Advanced Wastewater Treatment Technology

Mechanical Vapor Recompression and Membrane Polishing

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Introduction

- What is this new wastewater treatment technology?
- How does it fit within an existing manufacturing facility?
- How does each step work, and work together?
- Cost Comparison
- Advantages to Chemical Managers
- Summary

Basic Issue With Wastewater Treatment

Manufacturing Facility | **Wastewater** | **Wastewater Treatment** | **Two Waste By-products**

Aluminum Processing Facility

→ Waste Water Treatment System

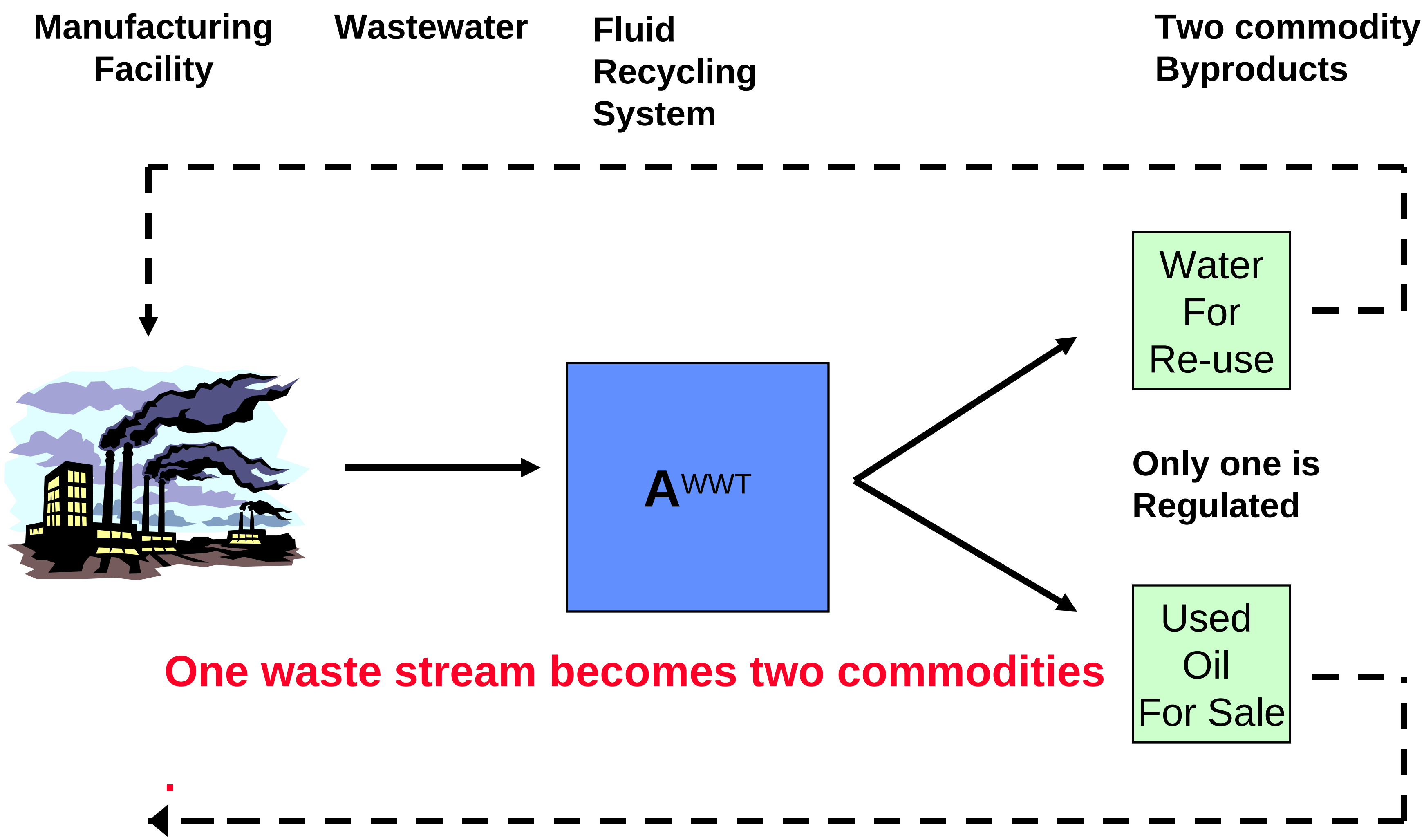
→ Waste-Water — **Cost To Discharge** →

Both are Regulated

→ Used Oil Sludge — **Cost To Haul** →

One waste stream becomes two waste streams

Advanced Waste Treatment Makes Sense



Design Objective

Treat any oil-like liquid, both water dilutable and not, such as from aluminum metalworking fluids, detergents and similar process fluids

- Separate the water phase for re-use
- Separate the oil-like phase for sale.

Oil-like materials can be from mineral, vegetable and animal origin.

- **Why ?**
  - Economic benefits
  - One less regulatory issue to worry about.
  - Improves environmental image, both internally and externally

What are Some of the Contaminants in Aluminum Metalworking Wastewaters?

Increasing Solubility

- **Hydrocarbon Products (Floatable, Suspended / emulsifiable, and Settleable Organics)**
  - Petroleum Oils, Vegetable Oils, Animals Oils, Waxes, Fatty Acid Soaps (Ca, Fe, Al), Chlorinated Esters and Paraffins
- **Floatable, Suspended, and Settleable Solids**
  - Graphite, Vibratory Debur, Floor "Dirt"

- **Metals**
  - Iron , Aluminum, Copper, Lead, Chrome, Zinc, Nickel, Manganese, Molybdenum
- **Non-metals**
  - Arsenic, Selenium
- **Dissolved Solids**
  - Salts (Sodium and Potassium Salts)

- **Dissolved Organics**
  - Amines, Amides, Esters, Glycols, Surfactants, Detergents, Fatty Acids, Fatty Alcohols, Antimicrobials, Phosphate Esters

Common Treatment Approaches

Chemical treatment

- Salt Splitting
- Polymer with / without salt splitting

Membrane Separation

- Ultrafiltration
- Microfiltration

Combined Technologies

- Chemical / Biological
- Membrane / Biological
- Membrane / Biological / Membrane
- Membrane / Membrane (UF/RO or UF/NF)

Issues With Common Treatment Approaches

Chemical

- Inflexible on various wastes
- Requires skilled Operator
- Creates salts within the process

Membrane (single)

- Membrane sensitive to fouling
- Salts and metals pass through membrane

Biological

- Not every chemical is readily biodegradable
- Industry is moving toward bio-stable chemistries

Combined Technologies

- Issues are generally compounded, not reduced
- High Reject rates

Product Rate to Reject Rate

Manufacturing Facility | **Wastewater** | **Wastewater Treatment** | **Two Waste By-products**

