Alan Rossiter

Executive Director, External Relations/Educational Program Development, UH Energy, University of Houston, since March 2019.

Engineering positions with Imperial Chemical Industries (ICI) (England), and SABIC (Saudi Arabia).

Linnhoff March, Inc., USA - industrial energy efficiency and waste minimization consulting. Several roles, including president.

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Bachelor's, master's, and doctoral degrees in chemical engineering from the University of Cambridge.

Licensed professional engineer (Texas), and Fellow of the American Institute of Chemical Engineers.

Harvey and the Beauty of the Steady State

TIEEP Energy Forum

April 2, 2020

Alan Rossiter

UH Energy, University of Houston

Estimated cost: $125 billion

TABLE 1. Harvey impacts on US petrochemical capacity, August 29, 2017. Credit: ICIS Supply & Demand database, ICIS analysis	
Petrochemical	Reduction in capacity due to shutdowns
Ethylene	36.6%
Benzene	31.1%
Polyethylene	25.5%
Polypropylene	24.8%
Propylene	23.3%

Source: Lessons learned from Hurricane Harvey, Laura Cassidy, Inform (AOCS), www.aocs.org/stay-informed/inform-magazine/featured-articles/lessons-learned-from-hurricane-harvey-march-2018
Accessed February 25, 2020

Harvey Also Obliterated Energy Efficiency

One Simple Equation…

Energy Intensity = Energy Consumption/Production
EI = EC/P

…says it all

Energy intensity rises (and efficiency falls) if:
- energy consumption increases
- production decreases
- especially during unstable or abnormal operations

