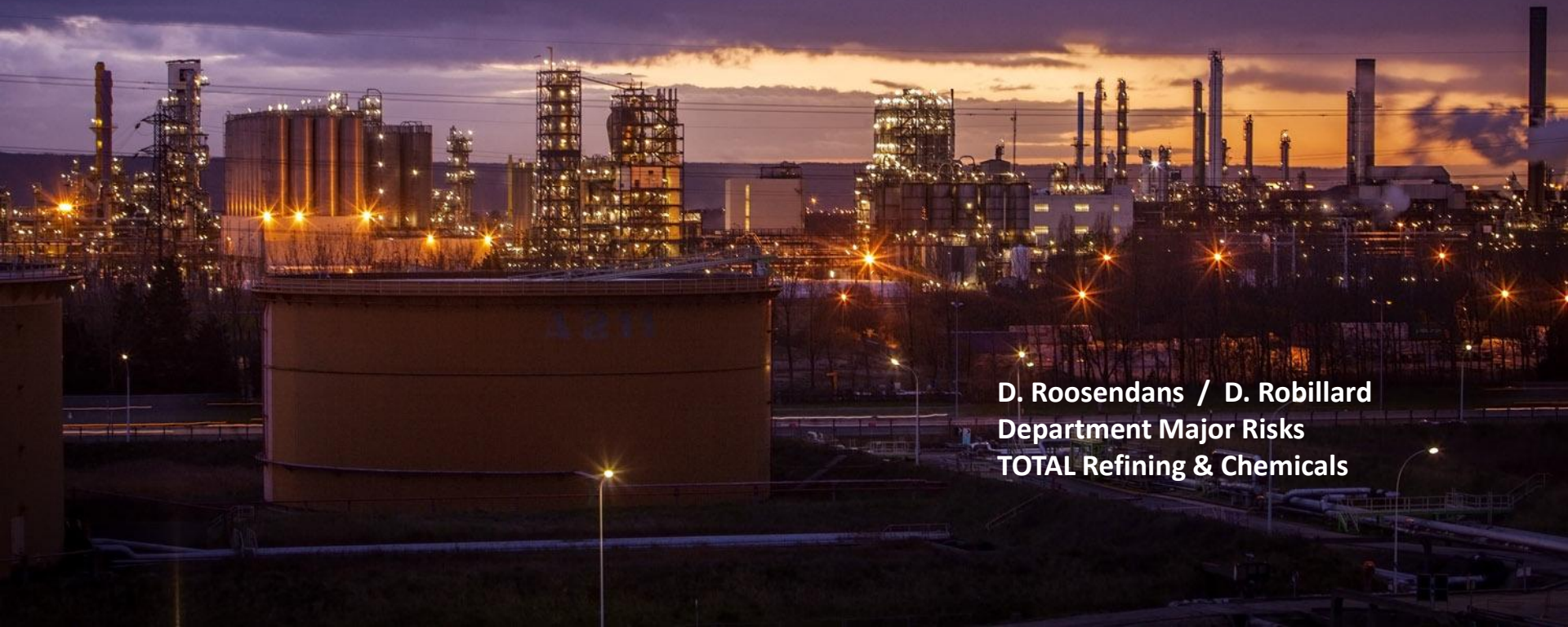
TOTAL
COMMITTED TO BETTER ENERGY

Analysis & Benchmark of 4 years of HiPo Events and Events with Real Major Consequences in TOTAL RC



