



The Hydrofluorocarbon Transition

Estimating Leakage of Refrigerants from Existing Systems in Washington – Report to Legislature

Tamara Dumitrescu

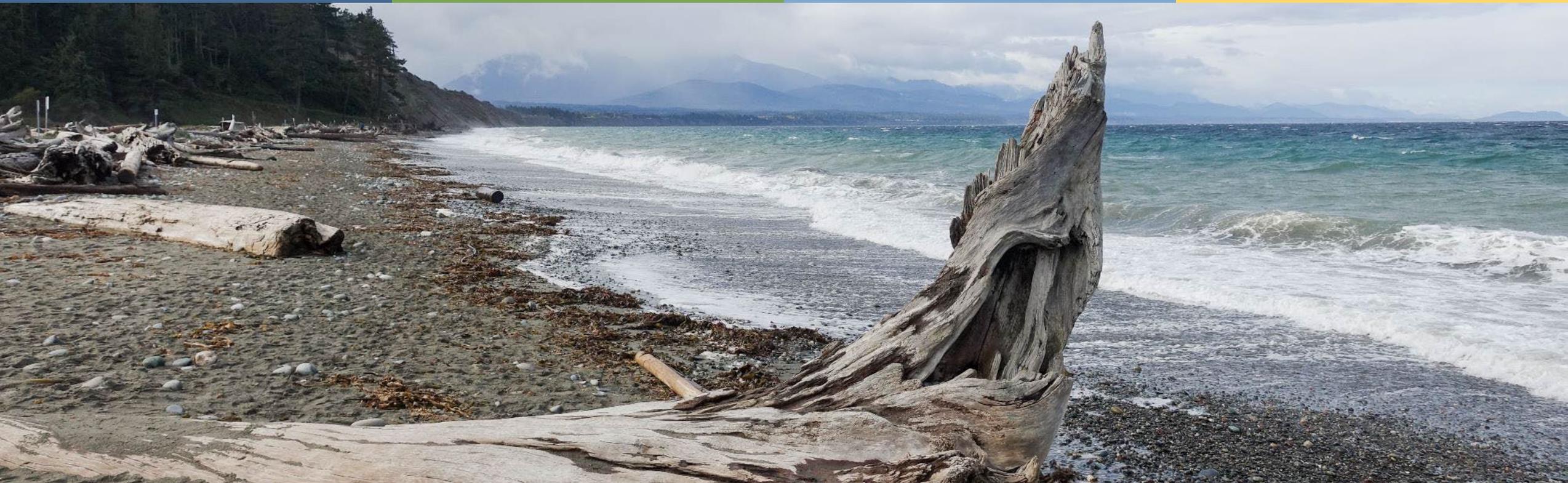
Technical Lead - Hydrofluorocarbons

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Start Recording

We will begin recording at this time.





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Hydrofluorocarbons (HFCs) Team

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Hydrofluorocarbons (HFCs)
Estimating Leakage of Refrigerants from
Existing Systems in Washington
Report to Legislature Webinar
Tamara Dumitrescu
Technical Lead - Hydrofluorocarbons