Our Agenda

A. Detailed examples

    1. Summer rainstorms

    2. Throughput cuts

B. Other situations

C. Apply observations to Harvey

D. Mitigation options

$$EI\downarrow = EC\uparrow \ / \ P\uparrow$$

Our Agenda

A. Detailed examples

    1. Summer rainstorms

    2. Throughput cuts

B. Other situations

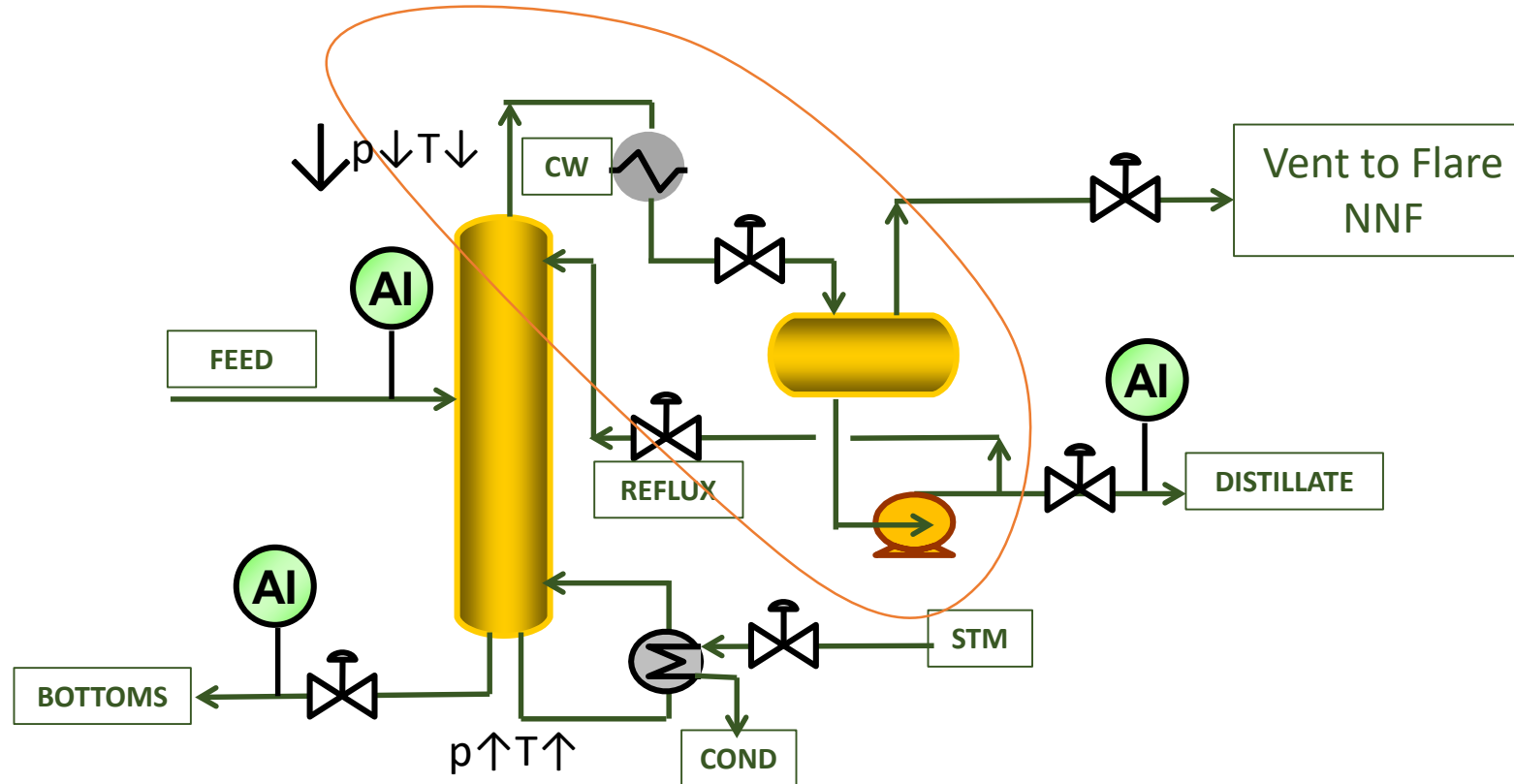C. Apply observations to Harvey

D. Mitigation options

Example 1: Summer Rainstorms

Distillation Column Performance

Many Overhead Systems are NOT Insulated

Courtesy: Charles Herzog

What Happens to the Column During a Rainstorm?

- Uncontrolled increase in condenser duty
- Pressure decreases rapidly
- Tray liquid vaporizes, goes to reflux drum
- Heavy ends contaminate distillate product
- Off-spec material has to be reprocessed

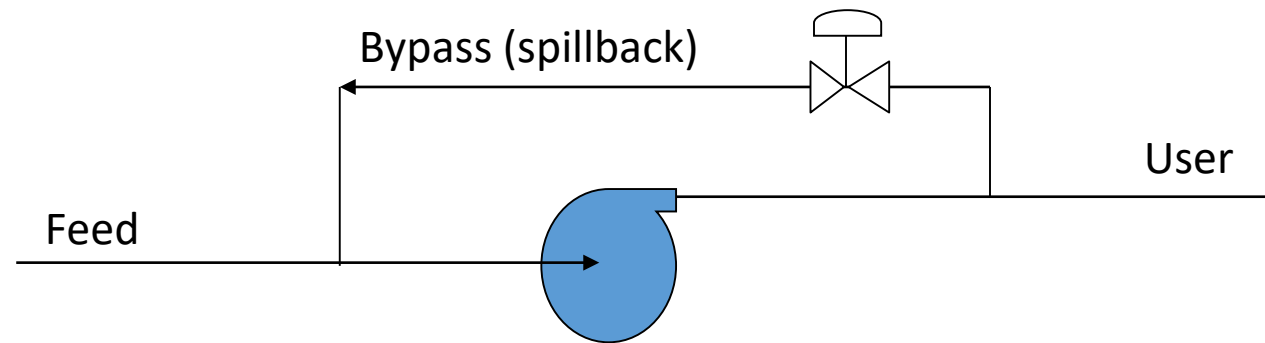$$EI \uparrow \uparrow = EC \uparrow / P \downarrow$$

Courtesy: Charles Herzog

Example 2: Throughput Cuts

Control of Centrifugal Pumps

Pump Control

i. Bypass Control

Bypass Control is Typically the Least Efficient Option

Pump

Feed

F

F+f

F+f

F+f

CW Supply

CW Return

Spillback

f

FIC

To User
(Constant
Pressure)

