INDEX

3E Plus®, 19, 210, 211, 213
correction for condensation, 213

AARU. See Ammonia absorption refrigeration unit

ACEEE. See American Council for Energy Efficient Economy

Acid gas dew point, 110

Air compressors. See also Compressed air systems
dissipation, 352
heat recovery, 237, 287
maintenance, 285
surge control, 201–4
system-wide control, 288

Air leaks. See Compressed air systems: air leaks; Furnaces: air leaks; Chillers and refrigeration systems: leaks

Air Movement and Control Association (AMCA), 198

Alliance to Save Energy, the, 35

American Boiler Manufacturers Association (ABMA), 127

American Chemistry Council (ACC)
Responsible Care® Energy Efficiency Award, 33, 38

American Council for Energy Efficient Economy, 35

American National Standards Institute (ANSI), 72

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 303

American Society of Mechanical Engineers, 109

Ammonia absorption refrigeration unit, 257
case study, 258

ANSI-American Society of Quality (ANSI-ASQ) National Accreditation Board (ANAB), 72

Anti-trust guidelines, 57

Aspen Utilities Operations™ from Aspen Technology, 240

Asphaltenes, 139

Aspirational goals, 37

Assessment
of heat exchanger cleaning incentives, 145, 146, 155
of pump energy performance, 186
of sensors, 306
of steam traps, 170

Automatic tube brushing system (ATBS), 271
Automatic tube cleaning system (ATCS), 271

Batch processes, xii–xiii

Behavior
changes to improve energy performance, 86, 87, 243
human, xi, 293, 322
organizational, xi

Benchmarking, xi, xiii, 56–65, 91
assessments, 57
cement, glass, pulp and paper, 65
comparable technology, 61
confidentiality, 57
data validation, 62–63
definition, 56
energy consumption, 59, 63
energy survey, 60
food products, 65
Benchmarking (Continued)
- improvement plans, 59
- in promoting energy efficiency activities, 7, 13, 16, 17
- incentives, 58–59
- industrial chemicals and fertilizers, 65
- local factors, 62
- mandated programs, 58–60, 63, 65
- metals, 63
- methodologies, 59–61
- perimeter, 61–62
- petrochemicals and plastics, 65
- petroleum refining, 64
- real estate, 85, 86, 349
- reporting, 57, 60, 63, 65
- sharing best practices, 42, 53, 90
- simple measures, 59

Best practices, 51
- development, 43
- ENERGY STAR, 81, 84, 92
- identifying, 44
- key performance indicators, 317
- reports, 60
- sharing, ix, 22, 42, 44, 52, 78, 79, 350, 352
- steam leak repair, 44
- steam traps, 170
- Superior Energy Performance (SEP), 74

Better Buildings, Better Plants program, 37

Boilers, 107–27, See also Furnaces, Steam systems
- blowdown, 117, 228, See also Steam systems
- burners, 115
- cleaning, 141
- CO boilers, 253
- convection section, 112–13, 117
- energy allocation, 52
- energy management strategies, 126
- excess oxygen, 121
- forced draft combustion air fan example, 199
- fuel-to-steam efficiency, 109, 243
- impact on fuel gas balance, 253, 257
- induced draft, 119
- instrumentation and control, 119–22
- maintenance, 122–26
- natural draft, 119
- on-purpose steam production, 184
- optimization, 19, 91
- overhead costs, 166
- refractory, 122
- stack loss, 111
- stack temperature, 111
- superheated steam production, 182
- waste heat, 180
- wet steam production, 182

Breakthrough technologies, xiii, 100, 297–98, 324

Capital investment, 15, 19, 20, 34, 44, 54
- budget, 22, 33
- designated for energy efficiency, 45, 50, 91
- energy standards, 55, 101
- for improvement plans, 59
- funding, 39
- hurdle rate for energy conservation projects, 65
- in benchmarking, 57, 58, 61
- in furnace upgrades, 102
- include energy efficiency in decisions, 40
- motors and drive systems, 40
- performance contracting, 34
- trade offs, 275, 328, 332

Carbon dioxide
- reduction, 8, 25
- sources, 82
- Carbon footprint. See Environmental footprint

Carbon monoxide
- incomplete combustion, 126
- measurement, 121
- Catalysts, xi, xiii, 100, 123, 331
- CDU. See Crude distillation unit
- Centrifugal compressor surge control. See Compressor surge

Centrifugal fans, 195–99
- affinity laws, 197
- comparison of VFD to IGV control, 199, 203
- inlet guide vanes (IGVs), 196
- outlet dampers, 196
- speed control, 197

