Canadian Nuclear Society
Waste Management, Decommissioning and Environmental Restoration
for Canada's Nuclear Activities: Current Practices and Future Needs
Ottawa, Ontario Canada May 8-11, 2005

APPROACHES TO OVERALL ARCHITECTURE OF TRANSPORT SYSTEMS FOR SPENT FUEL AND HIGH LEVEL WASTE: EXAMPLES FROM EUROPE AND CANADA

Vincent ROLAND, COGEMA LOGISTICS
Tara NEIDER, TRANSNUCLEAR Inc.

ABSTRACT - INTRODUCTION

As over the years, the nuclear industry worldwide was developing and building a clean, efficient and safe energy supply, it also built along the essential link for any global industry, transportation.

The early approach at IAEA of creating international recommendations that then would be integrated into national laws came as a blessing to the structuration of transport

This enabled a clear, recognized safety regime that has a proven world track record of outstanding safety. It also gave us a common language, and one may say that within the nuclear community, there is indeed a nuclear transport community.

Because of steady and large flows of material for the nuclear cycles, countries where reprocessing of spent fuel takes place had to implement early on large transport structures and organizations.

In most countries where reprocessing is not yet the main path for spent fuel management, like in the USA and in Canada, large scale transport for the back-end is still at the inception stage.

Today the industry must demonstrate that waste is properly managed and that the peaceful use of nuclear energy delivers indeed the best economic and environmental value. Transport has to answer a part of this challenge if the industry is to grow further.

The paper will illustrate how the current continental Europe systems of transport progressively evolved so as to make daily deliveries of spent nuclear fuel to the COGEMA La Hague reprocessing plant a strong, dependable and effective system. It also shows that this experience is in the background of a major study ordered by ONTARIO POWER GENERATION from COGEMA LOGISTICS, as a contribution to the work of the trust now examining approaches to long-term management of spent fuel in Canada.

EUROPEAN EXPERIENCE IN THE BACK-END TRANSPORT AT* THE AREVA GROUP

Presently, this activity corresponds to more than 1000 back-end transport yearly among which 280 Spent Fuel casks and 20 HLW casks. To date more than 70,000 Spent Fuel Assemblies have been shipped by COGEMA LOGISTICS.

The existing spent fuel transport organization between European NPP and COGEMA La Hague Reprocessing Plant involves the following activities:

- Fuel assemblies selection and verification of acceptability at receiving facility.
- Cask selection and verification of:
  - NPP license for handling and loading.
  - Maintenance status.
  - Licensing status with respect to selected fuel assemblies.
  - Timely availability.
- Programmation of transport operations.
- Delivery of cask and inspection of readiness for operation.
- Loading of cask and checks prior to shipment.
- Shipment by rail (if NPP has a spur) or truck to transfer to rail station.
- Rail to COGEMA LOGISTICS railroad terminal at Valognes (Normandy, France) (figure 1).
- Cask inspection.
- Transfer to heavy haul trucks and last leg to La Hague Reprocessing Plant.
- Cask inspection for non-contamination.
- Unloading at La Hague wet (NPH) or dry (T0) facilities.

Almost every single day, at La Hague reprocessing plant, a loaded heavy cask is delivered and another one, shipped away empty.

What were then key features of the transport system in continental Europe?

- Use of rail transport with specialized rail cars qualified for commercial velocities so they can hooked to normal freight trains on the European Railway Network. This involves education and training of railway staff so that they can be confident their own safety is ensured.

Fig.1. COGEMA LOGISTICS Q76 wagon Q76

- Develop codes and benchmarking to ensure before loading that a given payload will not exceed the licensed thermal and radiation protection performance of the transport casks.
- Standardization of cask interface features. The main fleet of TN™ casks for that purpose is comprised of TN™12, TN™13 and TN™17 casks (fig.2). Maximum interoperability of casks is thus achieved.