D. Roosendans / D. Robillard
Department Major Risks
TOTAL Refining & Chemicals

TOTAL Refining & Chemicals

TOTAL Refining & Chemicals

REFINING

19 REFINERIES around the world*
5 in France, including one being converted to a biorefinery

No.1 refiner in Europe
12% of capacity
1.5 Mb/d**

No.9 refiner in the world
2% of capacity
2.0 Mb/d**

PETROCHEMICALS

26 SITES

No.2 petrochemical producer in Europe
9% of capacity
10.4 Mt/year**

No.10 petrochemical producer in the world
2% of capacity
21.4 Mt/year**

SPECIALTY CHEMICALS

95 SITES

HUTCHINSON*

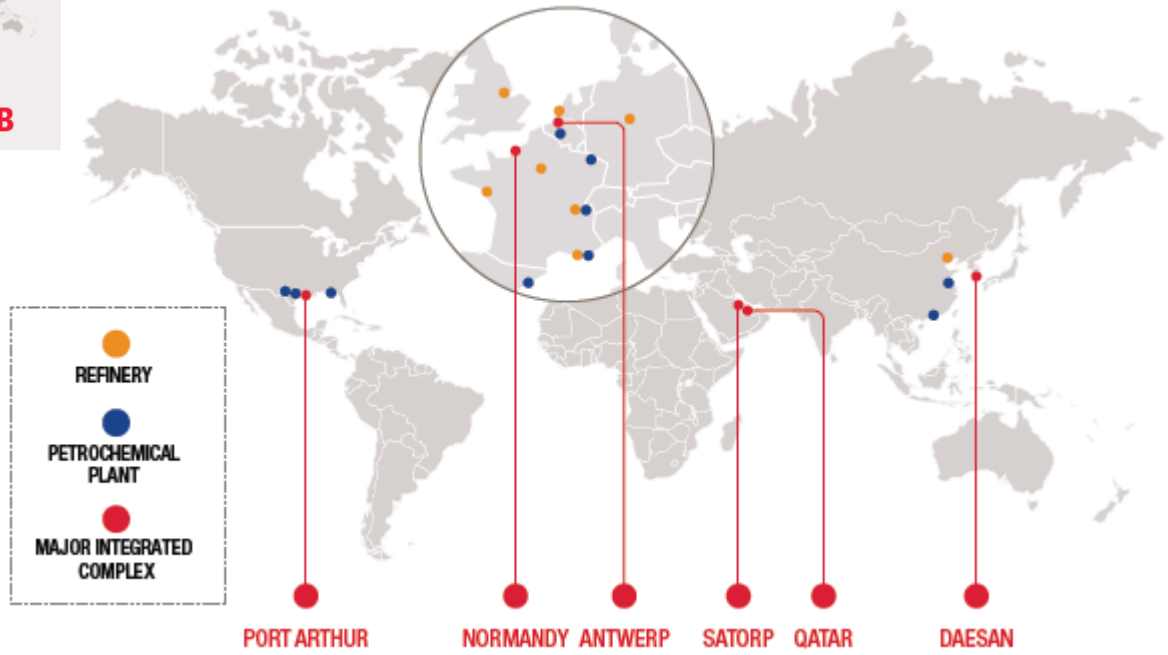
Global leader in elastomer processing

34,200 employees

2016 revenue
$4.5B

8 TECH AND/OR R&D CENTERS***

Main Refining & Petrochemicals Sites



Safety Indicators in TOTAL RC

Safety Performance Indicators in TOTAL RC

- HSE performance indicators
  - Leading Indicators
  - Lagging Indicators
  - Monthly follow-up of these indicators