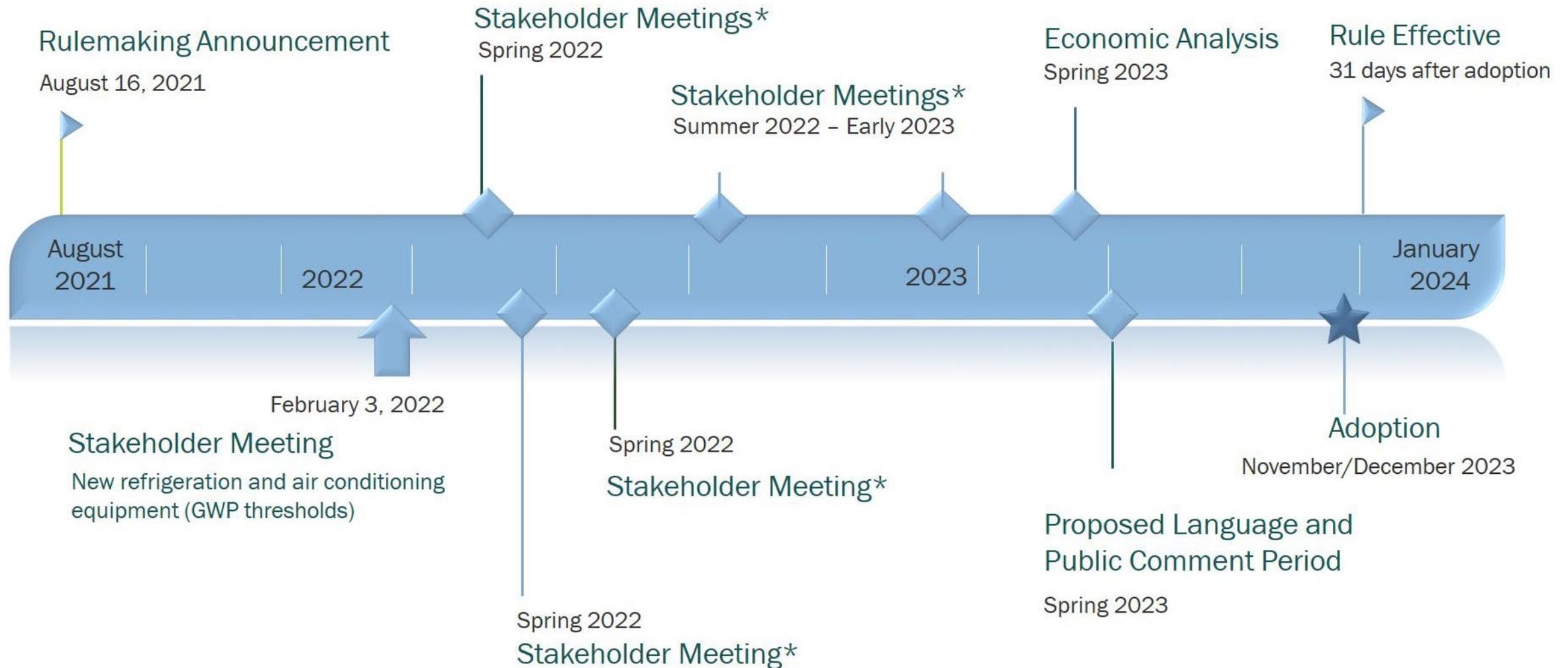
AGENDA

- House Bill 1050, Section 9
- Methodology
- Preliminary Results
- Refrigerant Management Program Leak Rates

In Rulemaking Now

- Chapter 173-443 WAC, Hydrofluorocarbons (HFCs)
- Chapter 70A.60 RCW, Hydrofluorocarbons Emissions Reduction (HB 1050, Section 9)