Centrifugal pump capacity control systems, 186–95
- oversizing of pumps, 187
- parallel pumping systems, 194
recirculation flows, 187
recirculation flows – bauxite refinery example, 188
throttle valves, 189–94
trimming impellers, 187
variable frequency drives (VFDs), 187
Certified Practitioner in Energy Management Systems (CP EnMS), 76
Chemical cleaning, 141
Chemical industry significance of energy use, 37
Chillers. See Chillers and refrigeration systems
Chillers and refrigeration systems, 261, 262
absorption refrigeration, 262
automation, 275
cost-Related improvements, 269–72
efficiency improvements, 269–76
equipment, 263
energy allocation, 52
insulation, 212
leaks, 271
operating costs, 212
retrofit opportunities, 273–76
system-related improvements, 272–73
terminology, 263
vapor compression refrigeration cycle, 262
Classification of opportunities for improving energy efficiency, 95–103
departmental classification, 96–100
equipment, utility system and process classification, 102
overview, 95
timeframe classification, 100–102
Clean Energy Ministerial Global Superior Energy Performance Partnership (GSEP), 78
Clean in place (CIP), 140
CO boilers, 253
CO₂. See Carbon dioxide
Coefficient of performance, 264
Cogeneration. See Combined heat and power
Combined heat and power, 219, 222–25, 242
combined cycle cogeneration system, 224
cost savings, 269–76
equipment, 263
efficiency improvements, 199
energy savings, 322
energy efficiency, 224
factors, 263
heat recovery, 287
inertial load, 262
intermittent users, 281
life cycle cost analysis, 282, 283
maintenance, 101, 285
network, 284
operating costs, 204, 279, 282–84, 289
pneumatic controls, 284
receiver, 203
replacement of air-driven motors with electric, 284
receptors, 203
savings, 204, 284, 285, 288, 289
savings opportunities, 282
size, 284
system pressure, 281
systems approach, 277
vacuum generation, 284
venting, 201
Compressor surge, 200–204, 322
capacity, 201
control in air compressors, 201–4
capacity, 201
control in process compressors, 201
definition, 200
Compressors. See also Air compressors,
Centrifugal fans, Rotating equipment
Chillers and refrigeration, 262, 263, 269–76
control, 201, 203, 279
efficiency, 279
energy savings, 322
refrigeration, 258
switchable, 233, 255
Continuous improvement, ix, 22, 51, 101, 243, 244, 246, 250
kaizen, 314
Continuous processes, xii–xiii, xiii
   use of compressed air, 277, 282
Continuous processing, 26, 33, 34
Cooling water systems, 261
   cooling towers, 261, 264
   distribution, 268
   efficiency improvements, 264–69
   fouling mitigation, 139
   life cycle cost analysis, 265
   maintenance, 267
COP. See Coefficient of performance
Corporate energy manager. See Energy manager: corporate
CP rules. See Pinch analysis: CP rules
Crude distillation unit, 64
   description, 328–31
   off gas, 254
   pinch analysis, 328–43
   preheat train cleaning, 139, 143–63
   preheat train maintenance, 99
   preheat train revamp, 328–43
   shale oils, 144
   throughput constraints, 143