Aluminum Processing Facility

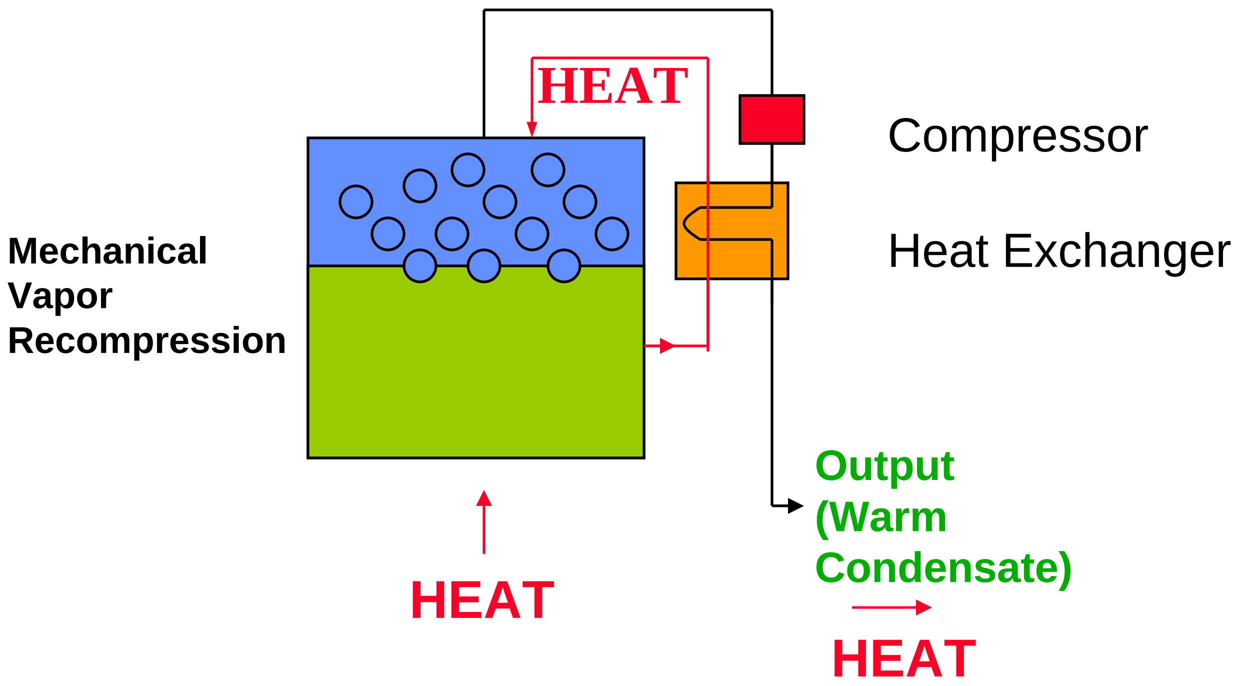
→ Waste Water Treatment System

Product 98% → Waste-Water

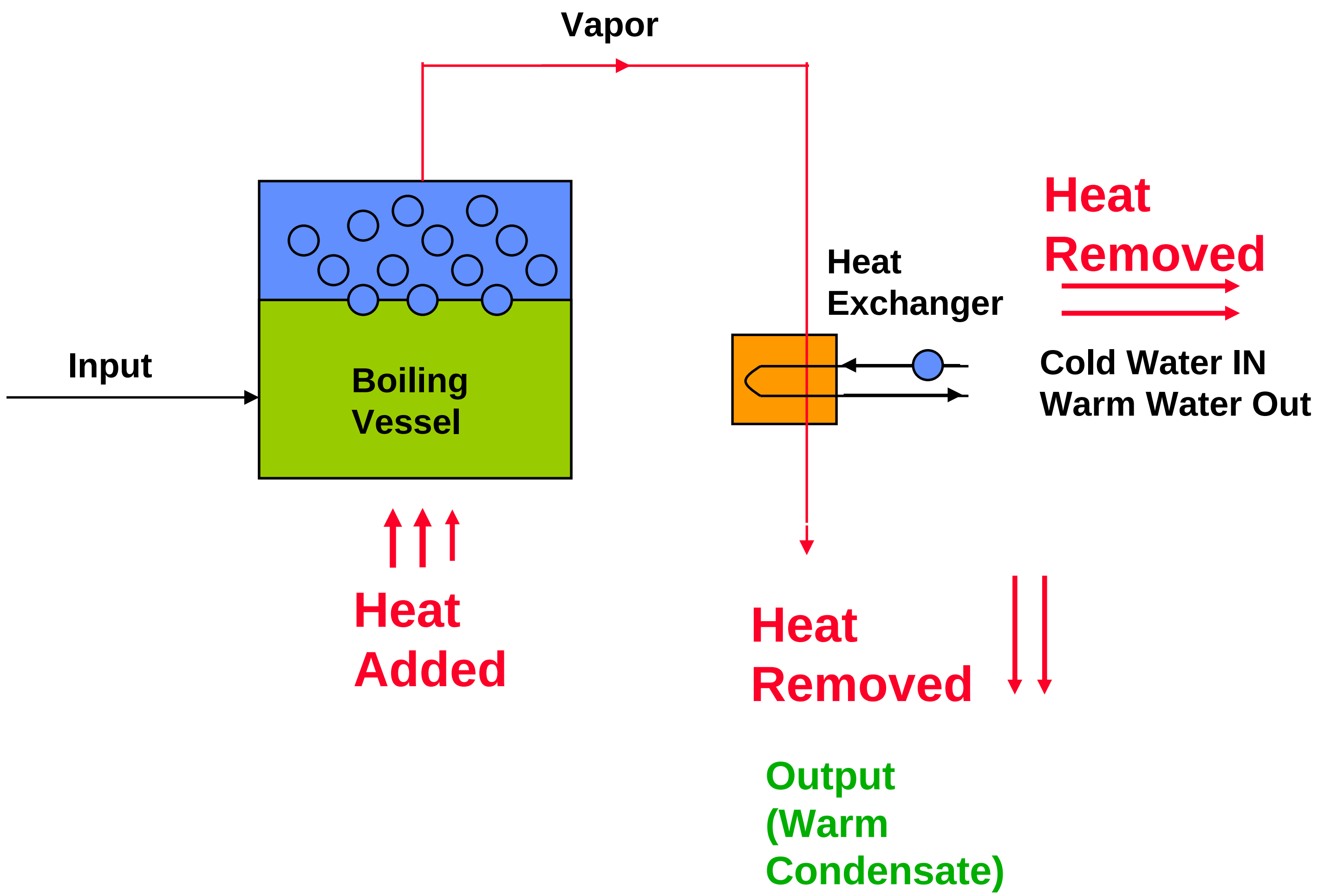
Reject 2% → Used Oil Sludge

So What is Mechanical Vapor Recompression?

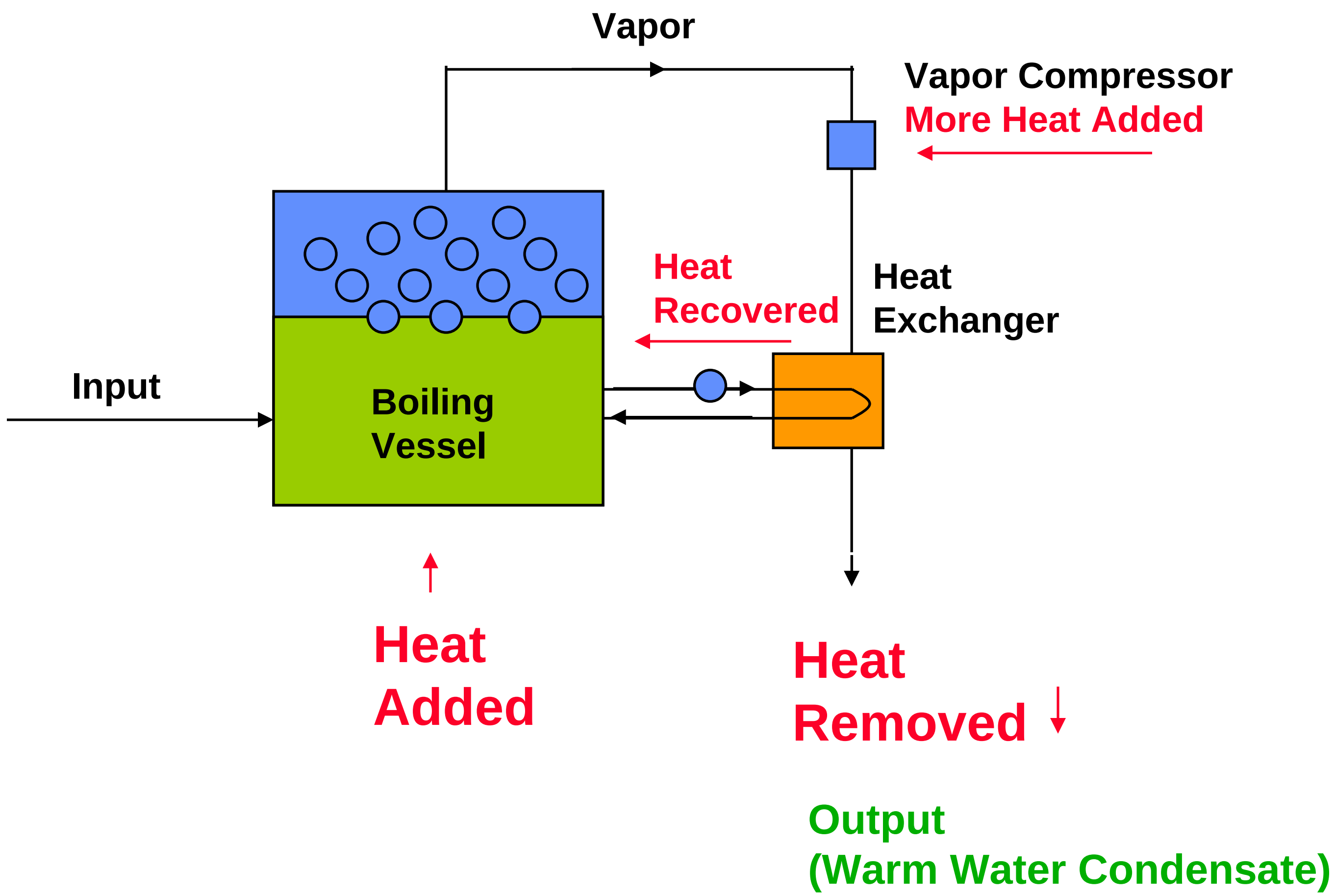
1. **Distillation, Followed by**
2. **Mechanical Compression of the Distillate**
3. **Recovery of the Heat into the Boiling Zone**
4. **Condensing of the Vapor**