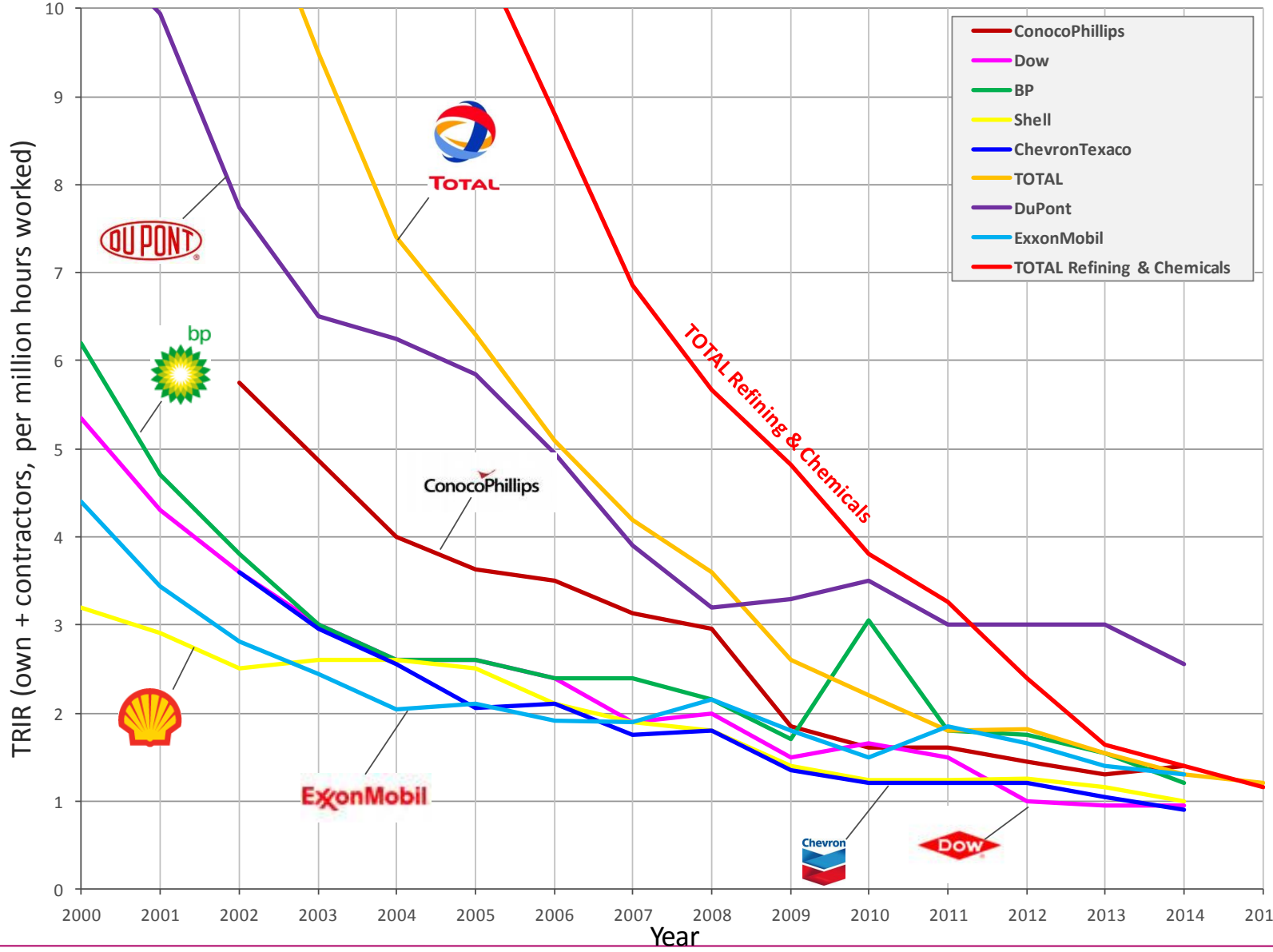
- Leading indicators
  - Number of failures of safety critical systems encountered during inspection, testing or operations
  - Number of reported substandard conditions/acts
  - Ratio of reported substandard conditions/acts per employee
  - Degree of realization of tests of safety critical systems
  - Number of out of date implementation of works following recommendations of inspection service
  - Number of excursions of safe operating window
  - Number of permit violations related to air emissions
  - Number of permit violations related to water emissions

Safety Performance Indicators in TOTAL RC

- **Occupational Safety Lagging Indicators**
  - Total Recordable Injury Rate (own employees + contractors)
  - Total Loss Time Injury Rate (own employees + contractors)
  - TOTAL number of injuries (with and without loss time cases)

- **Process Safety Lagging Indicators**
  - Number of LOPC of hazardous products (Tier1 + Tier2, API754)
  - Number of fires and explosions
  - Process Safety Event Rate (Tier 1) (using API754 classification)
  - Process Safety Event Rate (Tier 2) (using API754 classification)

Safety Performance Indicators in TOTAL RC



LOPC

- A loss of primary containment (LOPC) = accidental, sudden and uncontrolled loss of combustible, flammable, explosive, corrosive, toxic products or products dangerous to the environment whatever steps are taken to confine or collect them or to protect the environment.
- The products to which this indicator relates are those identified in API 754.

Benchmark with CONCAWE, AFPM & GBG data

CONCAWE

- Benchmark study in 2014 was performed by CONCAWE (downstream oil & gas in Europe) on safety performance of European refineries
- The study includes feedback from 37 CONCAWE members and represents about 98% of European refining capacity (EU-28, Norway and Switzerland)

AFPM

AFPM
American
Fuel & Petrochemical
Manufacturers

AFPM Process Safety Event Statistics
for the Petroleum Refining
and Petrochemical Industries