Data errors, 41
Deaerator. See Steam systems: deaeration
Deming cycle. See Plan-do-check-act cycle
Department of Energy. See United States Department of Energy
Deregulation of electricity markets, 244
Discrete manufacturing, 314
Distillation, 19, 43, 89, 100, 220
   air cooler example, 317–18
   feed-bottoms heat exchange, 315, 320, 323
   heat recovery, 274, 328–43
   improvements, 100
   in reaction/recycle systems, 320–21
   isomerization unit example, 318–19
   optimization, 102
   overhead condensers, 139
   overhead temperature, 260
   pinch analysis, 328
DOE. See United States Department of Energy
Dow Chemical Company, The, 25–36
   achieving energy savings, 33
   climate strategy, 28
   company overview, 25
   Energy Efficiency and Conservation program, 29–31
   energy strategy, 26–28
   funding for energy projects, 33
   Global Asset Utilization Reporting system, 32
   internal operations, 28
   products and services, 35
   supply chain, 35
Eastman Chemical Company, 37–47
   capital projects, 44
   data collection, 41
   document strategy and principles, 39
   employee awareness, 42–44
   energy efficiency awards, 38
   energy efficiency programs, 38
   energy initiatives, 44
   energy intensity goal, 37, 38, 40
   energy management program consistency, 45
   energy management program growth, 46
   energy management program results, 46
   energy policy, 38
   energy team, 38, 39, 44
   executive level support, 38
   Sustainability Council, 39
   sustainability goals, 37
   use of external resources, 41
Eductor, 222
EE&C. See Dow Chemical Company, The: Energy Efficiency and Conservation program
Electric motors. See Motors
Employee behavior. See Behavior
Energy allocation, 52
Energy consumption
   baseline, 73
   building sector (commercial and residential), 83
   business unit, 71
   effect on emissions, 160
   effect on yields, 316, 321
   EnPIs, 350
   global, 107
   industrial, 83
   measurement, 14, 38
   monitoring, 8
   oil refining, 88, 89, 107
   olefins, 107
   petrochemicals, 88, 107
plant, 74
process industry sectors, 88
significant energy use, 70
systems approach, 278
trade off with capital investment, 328
trade-off with production, 143
transparency, 58
Energy cost. See Energy price
Energy dashboards, 161, 354
goals, 360
Energy Efficiency and Conservation program.
See Dow Chemical Company, The: Energy Efficiency and Conservation program
Energy efficiency improvement goal, 37, 38
evaluating progressl, 39
measurable, 40
Energy intensity, 27, 37–41, 46
defining measurement, 41
Energy Intensity Index (EII°), 89
Energy losses in throttling valves, 193
Energy management programs, xiii, See also
Energy management systems
accounting, 14–16
baseline, 13, 20, 34, 38, 46, 53, 71–74, 87, 126
circular process, 5
common challenges, 49–50
components and systems, 12–13, 95
consistency, 45
core program components and projects, 101
corporate commitment, ix, 6, 8, 16, 27, 36, 37, 51, 82, 84, 86, 126, 249
corporate leadership, 28, 49–51, 55, 86
data collection and analysis, 13–16, 50
data-based decisions, 39
defining key energy measures, 41
documentation, 39
Dow Chemical Company, The, 25–36
Eastman Chemical Company, 37–47
educating employees, 55, 293
employee awareness, 42–44
energy consumption goals, 8, 13
external reporting, 41
frequency of data measurement, 41
General Mills, 48–55
goal setting, 16–17
growth, 46, 48
HVAC, 44, 50, 300–312
identification of opportunities, 17–19
implementation of opportunities, 19–20
importance of executive level support, 38
in new product development, 55
informal leadership, 55
insulation, 11, 17, 19, 38, 44, 59, 207–16,
See also Thermal insulation
international, 76–79
launching a program, 5–8
leadership, 86, 176
lighting, 38, 44, 45, 50, 290–99
metering and instrumentation, 38, 40
overall approach, 3
personnel, 50–51
program leadership, 28, 51
project engineering tools, 55
projects, 44
quick hit activities, 15, 51, 100, 320
re-evaluation and renewal, 22
reporting and recognizing achievements, 20–22
reporting of energy reviews, 14–18
reporting structure, 10, 11
reporting systems and tools, xi, 22, 26–32, 36, 50, 52, 161, 354
resources, 102
resources, roles and responsibilities, 8–12
results, 25, 27, 28, 37, 46, 49
safety benefits, 45
site energy leader, 10, 29, 30, 32, 36, 53, 354
steam leaks, 38, 44, 179–85
steam trap reporting systems, 176
steam traps, 44, 164–78
Superior Energy Performance® (SEP™), 72–76
sustainability benefits, 45
sustainable operating improvements, 20, 31, 52, 53, 126, 243, 250
sustainable programs, 4, 8, 26, 38, 45, 50, 55, 84, 101, 146, 162, 164–78, 246
team leadership, 31
timeframes, 100–102
tools, 18–19
training, 38, 42, 51, 53, 55, 70, 71, 73, 79, 98, 161
use of external resources, 17, 40, 41, 50, 51, 54, 174, 267, 315
value of, 4