Conventional Distillation /Condensation Model



Conventional Mechanical Vapor Compression Distillation Model



Current Technology
Basic Thermal Evaporation

- **Purpose:**
  - Concentrate waste by evaporating water using thermal energy

Basic Thermal Evaporation

Two forms of energy required to boil water:

a. Raise water to boiling (212 Degrees F)

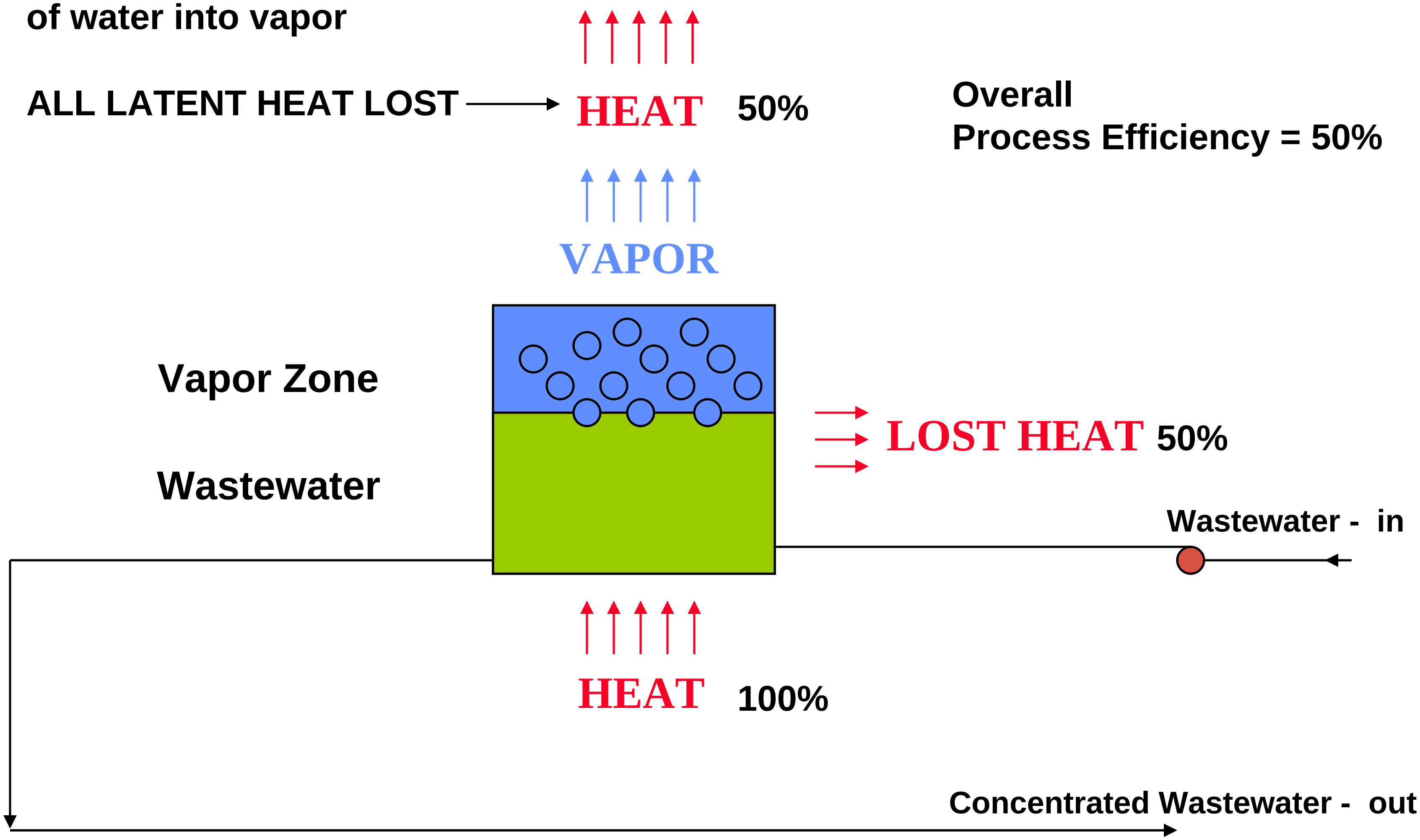
Sensible heat (1 BTU required to raise one pound of water one degree F)

b. Turn water into steam at 212 degrees F)

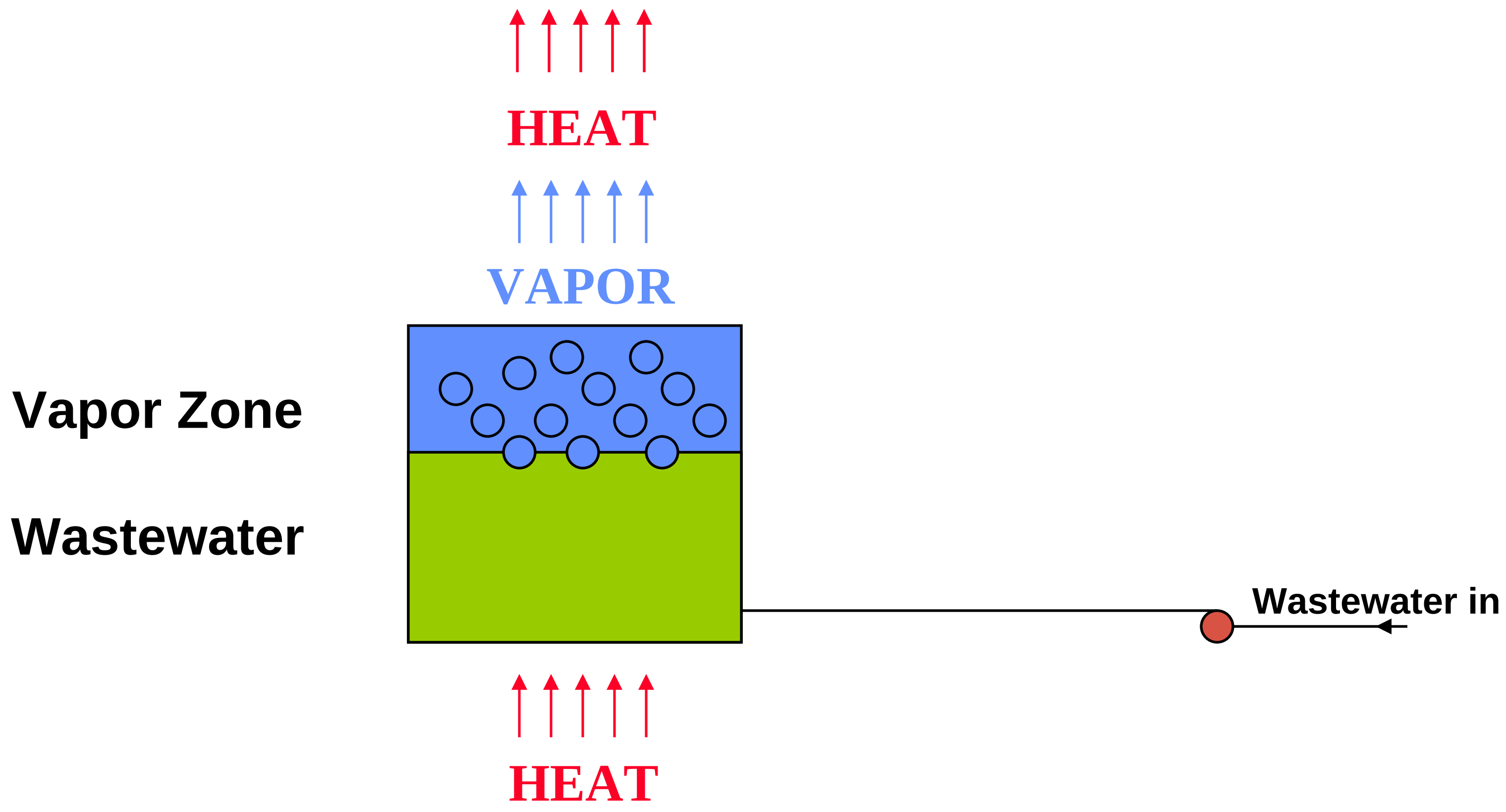
Latent Heat (960 BTUs required to turn one pound of water at 212 degrees F into steam vapor at 212 degrees F)