Fig.2. TN™13, and TN™17 casks

- Dry and wet unloading facilities.
- Make maintenance integral part of the every day programmation process: COGEMA LOGISTICS has developed a comprehensive set of software allowing to visualize at a click the fleet status.
- Ability to give technical support at shipping facilities.
- Working permanently with local and national Authorities, and media so as to make them aware of the high standards of safety and security, real time tracking system, emergency preparation of personnel and equipment in place.

Another major key of the European transport system that we have devised is our process and analysis method to implement the proper transportation route.

The first step of this process is gathering NPP data on:

- Spent fuel population (nature, characteristics).
- Constraints for cask handling from delivery to pool.
- Fuel handling at pool.
- Utilities, effluent handling.

In parallel, we analyse:

- Compliance of proposed systems with local regulatory and legal constraints.
- Possible routes (rail, road, sea) with identification of singular points such as bridges, tunnels, harbor cranes.

In general, it is impossible to alter the gauge of a tunnel but it is often possible to refer to the competent authorities for overweight loads beyond the posted weight limit of a bridge.

The resulting analyses specific to each facility displays an array of possibilities.

In tables 1 and 2, for NPPX, for instance the study is comprised of:

- Reference documentation identification.
- Key constraints for packaging selection.
- Road, railway network and harbors.
- Regulatory requirements:
  - Local,
  - International.
- Cost / benefit / time schedule pricing and analysis.

Route No. 1	Mode	Transport equipment	Constraints	Constraints related to the weight and diameter (dia) of the packaging
– XNPP / X	Road	Road transport unit, stowage system and tarpaulin to be determined (local subcontractor)	Multi-axle extra long semi-trailer / fairly long travel time (about 8 hours)	• 130 tons • to be determined
– X / Cherbourg	Sea	INF 2 or INF 3 ship. Stowage to be determined	Using of COGEMA LOGISTICS gantry crane	Depending on the crane
– Cherbourg/ Valognes terminal	Railway	Q7 or NG wagon		• 140 tons (Q7 or NG) • Dia ≤ 3000 mm.
– Valognes terminal/ COGEMA La Hague plant	Road	Titan or Tractomas tractor + SR9 NG semi-trailer. Stowage to be adapted (1)		• 100 to 140 tons • Dia ≤ 3000 mm

(1) Except for existing containers type TN^{TM} 17/2 or TN^{TM} 12/2 belonging to COGEMA LOGISTICS

Table 1: multimodal approach, route n°1

Route No. 2	Mode	Transport equipment	Constraints	Constraints related to the weight and diameter (dia) of the container
– XNPP/X	Road	Road transport unit, stowage system and tarpaulin to be determined (local subcontractor)		• 130 tons • to be determined
– X / Valognes terminal	Railway	Q7 or NG wagon	Obtain authorizations to exceed 103 tons	• 140 tons (Q7 or NG wagon) • Dia ≤ 30000 mm (1)
– Valognes terminal / COGEMA La Hague plant	Road	Titan or Tractomas tractor + SR9 NG semi-trailer. Stowage to be adapted (1)		• 100 to 140 tons • Dia ≤ 3000 m

Table 2: multimodal approach, route n°2

Supprimé : Dia ≤ 2800 mm

Supprimé : 0

Supprimé : Dia ≤ 2800 mm

The following table (table 3) gives the main actions to be considered for transport using TN™17, TN™12/1 or TN™12/2 or TN™24DH packagings:

Supprimé : ¶

	Route No. 1	Route No. 2	TN™ 17	TN™ 12/1 or TN 12/2v	TN™ 24DH
Approval	X	X	Extension with Safety analysis X validation	Light extension X validation	Extension with Safety analysis X validation
Cask	X	X	COGEMA European fleet	COG. Europe (*)	existing
Basket	X	X	Type 933 to be made	Existing units to be scheduled (*)	existing
Packing	X	X	To be made	To be made	N.A.
Loading	X	X	Lifting system to be improved (lifting beam, hooksticks) Accessories required: • Small tooling • Draining / drying module • Pool parts	Requalification of crane (**) Lifting system to be improved (lifting beams, hooksticks) Accessories required: • Small tooling • Draining / drying module • Pool parts	Requalification of crane (**) Lifting system to be improved (lifting beams, hooksticks) Accessories required: • Small tooling • Draining / drying module • Pool parts
Skirt	X	X	Metallic, to be made	Metallic, to be made	Plastic (or metallic to be made)
BU-meter	X	X	To be provided	N.A.	N.A.
Unloading in La Hague plant	X	X	(NPH/T0)	(NPH/T0)	Auxiliaries to be provided (NPH)
Transport system: • Road frame in France	X	X	Existing	Existing	To be developed and made
• Tarpaulin in France	X	X	Existing	Existing	To be developed and made
• Wagon	X	X	Q7 or Q76	Q7 or Q76	Q7 or Q76
• Wagon frame	X	X	Existing	Existing	Existing
• Wagon canopy	X	X	Existing	Existing	Existing
• Sea frame	X		Existing	Existing	To be developed and made
• Road transport system in X	X	X	To be rented	To be rented	To be rented
• Road frame in X	X	X	To be developed and made	To be developed and made	To be developed and made
• Tarpaulin in X	X	X	To be developed and made	To be developed and made	To be developed and made
PUI-T(***)	X	X	OK	OK	Plan to be produced

Supprimé : PNTL equipment?

Supprimé : To be made

Supprimé : o be made

(*) *Depending on the real transport dates a TN12/2 ™ cask can be dedicated for XNPP.*
A TN ™12/1 cask can be easily booked for XNPP too.

(**) *Essential condition for this packaging.*

(***) *Emergency response plan adapted to transport conditions.*

Table 3: main actions to be considered

<u>THE CANADIAN WASTE MANAGEMENT PROGRAMME: IMPLEMENTING AREVA METHODOLOGY</u>

Prompted by the Canadian Nuclear Fuel Waste Act of 2001, Ontario Power Generation Long-term Waste Management Technology Department (Ontario Power Generation, hereafter referred to as OPG), acting on behalf of the Joint Waste Owners[1], contracted with COGEMA LOGISTICS and its U.S. subsidiary Transnuclear, Inc., both AREVA group companies, to provide both conceptual designs and cost estimates for a Used Fuel Transport System (UFTS):

1- Preparation of conceptual designs for all components of a system for transportation of used fuel from current storage facilities in Canada to a centralized long-term management facility;
2- Development of shipping program logistics;
3- Based on conceptual designs, preparing a cost estimate for transportation.

The UFTS study has analyzed all transports of used fuel assemblies[2] from their current storage facilities in Canada to a centralized long-term management facility, also in Canada. The centralized long-term management facility would be a Deep Geologic Repository (DGR) or a Centralized Extended Storage (CES) facility.[3]

The UFTS study was needed to compare various option for long term management of used fuel produced by Canadian reactors (see figure 3).

Figure 3

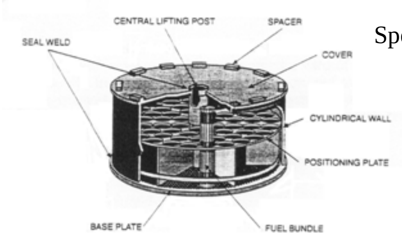
For the purpose of the UFTS study, it was assumed that the Waste Management Organization would be responsible for providing or contracting transportation services for all of the waste owners.

The study uses a transportation program applicable to the 2035 in-service date of receiving facility where needed to develop design concepts and logistics.

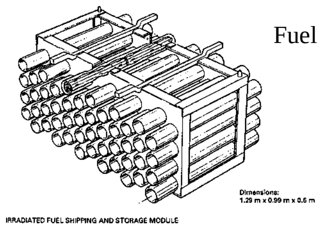
1 The Joint Waste Owners are OPG, Hydro Quebec, New Brunswick Power and Atomic Energy Canada Limited.
2 Canada's commercial nuclear reactor fleet approximately 3.6 million assemblies.
3 This decision will be made by the Canadian federal government after reviewing the options required by the Nuclear Fuel Waste Act (Canada 2001).