INDEX
Energy management standard  
  international, 85  
  ISO 50001, 66–80, 243  
  regional, 66  
Energy management systems, 24, See also  
  Energy management programs  
    automated, 275, 280, 308  
    displays, 354  
  EnPIs, 353  
  ExxonMobil Global Energy Management System (GEMS), xi  
  ISO 50001, xi, 35, 66–80  
    regulated, 77, 79  
Energy management tools  
  ENERGY STAR, 81  
  United States Department of Energy, 18, 38  
Energy manager, xiii, 4  
  as program champion, 168  
  as resource manager, 95, 102  
  associating with peers, 10  
  cheerleading, 9  
  corporate, 3, 50, 51, 87, 100  
  facility or site, 10, 100  
  mentoring, 42  
  networking, 90  
  recognition of accomplishments, 44  
  responsibilities, 4, 8, 11, 12, 45  
  tools to assist, 79  
Energy metrics, 9, 30, 320  
  EnPIs, 71, 349–60  
    for furnaces and boilers, 126  
    in Superior Energy Performance, 72  
    key performance indicators, 317  
Energy performance indicators. See EnPIs  
Energy policy, xi, 6, 8, 38, 45, 70  
Energy price  
  impact on energy management programs, 3, 7, 20, 27, 46, 49, 244, 252, 296  
  impact on maintenance, 216  
  impact on plant design, 59, 60  
  impact on project returns, 13, 20, 44, 54  
  in ISO 50001, 70  
  incorrect perceptions, 50  
  tracking, 16  
ENERGY STAR®, 6, 10, 41, 42, 51, 81–92  
  Battle of the Buildings, 43  
  certification, 87, 90  
  compliant computer, 82  
  energy guides, 88  
  history, 81–83  
  Industrial Focus, 88  
  lighting guidelines, 291, 293  
  logo, 43, 83, 86, 87  
  networking forum, 91  
  Partner, 35, 38, 42, 43, 46, 87, 90  
  Partner of the Year Sustained Excellence Award, 38  
  petrochemical industry, 88  
  petroleum refining, 88  
  plant energy performance indicator (EPI), 88  
  Pledge, 42  
  Portfolio Manager, 43  
  process industrial and commercial sectors, 84–87  
  tools and strategies, 81  
Energy sustainability, ix  
Energy team  
  credibility, 19  
  Dow Chemical Company, The, 31  
  Eastman Chemical Company, 38, 39, 44  
  Ford Motor Company, 289  
  General Mills, 48, 51, 52, 54, 55  
  membership, 22  
  priorities, 30  
Energy usage  
  allocation, 52  
  data collection, 50  
  management, 52  
  material balances, 5  
  means of reducing, xi, 100  
  measurement, 353, 359  
  profiles, 6  
  reducing in cooling towers, 265  
  reducing in HVAC systems, 302  
  reducing with variable frequency drives, 199  
Engineered improvements, 96, 99  
Engineering practices, 19  
Enhanced heat transfer, 128–38  
EnPIs, 71, 349–60  
  baseline, 71  
  data collection, 353–54  
  data normalization, 350  
  energy consumption, 350  
  instruments and meters, 352, 353, 358  
  multivariable regression, 350, 354–58, 359  
  process application, 358
selection of parameters, 350–52
steam system, 358
training, 350
Environmental compliance, 121, 143
in oil refinery fuel gas management, 251, 257, 259
in optimizers, 243, 246, 250
Environmental costs, 144
Environmental footprint, 25, 28, 35, 49
Environmental impact of energy use, 4, 15, 81, 84
estimating, 7
heat exchanger cleaning, 160
ISO 50001, 70
NOx formation, 119
reporting, 6, 8
steam traps, 167
tracking impact, 15
Environmental protection, 81, 83
Environmental Protection Agency. See United States Environmental Protection Agency
Environmental responsibility, ix
Environmental stewardship, 37
EPA. See United States Environmental Protection Agency
ePEP. See United States Department of Energy: Plant Energy Profiler
Equipment monitoring
heat exchanger fouling, 143–63
EXPRESS™ from IHS ESDU, 160
ExxonMobil, xi

Fans, 52
FBHE. See Feed-bottoms heat exchanger
FCCU. See Fluid catalytic cracking unit
Feed-bottoms heat exchanger, 315, 316, 320, 323
Feed-effluent heat exchanger, 129, 315, 320
FEHE. See Feed-effluent heat exchanger
Firebox, 111
First law efficiency. See Thermodynamics: first law efficiency
Flare gas recovery, 252
Fluid catalytic cracking unit, 317
fuel gas production, 252, 255
hot feed/cold feed example, 96–98
severity, 252, 321
temperature approach for heat integration, 334
Forms of energy, 219
relative values, 220
Fouling. See Heat exchangers: fouling
Frequency of data measurement, 41
Fuel gas cushion, 251, 252
Fuel gas management, 251–59
Furnaces, 107–27. See also Boilers
air leaks, 114, 124
air preheat, 118
air preheat with gas turbine exhaust, 225
blowdown, 117
burners, 114
capacity growth, 111, 113
convection bank, 102, 107
convection box, 112
convection section, 112–13, 116–17
convection section cleaning, 125
crude distillation unit, 139, 145, 331, 336, 340
design criteria, 110
efficiency, 109, 323, 332
emission limits, 145
energy management strategies, 126
excess oxygen, 121
firebox, 111
heat integration, 117
HOTSEAL™ - Tube Penetration Seals, 113
induced draft fan, 119
instrumentation and control, 119–22
insulation and sealing, 111–13
maintenance, 122–26
natural draft stack, 119
olefins, 107–27
operational optimization, 102
peep doors, 112, 124
radiant box, 113
radiant coil, 111
radiant coil design, 114
radiant heat intensity, 111
radiant tubes, 112, 116
refractory, 19, 111–12, 122–23
stack loss, 110
stack temperature, 110
tools, 18
tuning, 3
upgrades, 33, 102