Basic Thermal Evaporator Model

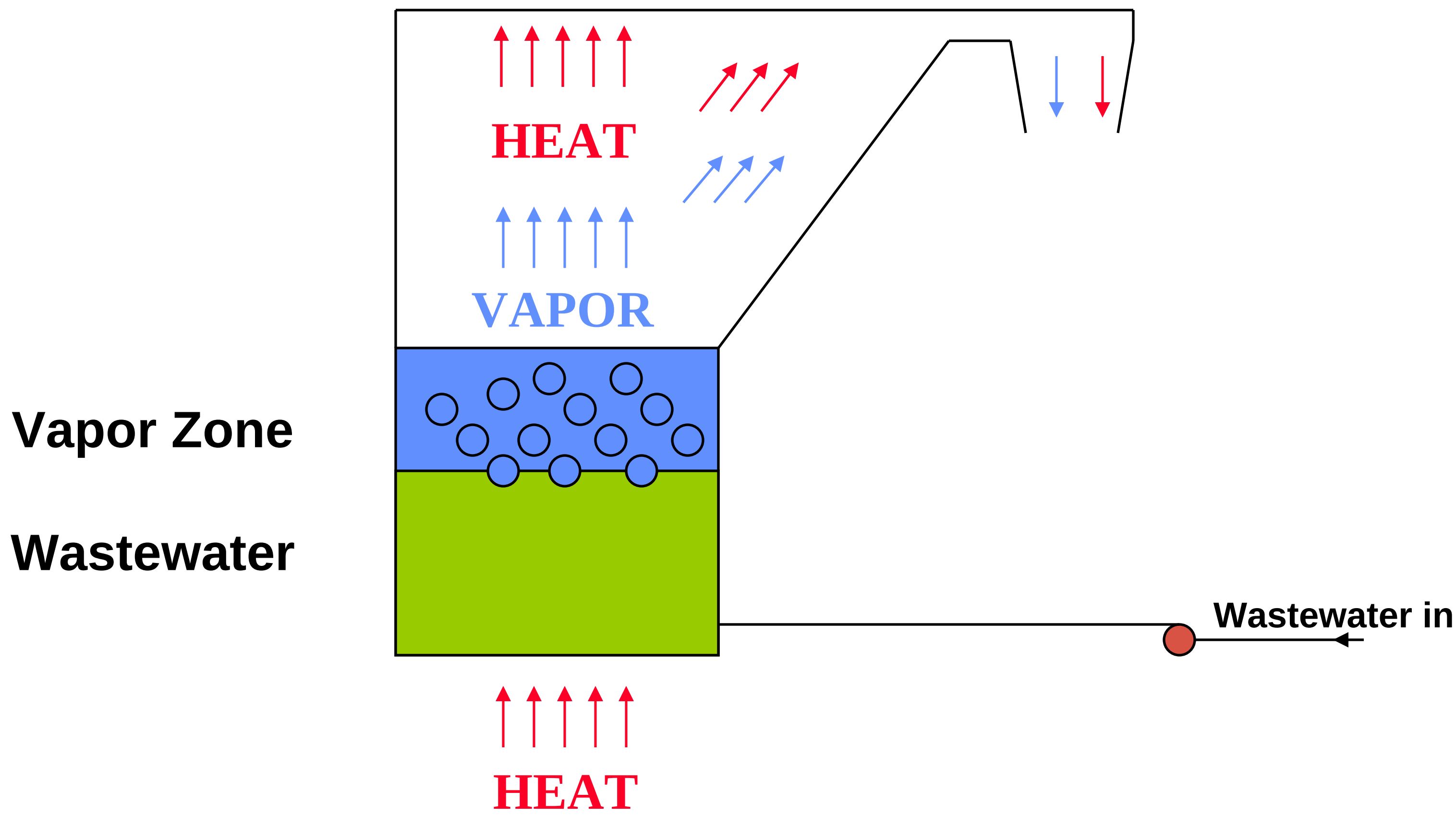
960 BTUs/ to turn one pound of water into vapor



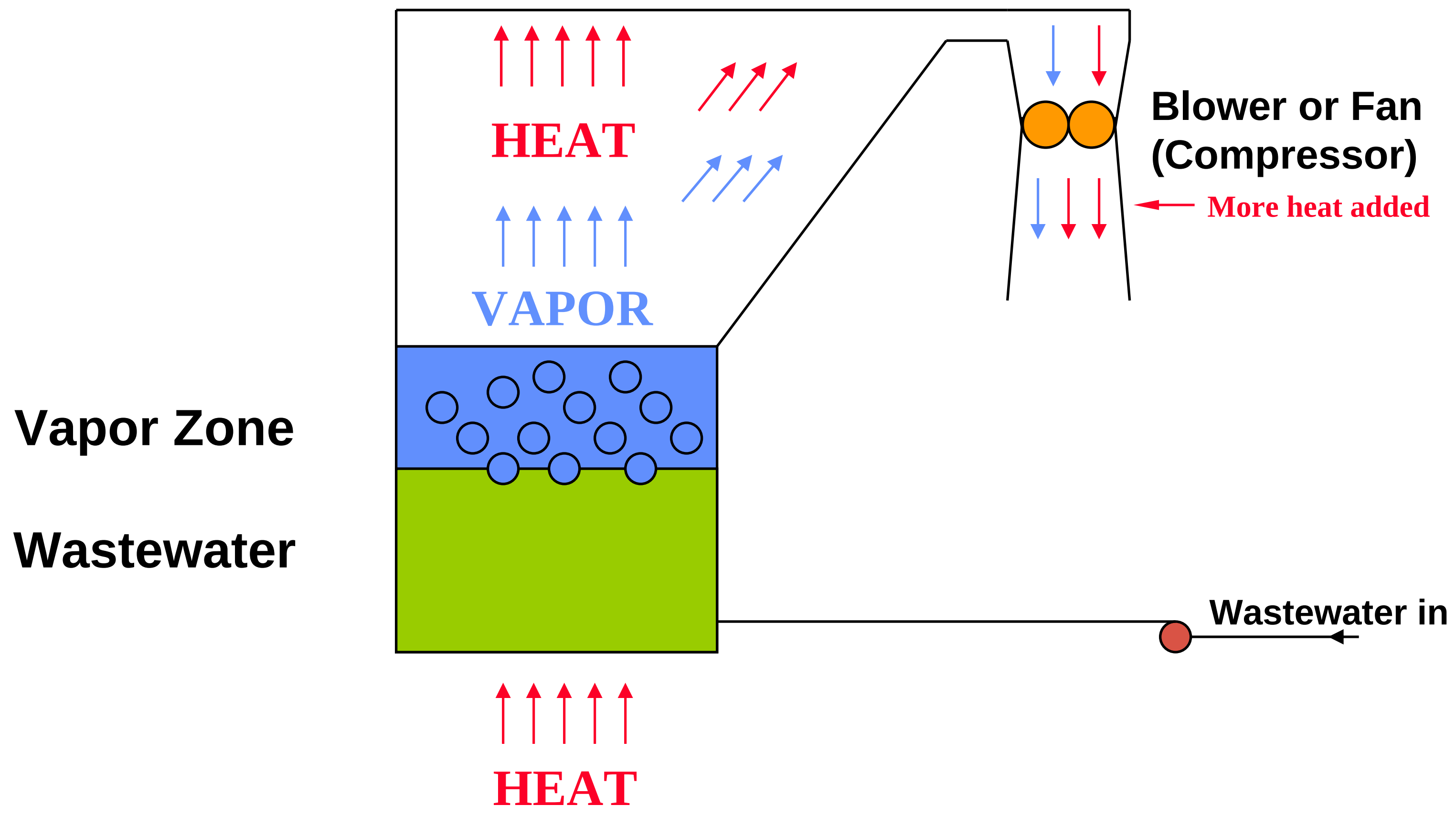
Basic Mechanical Vapor Compression Evaporator Model