HFC Rulemaking Timeline



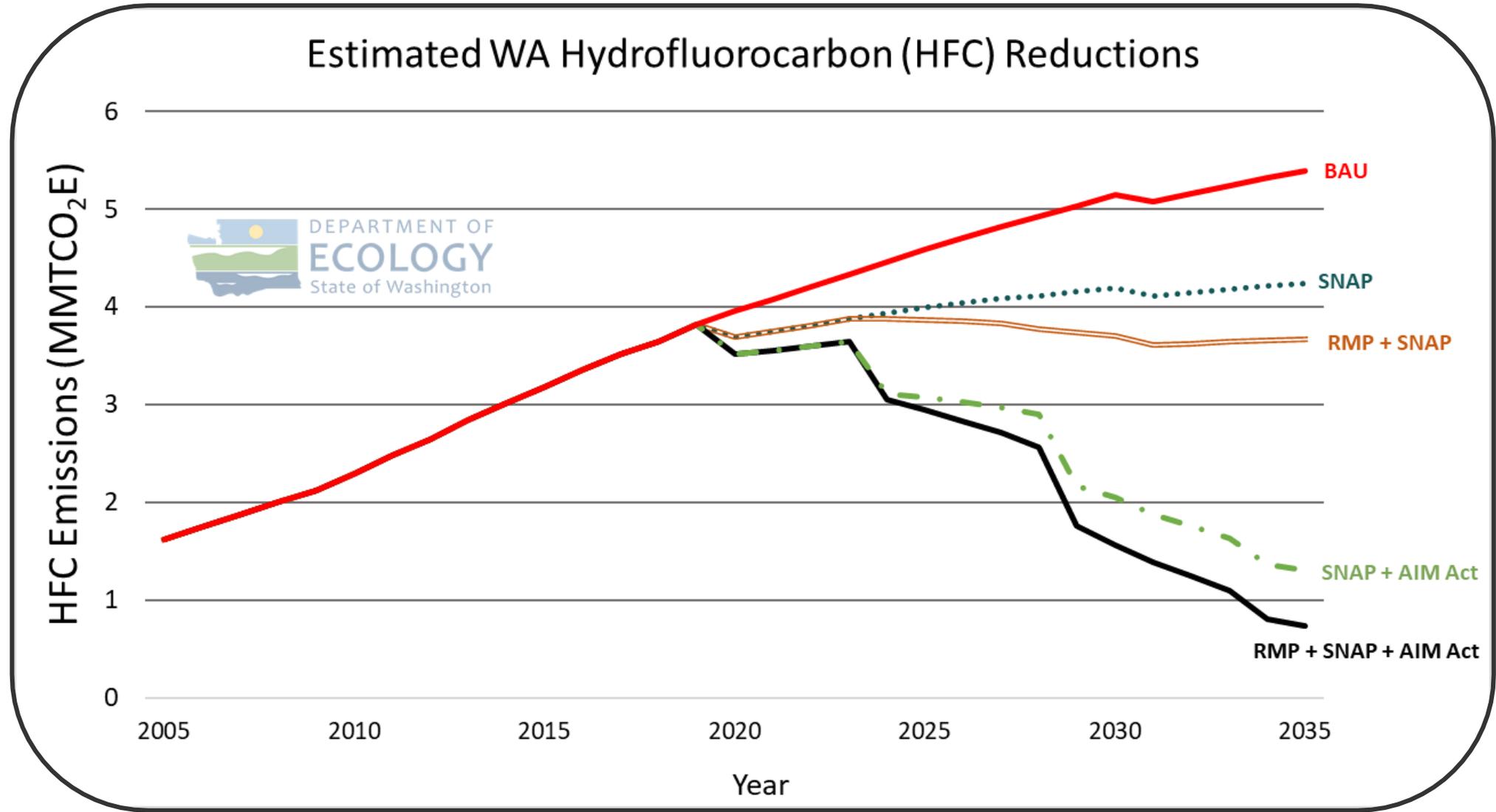
*Meeting timeframes are tentative and subject to change

Statutory Direction for this Report

Section 9, Chapter 315 of the Laws of 2021

“The department shall establish a refrigerant management program designed to reduce emissions of refrigerants **beginning *no earlier than January 1, 2024, and no earlier than the adjournment of the regular legislative session following the submission of a report*** to the appropriate committees of the legislature by the department estimating leakage of refrigerants from existing systems in Washington”