Gas turbine, 224, 239
GAUR. See Dow Chemical Company, The: Global Asset Utilization Reporting system
General Mills, 48–55
  company overview, 49
  corporate commitment, 51
  energy program challenges, 49–50
  energy program fundamentals, 51–53
  energy program results, 48
  energy team, 48, 50–51, 54
  future challenges, 54–55
  technology innovation, 53
GHG. See Greenhouse gas
Global Asset Utilization Reporting system.
  See Dow Chemical Company, The: Global Asset Utilization Reporting system
Global Energy Management System (GEMS), xi
Goals
  business performance, 58
  communication of, 9, 101
  corporate, 95
  energy efficiency, 5, 27, 37–40
  energy improvement, 59, 62
  energy management programs, 16–17
  energy performance, 86, 87
  energy reduction, 256, 259
  energy savings, 13, 18, 20, 22, 26, 27, 30, 33, 36, 78
  for energy dashboards, 354, 360
  greenhouse gas emissions, 28
  importance of, 7, 8
  in ISO standards, 69
  of control strategy, 280
  optimization, 246
  policy, 77
  rewards for achieving, 250
  setting, 12
  sustainability, 28, 37, 54
Green Lights, 82
Green Team, 42
Greenhouse gas, 7, 25, 27, 28, 32, 35, 70, 71
due to leaking steam traps, 167
impacts for common fuels, 7
market-based programs, 34, 81
Heat exchanger grid diagram. See Pinch analysis: heat exchanger grid diagram
Heat exchangers
  balancing duties, 146
  boiling surface enhancements, 132
boundary layer interrupters, 136
chemical cleaning, 141
classification of enhancement techniques, 131
clean in place (CIP), 140
cleaning analysis, 143–63
cleaning costs, 145
cleaning cycle economic analysis, 155–60
cleaning cycle optimization tools, 160
cleaning incentives, 145, 146, 155
cleaning methods, 139–42
compact plate-fin, 131
comparison of cleaning options, 141
condensing surface enhancements, 133
continuous plate fin, 134
data reconciliation, 148–52
design, 128–31
dimpled tubes, 132
displaced flow inserts, 136
dropwise condensation, 133
enhancements, 128–38
extended surfaces, 134–35
feed-bottoms, 315, 316, 320, 323
feed-effluent, 129, 315, 320
fouling, 139–42, 143–63
fouling mitigation, 129, 130, 144
fouling monitoring program components, 146
High Flux™ tubes, 133
high-finned tube, 134
hydroblasting, 140
instrumentation and data, 147–48
low-finned tube, 133, 134
mean temperature difference, 129
microchannels, 131
network performance analysis, 152–55
non-TEMA baffles, 135
number of shells, 128
pinch points, 129
plate-fin, 134
predictive fouling, 162
process condensers, 129
rating, 129
revamps, 137
shell and tube, 129
static mixers, 135
surface nanostructures, 133
surface treatments and modifications, 131–33
swirl flow inserts, 136
temperature profile, 128, 129
thermal efficiency, 129
tube diameters, 130
tube inserts, 135–37
Heat integration, xii, See also Heat recovery constraints, 340
feed-bottoms heat exchanger, 315, 316, 320, 323
feed-effluent heat exchanger, 129, 315, 320
in olefins furnaces, 117, 118
in PFD reviews, 315, 319
in refrigerated processes, 274
pinch analysis, 326–47
standard configurations, 315–16
Heat recovery, xi, 274, 288, See also Heat integration
air compressor, 238
chillers and refrigeration systems, 273
compressed air systems, 287, 288
condition of equipment, 17, 99, 119
convection section cleaning, 125
crude distillation unit, 328, 342
fouling, 143
furnace convection section, 111, 112, 116, 119
heat exchanger cleaning, 153, 154, 160
in PFD reviews, 320
low grade heat, 54, 91
pinch analysis, 19, 34, 100
project database, 44
trade-offs, 328
Heat recovery steam generator, 224, 230, 239, 248, 257
Heat transfer coefficient, 129, 135
boiling surface enhancements, 132
calculation, 147, 152–54
commercial enhancements, 131
condensing surface enhancements, 133
effects of fouling, 145
high values for water and steam, 222
single phase surface enhancements, 132
temperature dependency, 154
Heating, ventilation and air conditioning. See HVAC systems
HEN. See Pinch analysis: heat exchanger network
HHV. See Higher heating value
Hierarchical process review, 314
High efficiency motors. See Motors
Higher heating value, 109
Hot water, 50, 52, 273
in heat recovery, 288
in HVAC, 305
vaporization causing cavitation, 188
HRSG. See Heat recovery steam generator
HSB Solomon Associates LLC, 89
Human behavior. See Behavior
HVAC systems, 52, 103, 261, 300–312
alignment of supply and demand, 301
baseline, 302
components, 300, 307, 308
control, 303–4, 305, 308
diagnostic monitoring, 308
economizers, 303, 306, 308
ergy cost, 300
ergy management programs, 44, 50
energy management system, 308
energy savings, 302–306, 309
functional testing, 308
heat sources, 305
maintenance, 304–6, 307
operating modes, 302–3, 308, 309
recommissioning, 307–9
sensor calibration, 305, 308
training, 309
types, 300
variable frequency drives, 304, 307
Hydroblasting, 140
Hydrogen compression, 257
in fuel gas, 35, 110, 251, 253, 256
in oil refining, 251, 253, 256, 328
production, 256, 257
recovery from fuel gas, 257
Hydrogen peroxide, 33
Illuminating Engineering Society of North America (IESNA), 291, 293
Improvement plans, 52, 53, 59
Inlet butterfly valve (IBV), 201
Inlet guide vanes (IGVs), 121, 196, 197, 199, 201, 204, 274
Innovation, 28, 36, 49, 51, 53, 55
Institute for Energy Management Professionals (IEnMP), 76
Institute of Industrial Engineers, xii
Insulation. See Thermal insulation
International Organization for Standardization, 66
system characteristics, 68–70
Isentropic efficiency. See Thermodynamics: isentropic efficiency
ISO. See International Organization for Standardization
ISO 14001, 67–70
ISO 22001, 69
ISO 50001, xi, 10, 35, 51, 66–80, 85, 243, 246, 250
adoption in geographic regions, 67, 68
government promotion, 77–78
growth in adoption, 67, 68
international collaboration, 78
international context, 76–79
international workforce qualifications, 79
procurement process, 70
purpose, 70
related ISO energy standards, 72
reporting requirements, 356, 358
US context, 72
ISO 9001, 67–70
Isomerization unit, 318–19