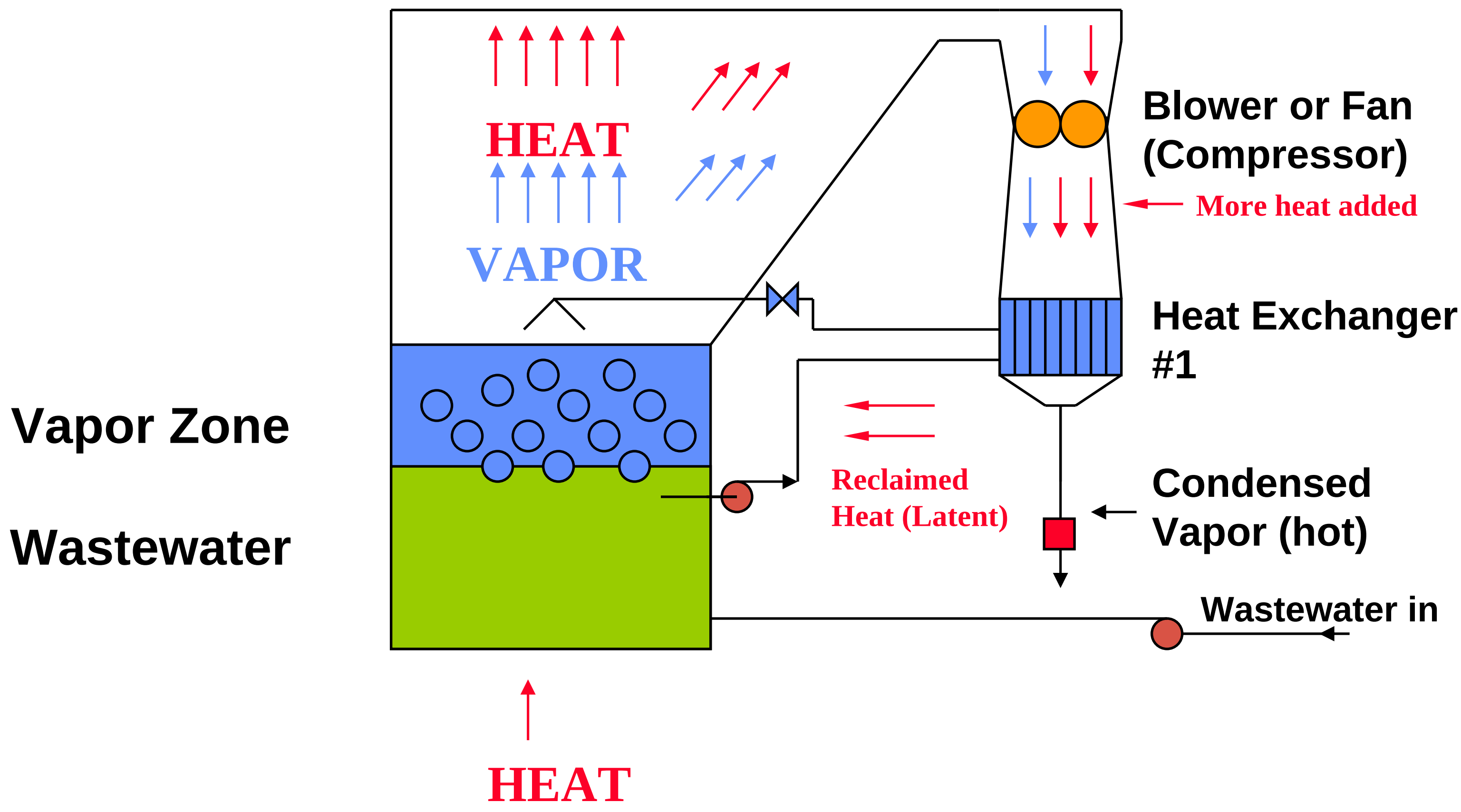
Basic Mechanical Vapor Compression Evaporator Model



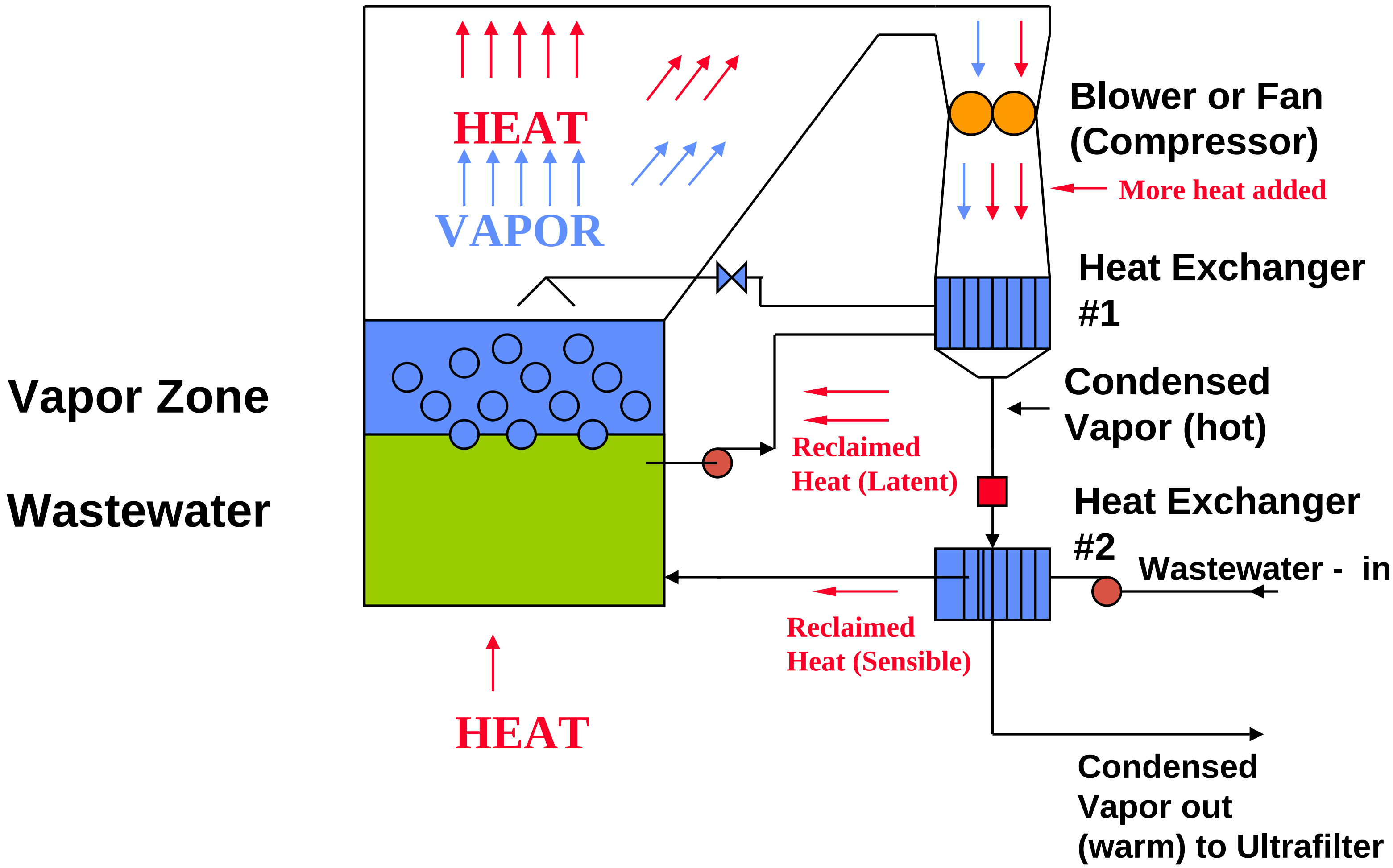
Basic Mechanical Vapor Compression Evaporator Model