The Goal – Reducing HFC emissions



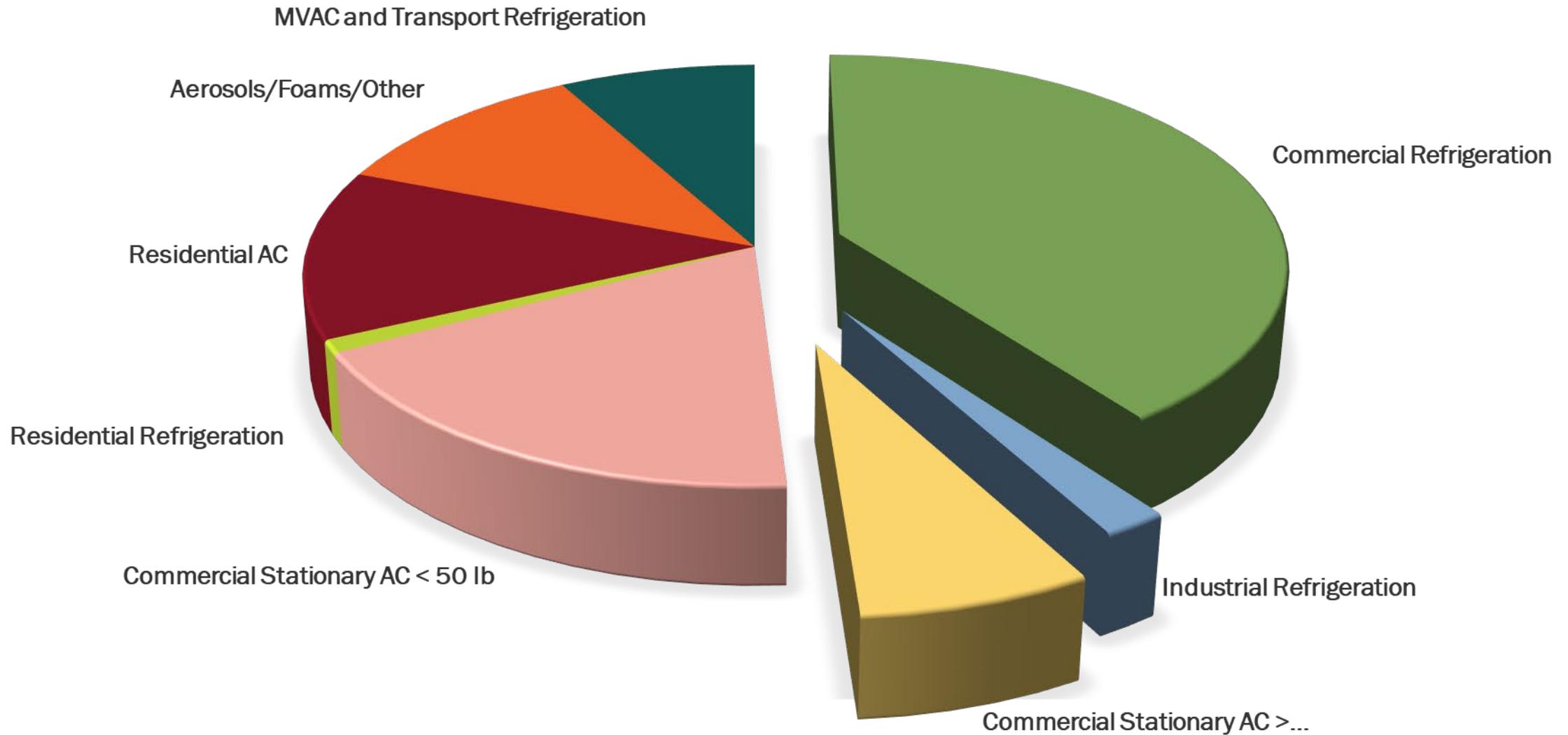
- ✓ Each component provides distinct reductions
- ✓ A key component to Washington achieving carbon neutrality by 2050

Refrigerant Management Program

Three main categories of equipment containing 50+ pounds of refrigerant:

- Commercial refrigeration
- Industrial process refrigeration
- Air conditioning systems

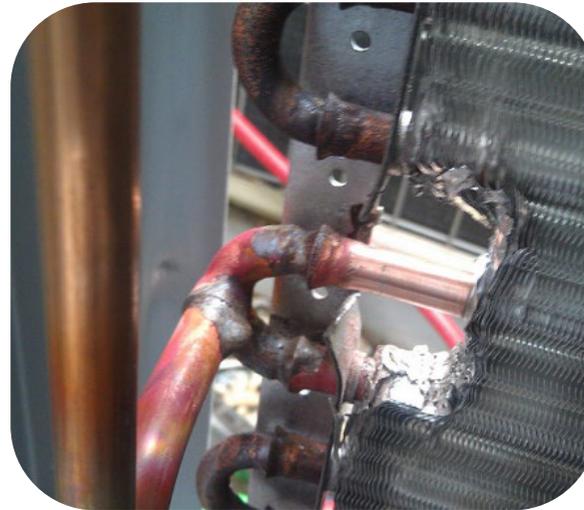
Projected WA HFC Emissions by End-Use



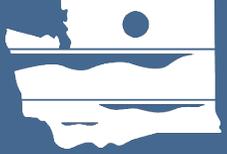
Refrigerant Leakage



Complex systems have many components and can fail at any time



In Washington, it is estimated that leaking equipment is responsible for more than 5.5 million metric tons of carbon dioxide equivalent emissions each year.



Methodology

Businesses in Washington

NAICS Codes

- Developed by Office of Management and Budget (OMB)
- Adopted in 1997
- Allows for comparability across North America

NAICS Selection Process

- CARB Statements of Reasons considered NAICS codes for their leak rate report
- Publicly available databases
- Using NAICS, we reviewed each sector and assigned a category:
 - Commercial Refrigeration
 - Industrial Process Refrigeration
 - Air Conditioning / Comfort Cooling

Emission Sub-categories

Washington businesses in each category are further broken down by square footage which allows categorization of businesses based on the assumed size of equipment.