Kaizen, 314
KBC Advanced Technologies, 318
Key performance indicators, 98, 101, 349–60
heat exchanger fouling, 161
in PFD reviews, 316, 321
reporting, 162
KPIs. See Key performance indicators
Kyoto Protocol, 35

Laws of industrial energy efficiency, xi–xii, 95
LHV. See Lower heating value
Life cycle cost analysis
compressed air systems, 282, 283
cooling water systems, 265
insulation, 35
lighting systems, 298
Lighting systems, xii, 52, 103, 290–99
alignment of supply and demand, 291
automatic control, 293–96
baseline, 291
compact fluorescent light bulbs (CFLs), 297
emergency lights, 290, 294
ergy costs, 82, 290, 293, 296
energy efficient, 82
energy management programs, 38, 44, 45, 50
energy savings, 292, 294, 297
fluorescent bulbs, 298
Green Lights program, 82
guidelines, 291, 293
incandescent bulbs, 298
induction lighting, 298
life cycle cost analysis, 298
light emitting diodes (LEDs), 297
lighting requirements, 293
maintenance, 296–98
manual control, 291–93
new technologies, 82, 297–98
operating modes, 291, 292
retrofits, 297
safety, 290
zoning, 292, 293, 294
Liquefied petroleum gas, 251, 252, 256–8
Lower heating value, 109, 213
Low-NOx burners, 116
LPG. See Liquefied petroleum gas
LyondellBasell, xii

Maintenance
as part of energy management programs,
20, 22, 55, 96, 98–99, 100–102,
122–26
benefits in energy management programs,
15
compressed air systems, 279, 285–87
cooling systems, chillers and refrigeration systems, 264–76
danger of reducing to save funds, 11
furnaces and boilers, 114, 122–26,
240
heat exchanger cleaning analysis, 143–63
heat exchanger cleaning methods, 139–42
heat exchangers, 128
heating, ventilation & air conditioning (HVAC) systems, 302, 304–7, 309
importance of communication, 99
insulation, 211, 214, 216
lighting, 296–97, 298
metering and measurement, 12, 14
optimization systems, 250
programs, 11
INDEX