F
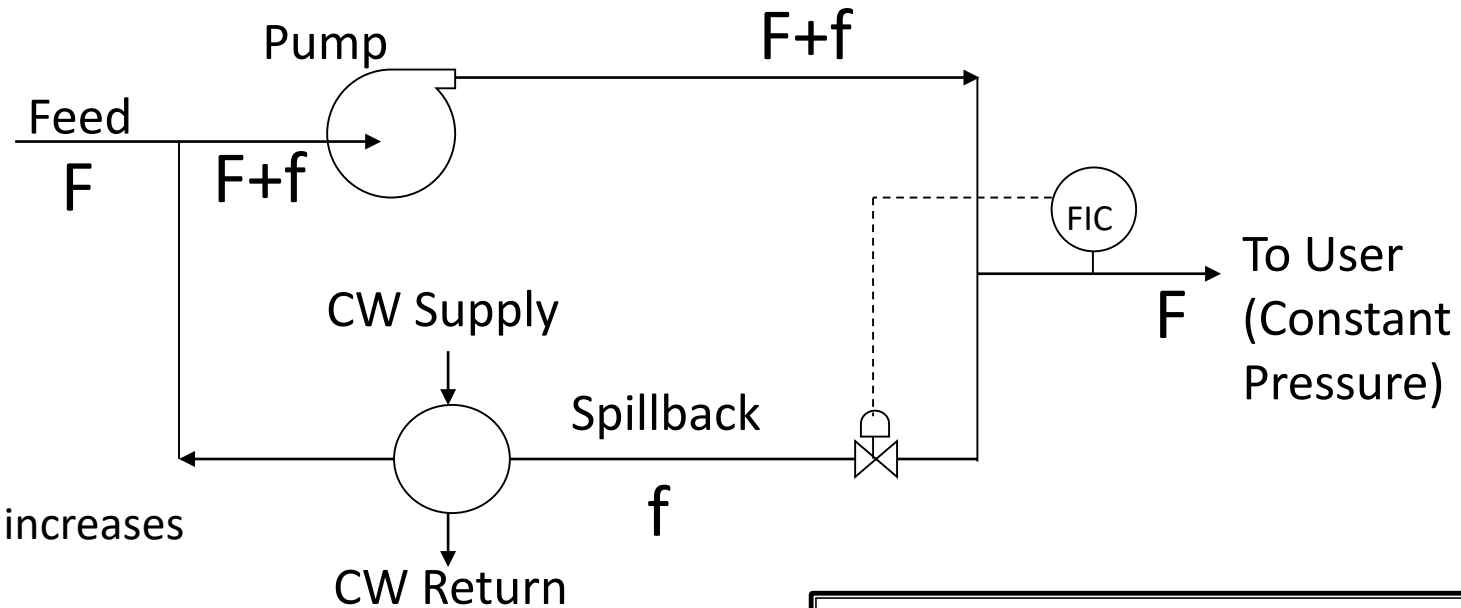
To reduce throughput F:
Spillback valve opens - f increases
F decreases
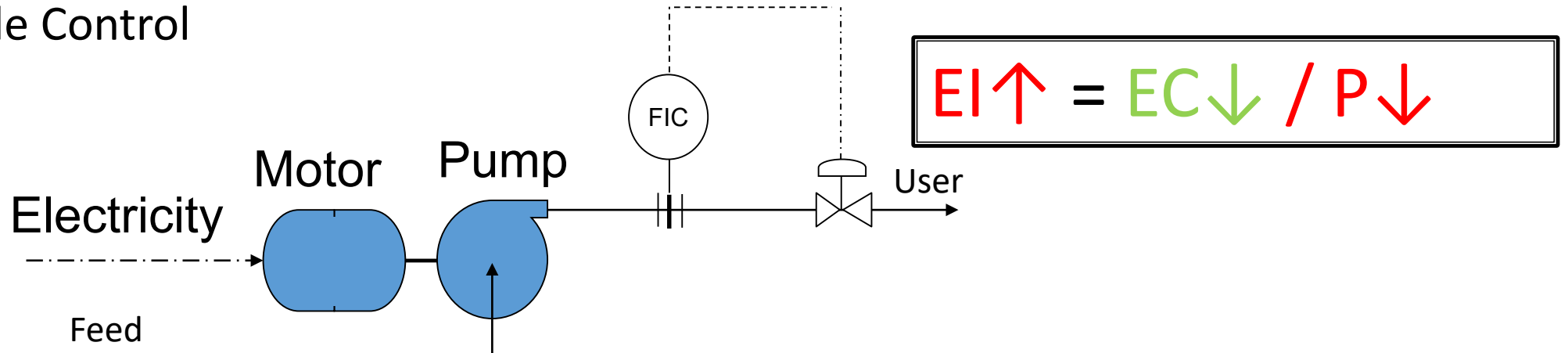Pressures in and out of pump ~constant.
F+f stays ~constant
Pump power stays ~constant

