PURPOSE

2011 legislature directed the Joint Transportation Committee to:

- Investigate the use of liquefied natural gas (LNG) on existing Washington State Ferry (WSF) vessels as well as the new 144-car class vessels and report to the legislature by December 31, 2011 (Transportation Budget)

The study is to:

- Assess WSF’s work and studies
- Identify the full range of issues
- Analyze the cost, risk, timeline, and related implications of
  - Changing the design of the new 144-car vessel to LNG
  - Retrofitting Issaquah class vessels
**APPROACH**

**WSF Reports**
- 144 Car Ferry Conversion
- Issaquah Class Conversion

**Other Reports**
- California Energy Commission
- Danish Ministry of Environment
- Det Norske Veritas
- Fjord1

**Interviews**
- BC Ferries
- Energy Providers
- Fjord1

**Concept Design & Life-Cycle Cost Schedule**

**WSF FLEET**

**Fleet Acquisition and Deployment Plan**
- 22 vessel fleet with planned 2 new 144 car vessels
- First new 144-car vessel (2014)
  - 2011-13 budget – diesel ferry
  - *Evergreen State* retires
- Second new 144-car vessel (if diesel 2015)
  - 16-year financial plan – vessel is either diesel or LNG
  - *Hiyu* retires
  - Increase service capacity – San Juans, Mukilteo, Fauntleroy-Vashon-Southworth
DIESEL FUEL

WSF
- Mix of ultra low sulfur diesel (ULSD)/biodiesel
- 2010 – used 17.3 million gallons (21 boat fleet)
  41% 5 Jumbo Mark I and II
  27% 4 Super Class
  22% 6 Issaquah Class
  10% 6 small vessels
- Issaquah class ferries – 3.7 million gallons in 2010
  - Ranges by vessel from 0.5 million gallons to 0.8 million gallons per year depending on the route
- Cost – 29% of 2011-13 biennium budget - $135.2 million
  - June forecast $4.30/gallon FY 2012 - $4.33/gallon FY 2027
  - Sales tax eliminated July 1, 2013

NORTH AMERICAN EMISSION CONTROL AREA (ECA)

Takes Effect in 2012 – Sulfur & nitrous oxide content requirements
- Little impact on WSF
- WSF uses ULSD - meets sulfur oxide content regulations
- WSF engines meet the nitrous oxide requirements
- Tier III compliant engines required after 2016 for new construction and/or major engine upgrades in existing vessels may have some impact
LNG

LNG
- Natural gas cooled to -259 degrees Fahrenheit
- Must be kept at that temperature or returns to gas

LNG Fueled Vessel
- 300 LNG carriers worldwide – none US flagged

LNG Fueled Ferries
- Operating in Norway only
- First LNG ferry built in 2000 – now approximately 16
- Fjord1 experience – operates 12 LNG ferries

Capital cost – 20% higher
Single fuel (LNG only) engine
Maintenance cost – 10-20% higher
Fuel cost – slightly higher than diesel
Bunkering – by truck or storage tanks
Crew size – same as diesel

NATURAL GAS/LNG U.S. PROJECTIONS

Economics Different Than Norway
- LNG less expensive in U.S. than Europe

US Natural Gas – 89% Domestic
- 9% pipeline imports from Canada & Mexico
- 2% LNG imports mainly from Trinidad and Tabago

Forecasts – Stable & Growing Domestic Supply
- Shale gas supply discovery
- Allowing import terminals to export domestic LNG

Forecasts – Stable Price – Lower Than Diesel

Natural Gas/LNG Prices Volatility
- Factors could increase future prices – difficulties extracting shale oil, drilling restrictions, US policy change to encourage natural gas autos
LNG WASHINGTON STATE PROJECTIONS

Integrated Resource Plans

- Required every two years by Washington State Utilities & Transportation Commission of 5 utilities operating in Washington State
- 2010 & 2011 IRPs show lower prices than IRPs filed in 2008-09
- All IRPs project relatively stable natural gas prices through 2030
LNG SUPPLY CHAIN

Three Types of Facilities
- Terminals
  - East & Gulf Coast
  - FERC approved import terminal at Coos Bay
    ✓ Not under construction
    ✓ Controversial – not included in any IRP forecasts
- Liquefaction facilities – convert natural gas to liquid
- Storage facilities -- store LNG
- Six liquefaction &/or storage facilities in the Pacific Northwest
  - Support utilities

WSF LNG

Two supply options
- Participate in a liquefaction facility
- Truck to WSF by third party
- Recommend – trucked by third party
  - Experience in Norway, Phoenix Transit
  - Liquefaction facilities – expensive, difficult to permit

Price forecast for WSF LNG
- Consultants forecast – $1.25 per gallon 2014 trucked (outside Northwest) to $1.52 per gallon in 2027
- Energy equivalent basis (i.e. it takes more LNG to get same energy as diesel)
  - 47% less cost than June diesel forecast 2014 / 40% less in 2027
- Annual savings will depend on vessels and routes
- Forecast basis
  - Transportation Revenue Forecast Council + factors from Poten & Partners – independent energy consultants
WSF LNG