rotating equipment, 40, 186, 192, 200, 237
standards, 12
steam leaks, 44, 179–85
steam traps, 30, 178, 164–78
Marginal steam cost. See Steam systems: marginal pricing of steam
Marginal steam price. See Steam systems: marginal pricing of steam
Material balance, 4, 5, 148, 239, 240, 314
MONITOR™ from Nalco, 160
Motivation, xi, 5, 86
early savings, 12
marketplace, 82, 87
overcoming obstacles, 51
performance targets, 30
recognition, 87, 90
steam trap program, 166
use of PFD reviews, 321–22
Motors, 85, 295, 300, See also Variable frequency drives
belt drives, 198, 305
dual speed, 266
efficiency, 188, 193, 199, 204–6, 272
electric compared with air-driven motors, 284
energy management initiatives, 44
fan power requirement, 197
heat recovery, 288
high-efficiency, xi, 204
life-cycle costs, 19, 40, 204
maintenance, 272
operating speed, 204
performance data, 18
power calculation for pumping, 188
power requirement, 254
power savings for cooling towers, 265, 266
prevalence in process industries, xiii
repair and replacement, 12, 275
switchable with steam turbines, 63, 232–34, 240, 247, 253, 255
Multivariable regression, 350, 354–59
MVR. See Multivariable regression
National Electrical Manufacturers Association (NEMA), 205
Natural gas, 3, 248
as feedstock, 27, 256
as HVAC heat source, 305
as industrial energy source, 26, 32, 41, 225, 248, 251, 257, 352, 358
greenhouse gas emissions, 7, 82
impact of price, 27, 54, 143, 244, 245
renewable sources, 35
Networking, 90
New technologies. See Breakthrough technologies
North American Insulation Manufacturers Association (NAIMA), 210, 211
NOx
emission regulations, 33, 121
emissions, 108, 116, 123
formation, 119
measurement, 121
reduction of emissions, 160
Octane, 252
Oil crisis, xi
Oil refining, xii, 96, 145
benchmarking, 64, 89, 90
crude unit. See Crude distillation unit
ing balance, 253–56
energy consumption, xii, 88, 89, 107, 240, 258
ENERGY STAR resources, 88
fluid catalytic cracking unit. See Fluid catalytic cracking unit
fuel gas management, 225, 248, 251–59
gas turbine application, 225
improvement measures, 88
isomerization unit, 318–19
operating modes, 316, 252
PFD reviews, 316
reactor reconfiguration example, 321
reforming, 252
sulfur limits, 251
Olefins, 107–27
Operating improvement, 34, 96
for lighting systems, 291–96
Operating modes, 15, 26, 316, 321, 350, See also Steam systems: operating modes
HVAC, 302–3, 308
Operations management, 7, 11, 168
Optimization, 15, 19, 59, 102, 319
  barriers, 248
  constraints, 243, 246, 248
  methods used for heat integration, 326
  of boilers and fire heaters, 91
  of flares, 91
  of fuel gas systems, 251–59
  of heat exchanger cleaning cycles, 99, 143–63
  of reactor conversion, 321
  of steam balances, 230, 240–41, 242–50
  real-time, 4, 12, 19, 98, 240, 242–50, 317 training, 248, 250

PDCA cycle. See Plan-do-check-act cycle

Persimmon™, 154

PFD reviews, 17, 313–25
  air cooler example, 317–18
  as a motivational tool, 321–22
  breakthrough technologies, 324
  cost estimating, 323
  data requirements, 314
  energy savings, 317, 319, 321, 322
  equipment modifications and additions, 320–21
  evaluating opportunities, 322
  heat integration, 315
  isomerization unit example, 318–19
  key performance indicators, 316, 321
  operating practices, 317
  operating targets, 316
  personnel, 314
  procedure, 314
  replicating ideas, 315
  technical credibility, 324
  variations, 314

Pinch analysis, xii, 19, 34, 100, 274, 326–43
  composite curves, 34, 327, 328, 334, 335, 343–47
  cost estimating, 332

CP rules, 328
  crude distillation unit, 328–43
  data extraction, 332, 333
  data requirements, 331
  distillation, 328
  energy savings, 335, 342
  energy targets, 334, 344, 347
  evaluation of options, 339
  grand composite curve, 328
  heat capacity flow rate (CP), 343
  heat exchanger grid diagram, 328, 336
  heat exchanger network, 336
  interval temperature, 336
  minimum allowable temperature approach, 327, 332, 344
  opportunities for removing inefficiencies, 339
  pinch definition, 327
  pinch principle, 328
  process pinch, 336–39
  retrofit procedure, 328
  software, 332, 334, 336, 339, 343
  transferring heat across the pinch, 336
  utilities, 332
  utility pinch, 336–39
  utility targets, 334
  with PFD reviews, 316, 324