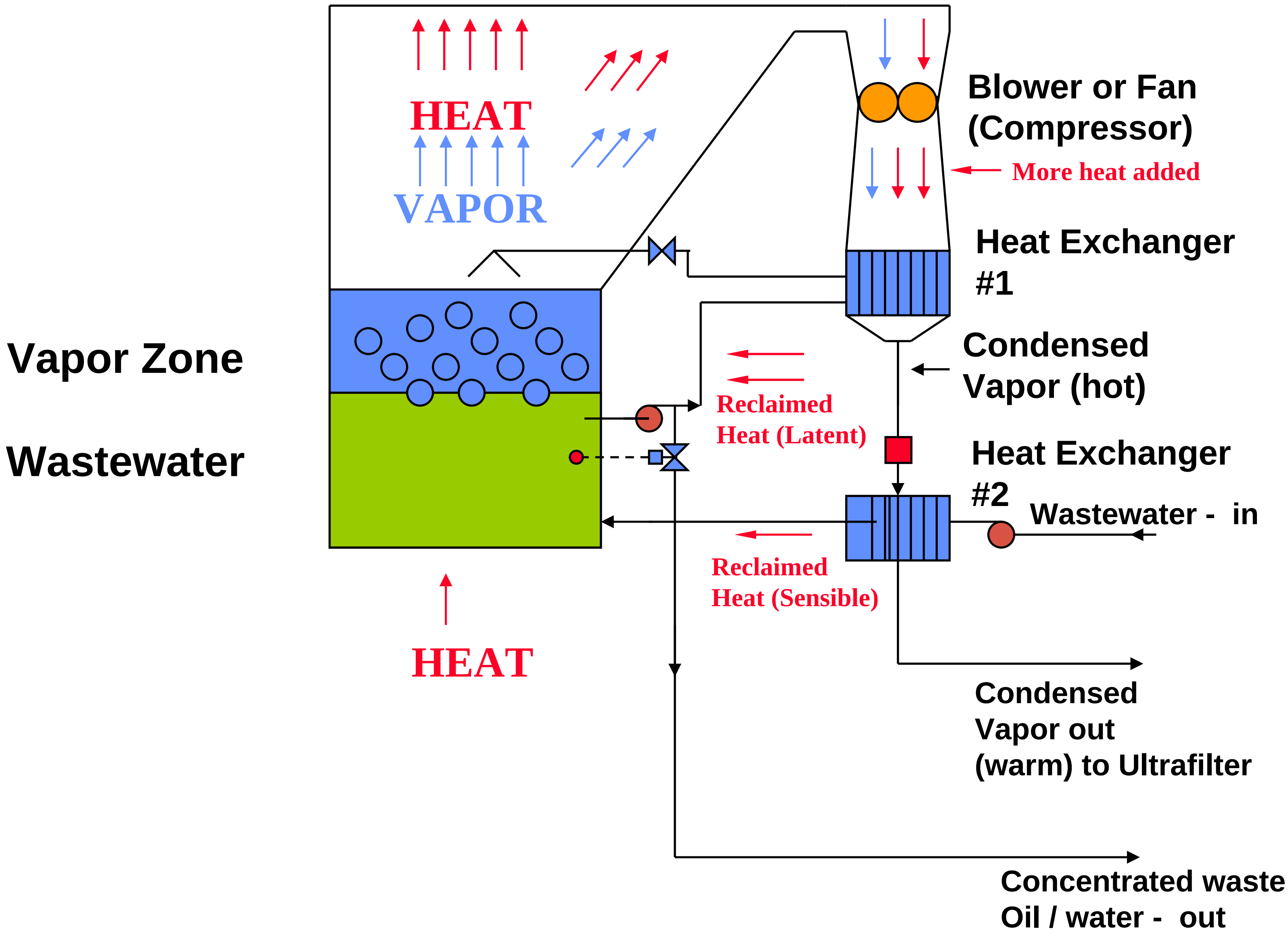
Basic Mechanical Vapor Compression Evaporator Model

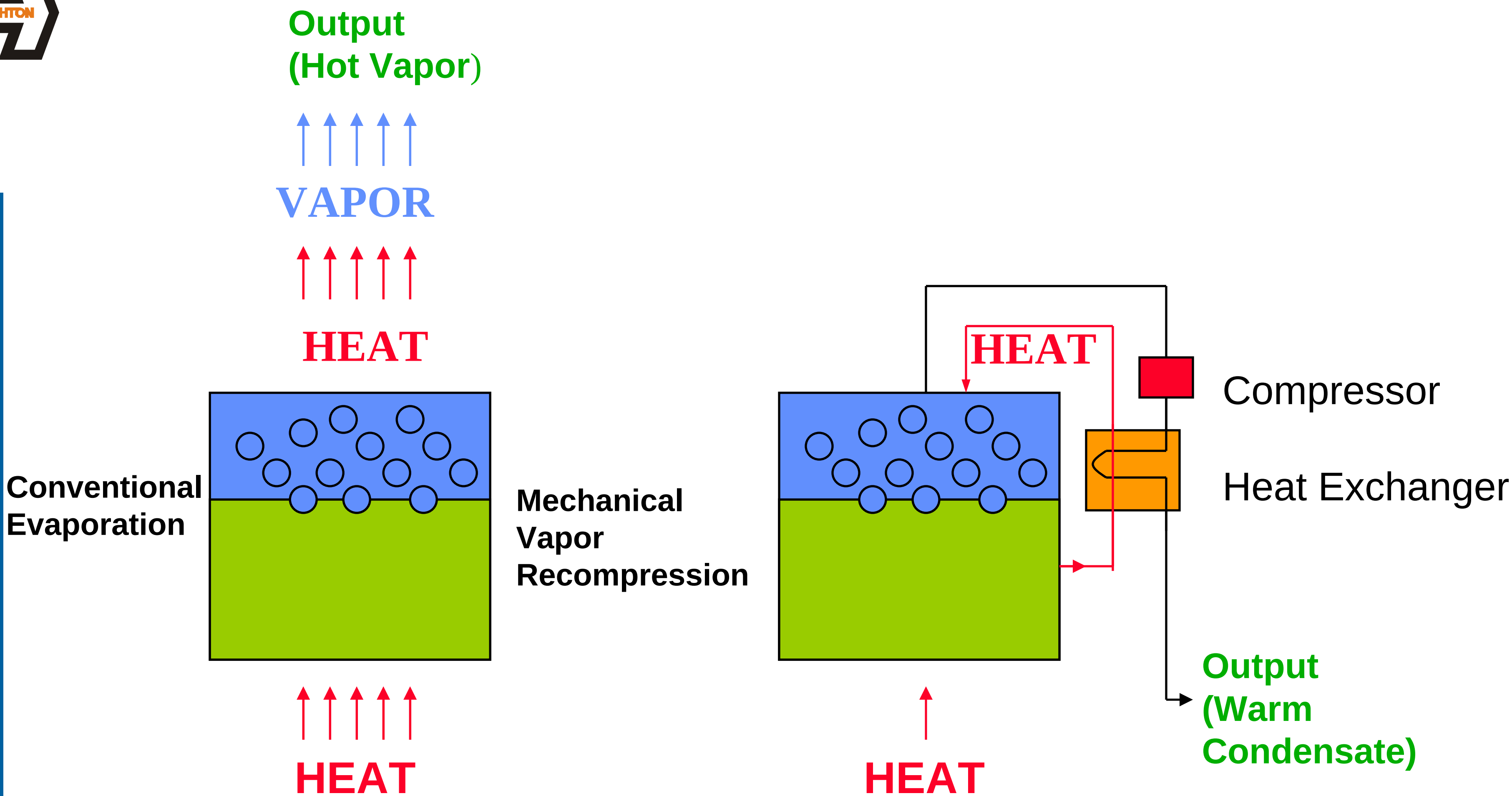


Basic Mechanical Vapor Compression Evaporator Model



Basic Mechanical Vapor Compression Evaporator Model





960 BTUs/ to turn one pound of water into vapor

1 BTUs to raise one pound of water one degree Fahrenheit

Cost Comparison
Conventional Evaporation VS. Mechanical Vapor Recompression

Energy Required to Treat 1,000 Gallons of Oily Wastewater

Conventional Evaporation @ 50 % Efficiency	Mechanical Vapor Recompression As Measured
15,936,000 BTUs	920,833 BTUs
	(16.2 X less energy)