- Small – 50 to 199 pounds
- Medium 200 to 1,499 pounds
- Large 1,500+ pounds

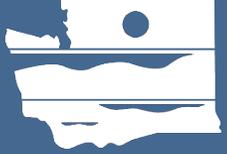
AND then

- Commercial Refrigeration – Centralized
- Commercial Refrigeration – Cold Storage
- Air Conditioning – Air conditioning
- Process Refrigeration – Process cooling

Breakdown of Businesses in WA

Equipment Type or Emissions sub-sector	Size	Units in WA 2020
Refrigeration Centralized	Small	1,270
Refrigeration Centralized	Medium	983
Refrigeration Centralized	Large	794
Refrigeration: Cold Storage	Small	328
Refrigeration: Cold Storage	Medium	153
Refrigeration: Cold Storage	Large	135
Refrigeration: Process Cooling	Small	87
Refrigeration: Process Cooling	Medium	581
Refrigeration: Process Cooling	Large	174
Air Conditioning	Small	37,431
Air Conditioning	Medium	25,659
Air Conditioning	Large	5,661

- Categorized by size:
 - Small – 50 to 199 pounds
 - Medium 200 to 1,499 pounds
 - Large 1,500+ pounds
- 360,000+ businesses in WA
- Potentially 73,000 will have RMP regulated equipment:
 - ✓ **4,505 Refrigeration systems**
 - ✓ **68,751 A/C systems**



Methodology

Calculations and Inputs

Calculation Method and Inputs

General Emission Formula:

$$\text{Emissions} = U \times C \times L$$

Emissions (lbs)

Units (**U**) = number of units in use

Charge (**C**) = average F-gas charge (lbs/unit)

Leak rate (**L**) = average annual leak rate
or loss rate

Engineering Factors*

$$1RT = 2,000lb \times \frac{144 BTU}{lb} \div 24 \text{ hour}$$

1 Refrigeration Ton (RT) = 12,000 BTU/hr
Refrigerant = 2 to 4 pounds/RT
Office Space Occupancy = 150 ft²/person

Cooling Requirements:

- Air conditioning
 - 25 BTUh/ft²
- Cold storage
 - 140 BTUh/ft²
- Frozen storage
 - 210 BTUh/ft²
- Per person occupancy
 - Additional 600 BTU/person

[*Calculating Cooling Loads \(engineeringtoolbox.com\)](http://engineeringtoolbox.com)

Commercial Refrigeration (Supermarkets)



Retail Food:

0.0225 lb/ft² commercial space*

- Small
 - 50 to 199 lbs
 - 2,200 – 8,899 ft²
- Medium
 - 200 to 1,499 lbs
 - 8,900 – 69,999 ft²
- Large
 - 1,500 lbs+
 - 70,000+ ft²

* CARB, 2009 – ARMINES Report, Inventory of Direct and Indirect GHG Emissions from Stationary Air Conditioning and Refrigeration Sources, with Special Emphasis on Retail Food Refrigeration and Unitary Air Conditioning

Commercial Refrigeration (Cold Storage)

Cold Storage

- 140 BTU/ft²*

Size Determinations:

- Small
 - 50 to 199 lbs
 - 1,400 – 5,699 ft²
- Medium
 - 200 to 1,499 lbs
 - 5,700 – 42,999 ft²
- Large
 - 1,500 lbs+
 - 43,000+ ft²

*BTU Calculator : Refrigeration Sizing | U.S. Cooler Walk-ins (uscooler.com)
Calculating Cooling Loads (engineeringtoolbox.com)

Commercial Refrigeration (Frozen Storage)

Frozen Storage

- 210 BTU/ft²*

Size Determinations:

- Small
 - 50 to 199 lbs
 - **950 – 3,799 ft²**
- Medium
 - 200 to 1,499 lbs
 - **3,800 – 27,999 ft²**
- Large
 - 1,500 lbs+
 - **28,000+ ft²**

*[BTU Calculator : Refrigeration Sizing | U.S. Cooler Walk-ins \(uscooler.com\)](#)

[Calculating Cooling Loads \(engineeringtoolbox.com\)](#)

Industrial Process Refrigeration

- Industrial process refrigeration often built subjectively
- Number of units determined solely by the number of businesses
- Size breakdown calculations:
 - Small
 - 30% of units
 - Medium
 - 40% of units
 - Large
 - 30% of units