Plan-do-check-act cycle, 67, 68, 243, 246, 250

Plant energy assessments. See Site energy assessments

Power factor, 205, 273

Power stations, 220, 222

Prandtl number, 129

Pressure swing absorption, 257

Price Equivalent Efficiency, PEE, 225–26

Prioritization of energy projects, 54

Process compressor and turbine efficiency improvements, 199

Process control, 12, 13, 19, 317

Process design, xi, 128, 129, 137

Process flow diagram reviews. See PFD reviews

Process Heating Assessment and Survey Tool (PHAST), 18

Process improvements, 313–25

Process industries, xii, xiii, xiv, 4, 10, 24, 225

cooling, chilling and refrigeration, 260, 261, 276

energy issues, xii–xiii
Steam ejector, 222
Steam leaks, 9, 179–85
detection, 183
estimation methods, 181
incentives for repair, 39, 179, 180, 183
maintenance, 11, 15, 17, 44, 101, 184
prioritization, 183
Rohm and Haas case study, 179–81
root causes, 182–84
zero tolerance policy, 179
Steam System Assessment Tool (SSAT), 18
Steam System Modeler Tool (SSMT), 18, 240
Steam systems, 85, 222–25
control, 242, 245
deaeration, 228, 235–38
derator feed water preheat, 237, 238
excess reliability, 243
instrumentation, 238, 242, 245
ladder diagrams, 230, 238
m arginal pricing of steam, 226–29, 240, 244, 319
modeling, 229, 237, 238–41, 250
operating modes, 240, 243
optimization, 240, 242–50, 358, See also
Optimization: real-time
pressure levels, 227, 231, 323, See also
Steam systems: steam headers
steam balances, 230–41, 256
steam headers, 180, 230–42, 359
steam venting, 231–32, 245, 247
steam/power system efficiency, 230
Steam traps, 17, 55, 99, 164–78, 180, See also
Steam systems
costs due to failure, 166–67
diagnosis, 170–72
drainage-failed, 165, 183, 184
failure modes, 165
failure rates, 166, 167
function of, 165
functional steam loss, 165
maintenance, 101, 176
principles of operation, 165
program implementation, 174–75
program sustainability, 177
selection, 169–70
survey, 164, 168, 172–74
testing, 175
training, 170, 172, 174
water hammer, 182
Steam turbine, 220, See also Steam systems
control, 242
e xtraction/condensing, 248
generator, 257
switchable, 240, 253
Sulfur dioxide, 240
Sunoco, Inc., 90
Superheater, 118
Superior Energy Performance®, 70, 72–76
certification requirements, 72
results, 72–75
US workforce qualifications, 75
use of multivariable analysis, 356
Surge. See Compressor surge
Sustainability, 39, 41, 77, 91
commitment, 35, 45
corporate, 33
g oals, 28, 37, 54
of energy management functions, 10
organization, 45
programs, 36
renewable energy, 41
report, 32, 41
Sustainability Council, 39
Telemetry, 273
TEMA, The Tubular Exchanger Manufacturers Association, Inc., 128, 135, 153
Thermal efficiency, 18
Carnot cycles, 221
furnaces and boilers, 108–13, 119, 123, 124, 323
heat engines, 220
steam superheaters, 118
Thermal imaging camera, 210
Thermal insulation, 35, 108, 207–16, See also
Energy management programs: insulation
3E Plus®, 19, 210, 211, 213
aerogel, 209
auto-ignition, 208
average wind velocity, 210
basic insulation properties, 207
calcium silicate, 209
calculating energy savings, 210
cellular glass, 209
cold services, 211–13
condensation heat gain, 213
corrosion under insulation, 208
cost estimating, 210
cryogenic services, 209
economic justification, 209
engineered improvements, 99
flanges, 215
ice as an insulator, 212
maintenance and renewal, 55, 216
mineral wool, 208
of furnaces, 111, 112, 115, 124
of steam traps, 175
personnel protection, 207
plant engineering standards, 12, 210
rotating equipment, 214
rules of thumb, 211
safety requirements, 210
training, 210
Thermodynamics, 219–22
  Carnot cycle, 220–21
  entropy, 221
  first law, 219
  first law efficiency, 220, 222, 224, 225
  heat engines, 220
  isentropic efficiency, 221, 224
  non-Carnot engines, 221
  Rankine cycle, 222
  reversibility, 220
  second law, 220, 326
  second law efficiency, 221
  steam turbine, 221
  thermal efficiency, 220
TLEs. See Transfer line exchangers
Tramp air, 123
Transfer line exchangers, 119, See also
  Quench exchangers
Treasure hunt. See Kaizen

United Nations Industrial Development Organization (UNIDO), 76
United States Council for Energy Efficient Manufacturing, 35
United States Department of Energy, xi, 35, 37, 38, 66, 68, 72–75, 349
  Better Buildings, Better Plants program, 37
  Better Plants Partnership, 35
  energy management tools, 18, 38
  Plant Energy Profiler, 17
United States Energy Information Administration, 83
United States Environmental Protection Agency, xi, 6, 81, 86, 89, 121
Units of measure, xix
Utility systems, 12, 14, 19, 95, 102, 240, 242–45, 247, 313

Variable frequency drives, 50, 91
  compressors, 272, 274, 279
  costs, 187, 189
  efficiency, 198
  fans, 200
  HVAC, 304, 307
  pumping systems, 190, 191, 200
VFD. See Variable frequency drives
Visual MESA™, 240, 245

Waterhammer, 182–83
Wet bulb temperature, 261, 265, 267, 306
Wobbe index, 119