Lab Test Evaporation / Condensation Unit


20 Gallon Per Minute Unit

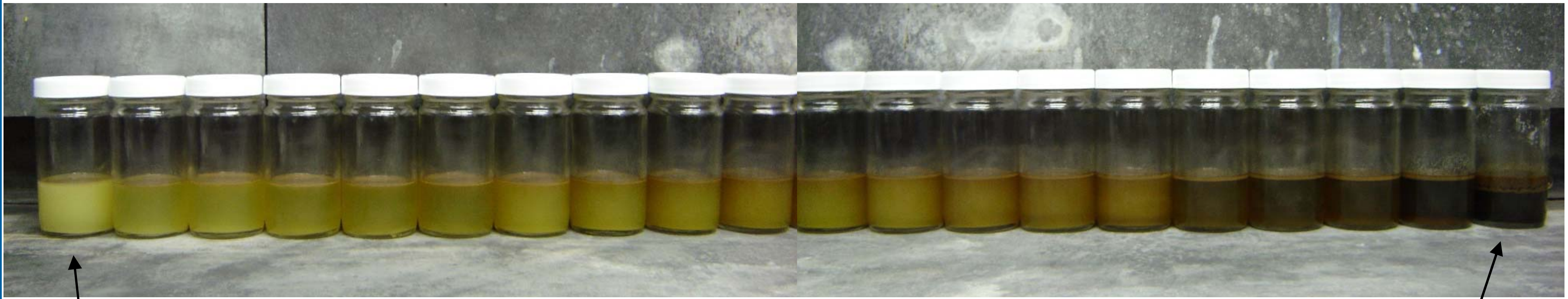
Influent Feed Pump

Primary Heat Exchanger

Secondary Heat Exchanger

Recirculating Pump

Progressive View of Sample Concentration



Less than 1% oil → 80% oil

Starting Sample

Concentrate from MVR
99.7 % Volume Reduction

Salable Oil

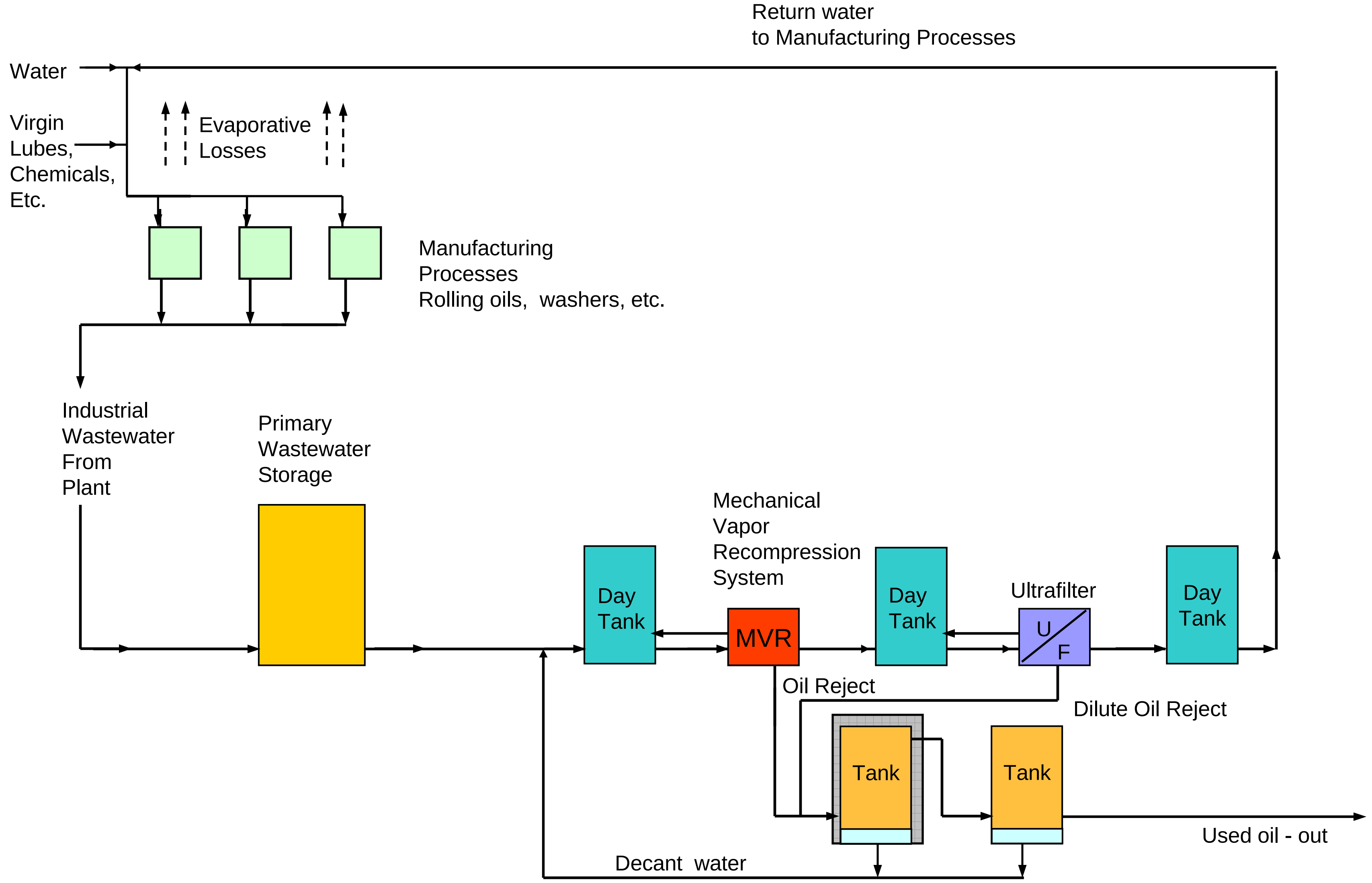
Treatment Process Steps

1. **Storage and flow equalization**

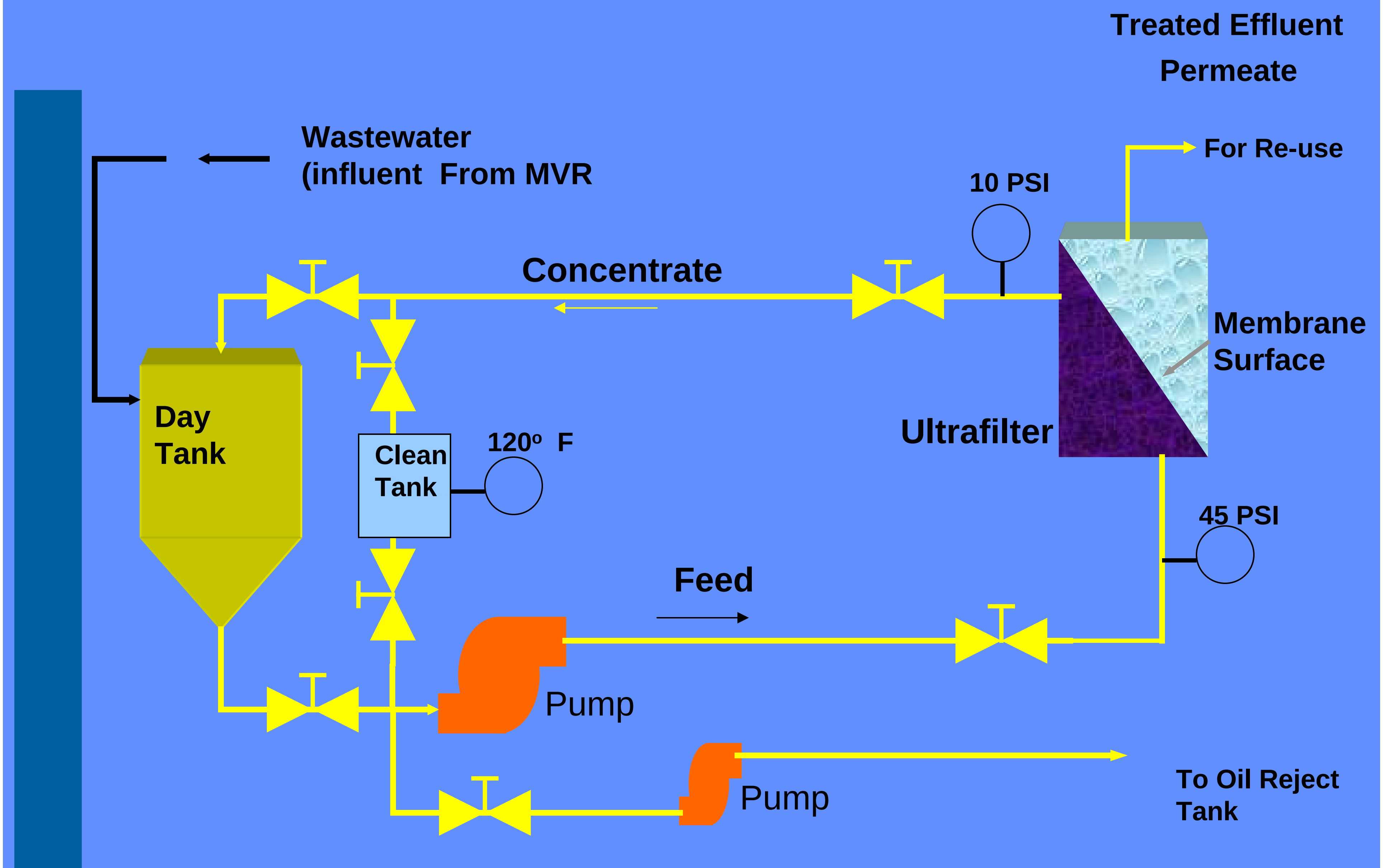
2. **Emulsified oil, most soluble organics, metals, and fine solids separation (Mechanical Vapor Recompression Distillation System)**