The work associated with the UFTS study has been divided in three phases:

Phase 1 – *Conceptual Design Studies.* The purpose of this phase was to carry out preliminary studies on the use of basket for transportation, use of OPG's Dry Storage Containers (DSCs) and use of road, rail and water modes of transportation. This phase also prepared a technical and narrative description of the conceptual designs and of conceptual procedures for operation of the system.



Spent fuel basket



Fuel storage module

Phase 2 – *Logistics studies.* The purpose of this phase was to establish nominal distances for transportation of used fuel, examine the feasibility of the off-site shipping schedule and prepare a shipping program description and detailed logistics for operation of the system described in Phase 1.

Phase 3 – *Cost Estimates.* According to guidelines provided by OPG, this phases has defined all cost for development, operation and decommissioning of the UFTS, so that these costs could be an input for comparison of options for long-term management of used fuel. The work has included development of a realistic schedule or timetable of activities on a nominal basis and costs has been assigned by year to major activities.

First were assessed options for transportation of used fuel currently stored in the baskets currently used in the dry storage facilities at Pointe Lepreau, Gentilly 1 and 2, Douglas Point, Whiteshell and Chalk River. The two options evaluated consisted in transporting the current basket with the fuel in the vertical orientation or unloading and repackaging of the fuel prior to transportation. The Dry Storage Transportation Package, the Irradiated Fuel Transportation Cask and potential existing and new conceptual cask designs were evaluated for transportation of the baskets.

Fuel Bundle Packaging	Transport Cask	Advantages	Disadvantages
Fuel in Spent Fuel Baskets with fuel vertical	DSCTP	• Is currently licensed for rail or sea transport in Canada.	• Transport Cask must be rotated 90° on axis. • Only licensed for rail or sea transport. • Package weight incurs transport restrictions • Difficult to load with baskets. • Can only hold two baskets. • Has seal-welded closure, intended for single use.
	IFTC	• Is currently licensed for transport in Canada. • The package is relatively lightweight and therefore incurs less highway restrictions. • With minor redesign, two large baskets could be accommodated.	• Transport Cask must be shipped horizontally, which has not been analyzed or licensed. • Difficult to load with baskets. • Can only hold one basket.
	A new Cask design	• Perfectly suited to ship baskets. • Could be designed to ship both baskets and modules.	• Design, Analysis and licensing required.
Repackage fuel in Standard Fuel Storage Modules	DSCTP or IFTC	• Can transport fuel in a more robust container. • Can transport fuel in either DSCTP or IFTC, which are currently licensed. • Can use one transportation package to transport all Canadian used fuel.	• Requires significant work effort prior to shipment. • A hot cell or transfer pool would need to be constructed at each site.

Second, we examined the feasibility of transportation of OPG's Dry Storage Containers (DSC) as part of the Used Fuel Transportation System (UFTS) from Pickering, Bruce and Darlington. Because work had already been done to design and license the DSCs for transport under the Dry Storage Container Transport Package (DSCTP) license, it was selected for evaluation transport, effects of DSC aging, as well as requirements for preparing this study. Requirements for the DSCs for transport were considered. It was concluded that the DSCTP should be used to transport all fuel bundles stored in DSCs at the time of transport, and the remaining fuel bundles in wet storage should be transported in a lighter package such as the IFTC.

	ADVANTAGES	DISADVANTAGES
Fabrication	• Does not require construction of additional Casks.	• Equipment to attach impact limiters and rotate package will be required. • A Number of sets of the Outer Packaging must be constructed.
Operations	• Does not require unloading of the fuel bundles from the seal-welded DSCs. • Roughly 2/3 of bundles will already be stored in DSCs at time of transport.	• Package must be rotated and placed into Outer Packaging.
Logistics	• Is already licensed for transport by rail or by water under the DSCTP SAR. • DSCTP can be licensed for road transport "easily".	• Package weight incurs excessive road transport restrictions.