Assumed natural refrigerants, up to 80% of units
(Ammonia, CO2, Hydrocarbons)

Air Conditioning

Refrigerant Charge =

$$\frac{[(\text{ft}^2 * 25 \text{ BTU/ft}^2) + (\# \text{ of employees} * 600 \text{ BTU/person})]}{\div (12,000 \text{ BTU/ton}) * 3 \text{ lb refrigerant/TON cooling}}$$

- Small
 - 50 to 199 lbs
 - **6,900 – 27,999 ft²**
- Medium
 - 200 to 1,499 lbs
 - **28,000 – 209,999 ft²**
- Large
 - 1,500 lbs+
 - **210,000+ ft²**

Ecology HQ Air Conditioning

Lacey HQ - rooftop units will fall within the requirements for the RMP

Leak Rates

Title VI of the Clean Air Act
Trigger Rates

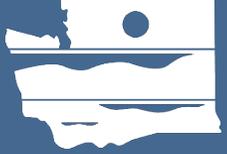
The following trigger rates
apply for a 12-month period:
Appliance Type

- Industrial Process Refrigeration, Leak Rate 30%
- Commercial refrigeration, Leak Rate 20%
- Comfort cooling, Leak Rate 10%
- All other appliance, Leak Rate 10%

Section 608 of the CAA, 40
CFR 82, Subpart F

Table from CARB, 2009

Equipment type	Refrigeration/ AC Equipment Type and Charge Size Category	Charge (lbs) / System	Avg. Annual Leak Rate – all systems
Refrigeration	Small Refrigeration Systems (>=50 lbs, <200 lbs)		
Refrigeration	Refrigerant Condensing Units	122	14%
Refrigeration	Medium Refrigeration Systems (>=200 lbs, <2,000 lbs)		
Refrigeration	Centralized Refrigeration System	704	15%
Refrigeration	Cold Storage	565	36%
Refrigeration	Large Refrigeration Systems (>=2,000 lbs)		
Refrigeration	Centralized Refrigeration System	2,486	21%
Refrigeration	Cold Storage	7,546	27%
Refrigeration	Process Cooling	3,640	7%
Air Conditioning	Small AC Systems (>=50 lbs, <200 lbs)		
Air Conditioning	Unitary AC Systems	100	11%
Air Conditioning	Medium AC Systems (>=200 lbs, <2,000 lbs)		
Air Conditioning	Centrifugal Chiller	1,007	1%
Air Conditioning	Packaged Chiller	526	7%
Air Conditioning	Large AC Systems (>=2,000 lbs)		
Air Conditioning	Centrifugal Chiller	3,978	2%



Methodology

Presenting the preliminary results

Emissions (pounds of refrigerant loss)



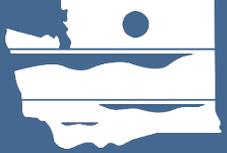
Equipment Type or Emissions sub-sector	Size	Units in WA 2020	Average Charge (amount) of F-gas in lbs.	Annual Leak (loss) Rate	Annual Loss in lbs (Units x Charge x loss rate)
Refrigeration Centralized	Small	1270	125	20.00%	31,756
Refrigeration Centralized	Medium	983	704	20.00%	138,439
Refrigeration Centralized	Large	794	3,635	20.00%	577,456
Refrigeration Cold Storage	Small	328	122	20.00%	7,995
Refrigeration Cold Storage	Medium	135	7,929	20.00%	214,003
Refrigeration Cold Storage	Large	153	494	20.00%	15,120
Air Conditioning	Small	37431	100	10.00%	374310
Air Conditioning	Medium	5661	3,978	10.00%	2,251,945
Air Conditioning	Large	25659	767	10.00%	2,037,324
Refrigeration Process Cooling	Small	174	125	30.00%	6,536
Refrigeration Process Cooling	Medium	581	1,100	30.00%	191,730
Refrigeration Process Cooling	Large	87	5,242	30.00%	137,052

Refrigerant Break Down

- 1st Generation Refrigerants
 - Natural Refrigerants
 - CFCs
- Transition from ODS Refrigerants
 - HCFC
 - HFC
- Transition to Low GWP Refrigerants
 - Natural Refrigerants
 - Low GWP Alternatives