EI↑ = EC↕/P↓

Pump Control

ii. Throttle Control

$$EI\uparrow = EC\downarrow / P\downarrow$$

iii. Speed Control (VFD)

VFD = Variable Frequency Drive

$$EI\updownarrow = EC\downarrow / P\downarrow$$
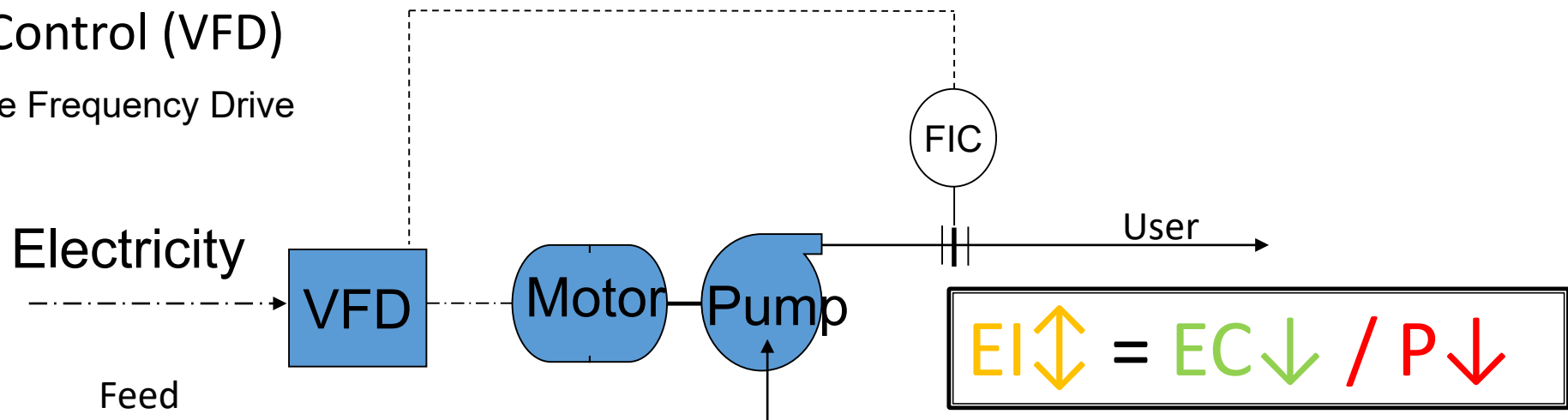
Convert from bypass to throttle control

Pump

Feed

CW Supply

Spillback

CW Return

FIC

To User
(Constant
Pressure)