3. **Trace insoluble organic separation (Ultrafilter System)**

Overall Flow Schematic



Basic Ultrafilter Model - Flow Schematic



Ultrafilter 50 Gallons Per Minute

Starting Sample

Condensed Distillate From MVR

Polished Sample After Ultrafilter

Design Objective

Must Meet the The Basic Requirement

1. **Does it fit with the Personality of the Organization?**

   - **All Mechanical System**
   - **No Chemicals (Defoamer, UF Detergent)**
   - **Industry Common Components**
     - **Blowers**
     - **Pumps**
     - **Heat Exchangers**
     - **Automatic Valves**
     - **Steam Traps**
   - **Easily Automated**
   - **Easy to Trouble Shoot**
   - **Energy Efficient**

System Performance

	Influent	Effluent
BOD5	5,000 – 10,000	200 - 400
COD	20,000 – 35,000	400 - 650
Oil and Grease	500 _ 5,000	< 10
TPH	250 – 3,500	< 5
TKN	200 – 400	< 20
TDS	5,000 – 10,000	< 20
TSS	3,000 – 6,000	< 0.1
Fe	300	< 0.01
Zn	15	< 0.01
Cu	5	< 0.01
Pb	2	< 0.01
Ni	1	< 0.01
pH	8.0 – 8.8	7.0 – 7.5

System Performance
Operating Cost Comparison
Cost ($ USD) / 1000 US Gallons

Method		Chemicals	Electricity	Total
Chemical Methods	NOR	$ 4.00	$ 1.00	$ 5.00
	WOR	$ 5.00	$ 2.00	$ 7.00
	WOR+ ATR	**$ 5.05**	**$ 5.50**	**$ 10.55**
	Product / Reject Ratio			**65 / 35**
Membrane Methods	NOR	$ 0.50	$ 2.50	$ 3.00
	WOR	$ 1.50	$ 3.50	$ 5.00
	WOR+ ATR	**$ 1.55**	**$ 7.00**	**$ 8.55**
	Product / Reject Ratio			**70 / 30**
MVR/ UF	**WOR + ATR**	**$ 0.00**	**$ 4.00**	**$ 4.00**
	Product / Reject Ratio			**99 / 1**

NOR = No oil recovery
WOR= With Oil recovery
ATR = Ability To Recycle Water phase back into the process
Energy cost assumed at $ 0.05 / kilowatt-hour

Benefits to Chemical Managers

Allows the use of more complex metalworking fluids and detergents.

Can be applied where water is scarce

Can be applied where discharge to local sewer is restricted

Can be added on to existing treatment (only MVR required?)

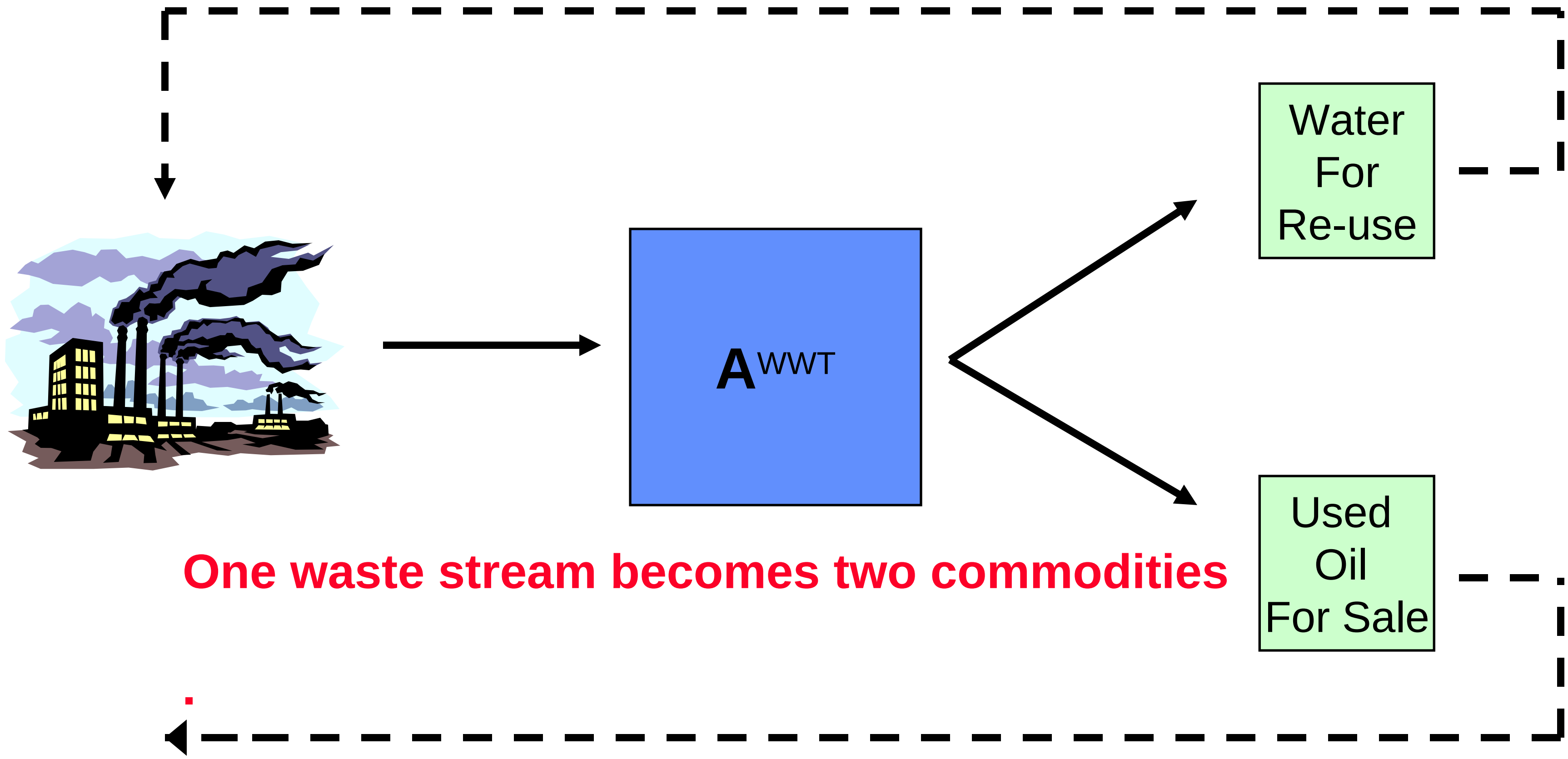
Turns oil into a commodity (adds value).

Easily Automated.

Summary

Advantage

- <u>**One waste stream becomes two commodities.**</u>



Thank You

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