2020 Emissions (MMTCO2e)

	Size	Charge amount	Refrigerant in lbs	Subtotals CFCs	Subtotals HCFCs	Subtotals HFCs	total by sub-sector
Retail Food	Small	50 to 200 lbs	31,756	0.0102	0.0049	0.0293	0.0445
	Medium	200 to 1,500 lbs	138,439	0.0006	0.0248	0.1528	0.1782
	Large	1,500 lbs+	577,456	0.011	0.1005	0.6783	0.7898
Cold Storage	Small	50 to 200 lbs	7,995	0.0009	0.0018	0.0096	0.0123
	Medium	200 to 1,500 lbs	15,120	0.0016	0.0034	0.0182	0.0232
	Large	1,500 lbs+	214,004	0.0267	0.0501	0.2514	0.3281
Industrial Process Refrigeration	Small	50 to 200 lbs	6,536	0.0021	0.0008	0.0041	0.0069
	Medium	200 to 1,500 lbs	191,730	0.0484	0.0225	0.1235	0.1944
	Large	1,500 lbs+	137,052	0.0302	0.0156	0.0904	0.1363
Air Conditioning	Small	50 to 200 lbs	375,310	0	0.2139	0.1077	0.3216
	Medium	200 to 1,500 lbs	2,037,325	0.8022	0.5177	0.8074	2.1273
	Large	1,500 lbs+	2,251,946	0.4638	0.0963	1.1199	1.68
Totals			5,952,913	1.3976	1.0523	3.3927	5.8426



Next Steps

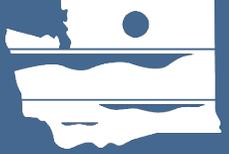
Refrigerant Management Program

Development & Implementation of the RMP

- For systems with ≥ 50 lbs. refrigerant
 - Both stationary refrigeration units and a/c
- Establish guidelines for leak detection & reporting requirements
 - Determined through rulemaking
 - May phase in requirements
- Expand database to
 - Additional reporting metrics
 - Streamline w/ CARB, where possible
- Hire compliance inspectors

Choosing a Leak Rate

Emissions sub-sector	System Size	EPA Trigger Leak (loss) Rate	Annual Leakage (lb)	CARB Identified Leak Rates		-20% of EPA Trigger		-30% of EPA Trigger	
Refrigeration Centralized System	small	20.00%	31,756	15.00%	23,817	16.00%	25,405	14.00%	22,229
	medium	20.00%	138,438	17.60%	121,826	16.00%	110,751	14.00%	96,907
	large	20.00%	577,456	16.60%	479,288	16.00%	461,964	14.00%	404,219
Refrigeration Cold Storage	small	20.00%	7,995	11.30%	4,517	16.00%	6,396	14.00%	5,596
	medium	20.00%	15,120	18.90%	14,288	16.00%	12,096	14.00%	10,584
	large	20.00%	7,995	11.30%	4,517	16.00%	6,396	14.00%	5,596
Air Conditioning	small	10.00%	374,310	11.30%	422,970	8.00%	299,448	7.00%	262,017
	medium	10.00%	1,966,762	1.40%	275,346	8.00%	1,573,409	7.00%	1,376,733
	large	10.00%	2,251,945	2.30%	517,947	8.00%	1,801,556	7.00%	1,576,362
Refrigeration Process Cooling	small	30.00%	6,536	10.00%	2,178	24.00%	5,229	21.00%	4,575
	medium	30.00%	191,730	10.00%	63,910	24.00%	153,384	21.00%	134,211
	large	30.00%	137,052	10.00%	45,684	24.00%	109,641	21.00%	95,936
Total (lb)			5,913,107		2,141,908		4,730,485		4,139,175
MMTCO2e (Total)			5.8426		2.2956		4.674		4.0898



Questions

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- Outreach & Engagement Janée Zakoren
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Ecology HFC Webpages:

Compliance assistance, submitting reports

- [Hydrofluorocarbons - Washington State Department of Ecology](#)

Rulemaking and Meetings

- [WAC 173-443-455 - Washington State Department of Ecology](#)

Informal comments:

- [Rulemaking - Informal Comment Period on Hydrofluorocarbons \(HFCs\) Rule and Air Quality Fee Rule \(commentinput.com\)](#)

More
Information

Use QR to learn
more about the
HFC transition in
Washington state.



Thank you