**Minimize Spillback:
Saves $150,000/year**
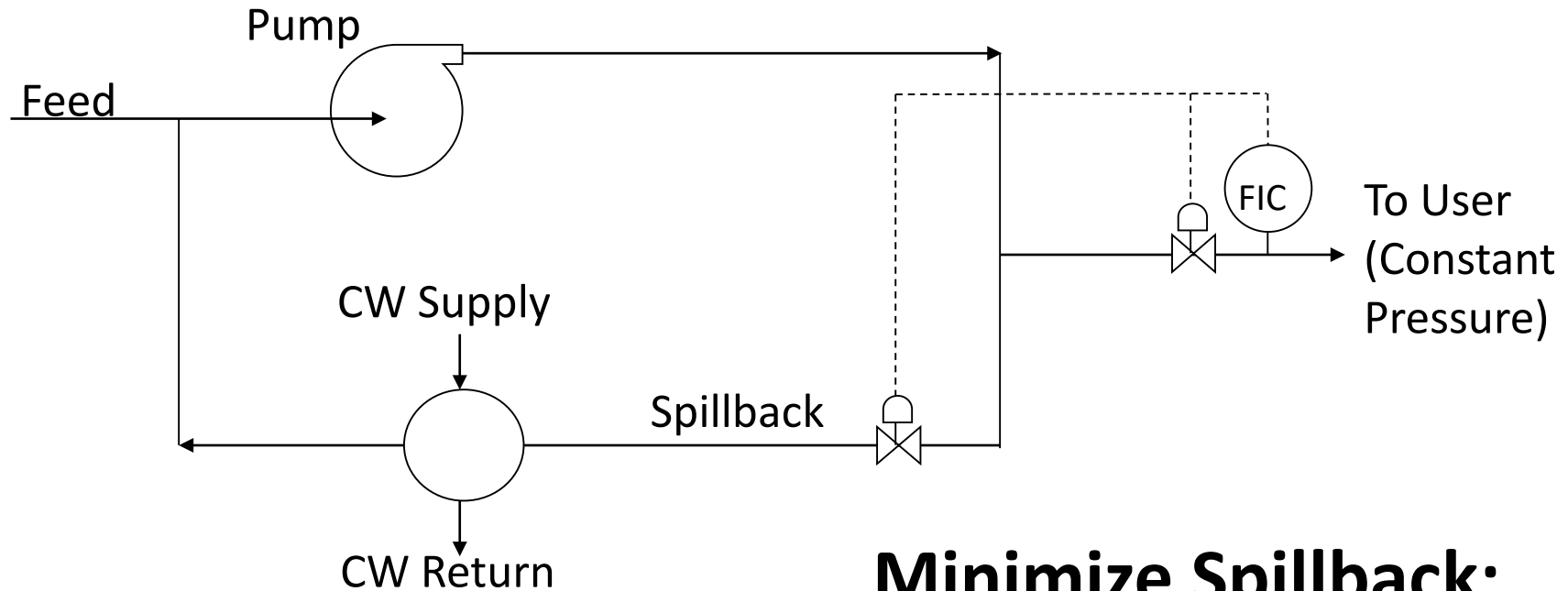
Verify safety/reliability issues

Our Agenda

A. Detailed examples
   1. Summer rainstorms
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Shutdown and Restart

- No production when plant is fully off-line; low energy use; EI = ∞.

- Shutting down and subsequent restarting typically takes several days.
  - Considerable energy is consumed, e.g., controlled cool down and subsequent reheating of furnaces and other equipment.
  - Little usable product is produced.
  - Off-spec product may be stored for subsequent reprocessing.

$$EI\uparrow\uparrow = EC\downarrow / P\downarrow\downarrow$$

A few more cases...

- Partial shutdowns (squats) – often used for maintenance or to recover from major plant upsets.

- Product or grade changes – may include stop/start, changing feedstock, adjusting temperature, pressure, flow rate, etc.

$$EI\uparrow = EC\downarrow / P\downarrow$$

Our Agenda

A. Consider a couple of examples in detail
   1.   Summer rainstorms
   2.   Throughput cuts

B. Other situations

C. Apply observations to Harvey

D. Mitigation options

So How Did Harvey Impact Energy Efficiency?

All of the inefficiencies apply:

- Rainstorms
- Equipment stopped/standby
- Shut down plants
- Extended period off-line
- Restarting operations
- Throughput cuts/standby operation because of logistical problems

$$EI \uparrow \uparrow = EC \downarrow / P \downarrow \downarrow$$

Our Agenda

A. Consider a couple of examples in detail

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Minimize or Mitigate EI Impacts

Design

- Insulate equipment.
- Provide surge capacity in feed and product drums.
- Upgrade control systems.

Operation

- Minimize the frequency of grade and product changes.
- Modify start-up and shutdown procedures, to eliminate unnecessary delays (subject to safety and equipment integrity)

External

- Increase resiliency of infrastructure & supply chain
- Effective emergency management to minimize downtime

References

- Charles Herzog, *Address Distillation Process Control during Design Phase to Save Energy and Increase Capacity*,11th AIChE Southwest Process Technology Conference, Sugar Land, TX, October 1, 2019

- Charles Herzog, *Improve Distillation Control*, Chemical Processing, Vol. 82, No. 2, p. 12, February 2020.

- Alan Rossiter, *The Beauty of the Steady State*, Chemical Processing, In Press, June 2020.

- Laura Cassidy, *Lessons learned from Hurricane Harvey*, Inform (AOCS), www.aocs.org/stay-informed/inform-magazine/featured-articles/lessons-learned-from-hurricane-harvey-march-2018