An intermediate milestone was issued of the *« Design Basis and Assumptions for the Used Fuel Transportation System »* reported the design basis to be used in subsequent conceptual design studies. This document ensured that every stakeholder and all waste owners had a clear and common understanding about the basis on which the UFTS designs should be developed. The conceptual designs had to meet all requirements and assumptions listed in the design Basis Document. The main features of each of the three alternative systems were as follows:

All Road:

- Most flexible with respect to location of centralised site
- The only "unimodal" system
- All fuel loaded in IFTC/BMs
- 12 trucks arrive at centralised site each week (on average)
- Total **18 747** shipments over program
- Unload DSCs at current storage sites
- Upgrade on-site roadways

Mostly rail:

- Road links to railheads where needed. **-** Fuel loaded in IFTC/BMs (except DSCs),
- All DSCs transported,
- 8.3 trucks arrive at centralised site each week,
- Total **1 930** rail shipments over program with 12960 connecting and additional road shipments,
- Assume road link to centralised site,
- Extend rail spurs into Pickering and Darlington UFDSFs and into Gentilly site,
- Up-grade on-site roadways at 2 possibly 3 sites,
- Potential cost savings from larger shipments.

Mostly water:

- Road link to centralised site,
- New /upgraded dock at 5 or 6 sites,
- Potential cost savings from larger shipments,
- All DSCs transported ; fuel from wet bays loaded in IFTC/BM (baskets or modules),
- 8.3 trucks arrive at centralised site each week,
- Total **647** water shipments over program with 12960 connecting and additional road shipment,
- Purpose-built vessel (self-geared).

A first volume of Final Report: *Conceptual Designs for Transportation of Used Fuel to a centralized Facility* is a synthesis of the study, giving a general view of UFTS, conceptual cask designs , conceptual designs for loading transportation casks, activities to prepare the shipment, conceptual vehicule and tie down system, general description of cask unloading. In addition, a brief description of emergency response provisions, general description of security measures, special manufacturing issues and general description of concepts for decommissioning are addressed.

The second volume of the Final report**:** *Logistics of Transportation of Used Fuel to a centralized Facility* gave a description of operation of the UFTS including origins of used fuel and general destination, modes, timescale and size of program. The shipping program i.e. numbers of bundles and shipments, transported from each curent storage site and received at the central site by year was described as well as shipping constraints for each mode (days/year, days/week, hours/day). The required numbers of vehicules, casks, drivers and management system were in the report.

A third volume was: *Cost estimate for transportation report.* The Used Fuel Transportation System components include the casks loading facilities at each Nuclear Power Plant, the Transportation Packages, the vehicles, the maintenance facility, the real time tracking system and the emergency means. The approaches were benchmarked with our European experience.

The Used Fuel Transportation System operations include all the operations from the loading of the modules or baskets into the Transportation Package to the Transportation Package unloading from the vehicle at the centralized facility and including the transportation equipment maintenance.

The development, construction, operation and decommissioning phases for the Used Fuel Transportation System are to span from year 12 to year 62 of the centralized facility development program (i.e. from 2017 to 2067, with the date of 2035). This schedule does not include the safety assessment and public affairs duration or impacts on the transportation program during the siting phase of the overall program.

CONCLUSION

Sharing of approaches, combining experience from elsewhere with specific contexts, such as the Canadian one, allow better prediction and sizing of those programmes that are key to nuclear energy development. By such approaches, we do believe that we can show our fellows earthmen that indeed we care, anticipate and optimize the safe disposal of our industrial residues, then setting the standard of our industry at the top of the scale of sustainable development.

Transport is no mere commissioning and handling at facilities. It involves a complex chain of decision for the long term reliability and efficiency of the whole system, for which experience feedback is essential. The expertise of TRANSNUCLEAR Inc. and COGEMA LOGISTICS, both AREVA Group companies, in transport system initiated in Europe more than 40 years ago was a key element in analyzing each parameters to study a coherent and efficient operational transport system for used CANDU fuels in Canada.