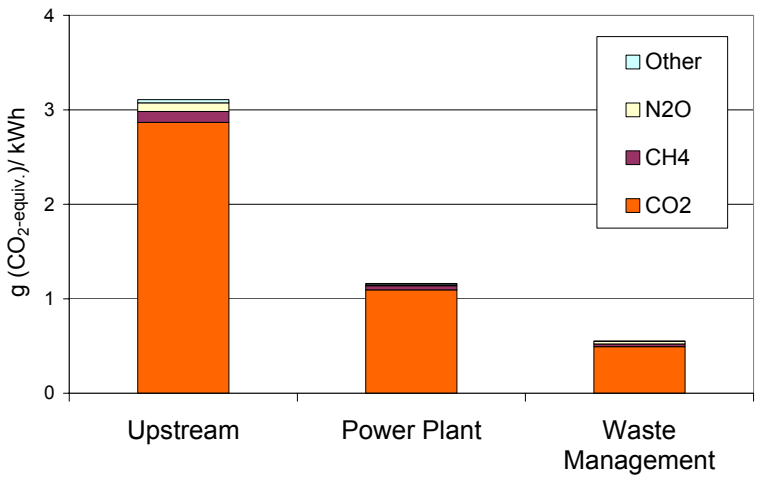
Greenhouse Gas GWP 100 a (ICPP 2001)
Example for PWR CH



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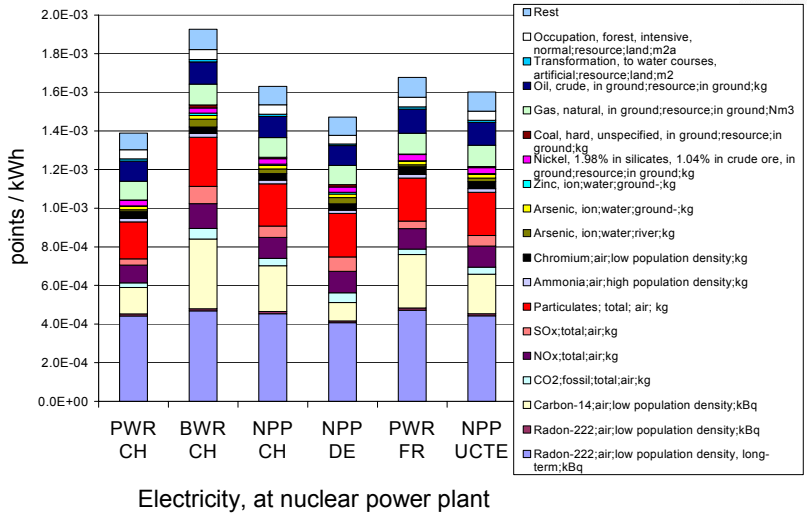
Example of LCIA: EI 99 (H,A)



Electricity, at nuclear power plant

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