Other Agencies
- Phoenix – 315 LNG fueled buses
  - 2011 - $1.05 per gallon delivered (pre-tax)
  - Prices peaked in 2008 at $1.60 per gallon
- BC Ferries – considering a conversion
  - Anticipate a 60% savings
  - Nearby liquefaction facility (Fortis)

LNG VESSEL OPERATIONS

Bunkering (i.e. refueling)
- Two options
  - Truck delivers to a terminal facility
  - Truck drives on to ferry
- Norway – operators prefer terminal facility

Impact on Vessel Speed, Performance, Maintenance
- Minimal impact on speed and performance
- Maintenance – based on Norway’s experience – higher cost
LNG VESSEL DESIGN CONSIDERATIONS

Engine
- Two options
  - Single fuel (LNG only) – more fuel efficient, greater emissions reduction, operationally more certain
  - Dual fuel (LNG/Diesel) – allows to change fuels if price or supply problems with either LNG or diesel

Regulatory Requirements - Design
- No US rules so Coast Guard using alternative approval authorization & international rules
- WSF work – most advanced for LNG passenger vessel in the U.S.
- USCG has provided letter as basis for design review with caveat that there may be more requirements
- Risk analysis required for LNG vessels
- Potential – Major conversion application for Issaquah class retrofit

LNG VESSEL OPERATIONS REGULATORY REQUIREMENTS

USCG
- USCG not yet begun to develop operational rules
- Design letter – states will most likely require clearing vehicle deck during fueling
- Rules for LNG carriers – bunkering
  - USCG supervision
  - Training of ship and shore personnel
  - Specification of a person in charge
  - Fuel staffing requirements
  - Length of duty restrictions on fueling staff
  - Restricted areas of operation
WSF LNG STATUS

Final report - consultants will compare WSF findings with our Independent findings

WSF New 144-car Vessel
  • USCG letter provide basis for design review
  • Design basis – Seattle-Bremerton
  • Dual and single fuel engine options considered
  • Fuel tanks above passenger deck (Norway below)
  • Bunkering assumed – by truck at night
  • Auxiliary generators – remain diesel

WSF Issaquah Class
  • Request for regulatory review – submitted Sept. 2011
  • Similar design to new 144-car LNG vessel

NEW 144-CAR LNG VESSEL

LNG fuel storage tanks
## ISSAQUAH CLASS LNG CONVERSION

![Image of ISSAQUAH CLASS LNG CONVERSION](image)

## WSF LNG COST ESTIMATE – 144-CAR VESSEL

<table>
<thead>
<tr>
<th>Per vessel New 144 ($ millions)</th>
<th>Dual Fuel Diesel/LNG</th>
<th>Single Fuel LNG</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$8.5</td>
<td>$9.9</td>
<td>$2.5</td>
</tr>
<tr>
<td>Design (one-time)</td>
<td>$0.8</td>
<td>$0.8</td>
<td></td>
</tr>
<tr>
<td><strong>Total with design</strong></td>
<td><strong>$9.3</strong></td>
<td><strong>$10.7</strong></td>
<td><strong>$2.5</strong></td>
</tr>
</tbody>
</table>

**Operation First Year**

<table>
<thead>
<tr>
<th></th>
<th>Dual Fuel Diesel/LNG</th>
<th>Single Fuel LNG</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel ($3.65/gallon)</td>
<td>$0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LNG ($1.05/gallon)</td>
<td>$1.4</td>
<td>$1.3</td>
<td></td>
</tr>
<tr>
<td>Engine M&amp;R</td>
<td>$0.3</td>
<td>$0.1</td>
<td>$0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1.8</strong></td>
<td><strong>$1.4</strong></td>
<td><strong>$2.7</strong></td>
</tr>
</tbody>
</table>

**Life-Cycle Cost – 30 years**

<table>
<thead>
<tr>
<th></th>
<th>Dual Fuel Diesel/LNG</th>
<th>Single Fuel LNG</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$47.5</td>
<td>$40.8</td>
<td>$61.2</td>
</tr>
</tbody>
</table>

**WSF Analysis**

- Over 30 year life, single fuel LNG engine option is the least expensive.
- Assumes LNG costs $1.05/gallon.
WSF LNG COST ESTIMATE - ISSAQUAH CLASS

LNG SCHEDULE

Six vessels
- Capital cost - $65 million
- Annual fuel savings - $9.8 million
- Payback - 7 years

New 144 Schedule
- First diesel - 2014
- Second LNG - 2016

Issaquah Class
- 18 months review, design, bid
- 6 months construction each

FULL RANGE OF LNG CONSIDERATIONS THAT WILL BE CONSIDERED BY CONSULTANTS

- Fleet plan
- Design
- Capital cost
- Operation cost
- Security
- Life-Cycle cost
- Public reaction
NEXT STEPS – REPORT NOV. 16 JTC MEETING

Norway research
- Design
- Retrofit
- Fueling
- Staffing

Cost Estimate
- Use Norway data to develop independent construction cost estimate
- Total project cost
- Norway data – project preservation & operation maintenance cost
- Fuel – confirm price projection

Implementation
- Sequencing – affect on fleet plan and out-of-service time/preservation
- Security
- Public outreach