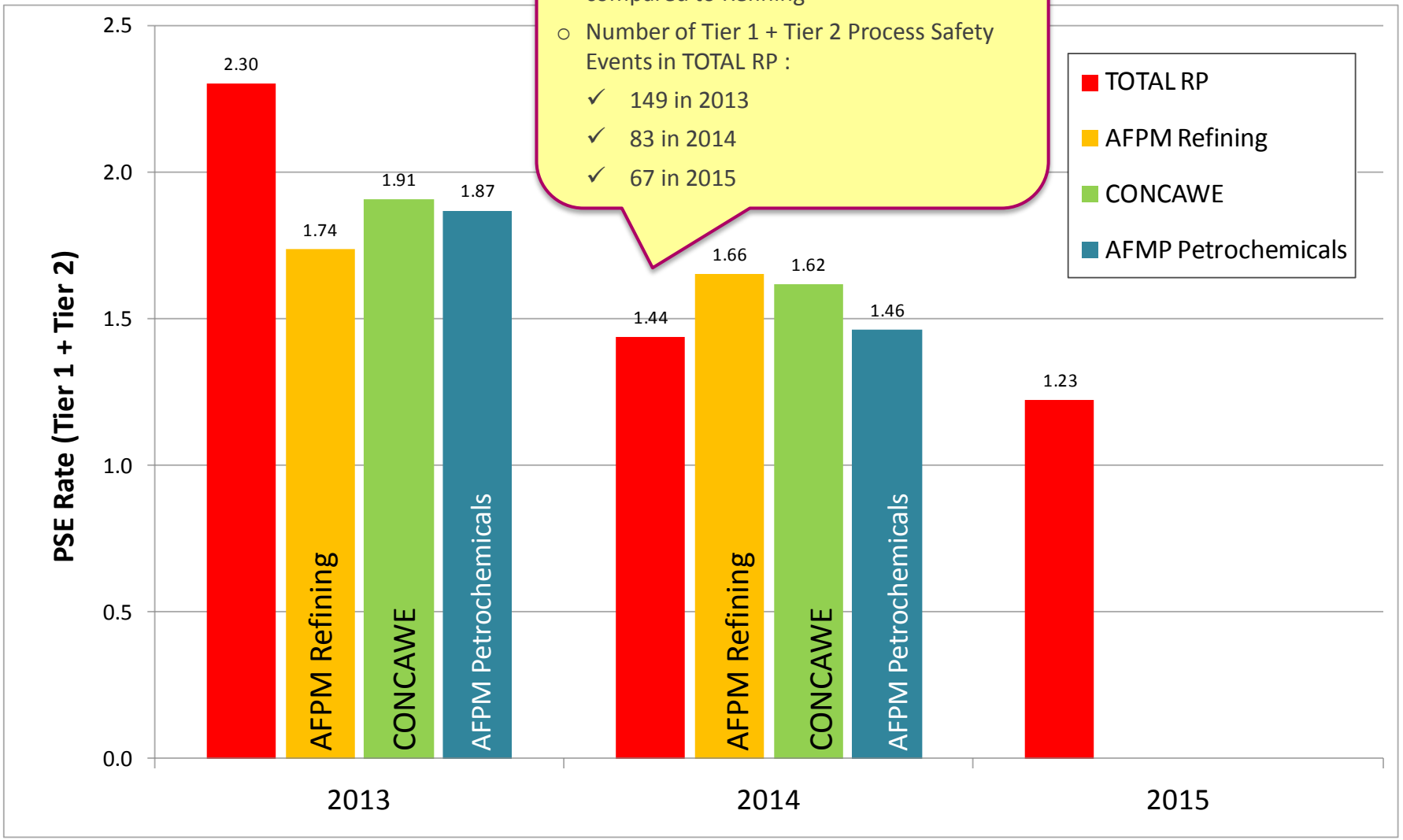
Published October 2015

2014 PARTICIPATING COMPANIES

Alon USA
American Refining Group, Inc.
Axiall Corporation
Big West Oil, LLC
BP Petrochemicals
BP Products North America
Braskem America, Inc.
Calumet Specialty Products Partners, L.P.
Celanese Ltd.
Chevron Phillips Chemical Company LP
Chevron U.S.A. Inc.
CHS, Inc.
CITGO Petroleum Corporation
Countrymark Cooperative Holding Corporation
CVR Energy, Inc.
Delek Refining Ltd.
Ergon, Inc.
ExxonMobil Chemical Company
ExxonMobil Refining & Supply
Flint Hills Resources, LP
Formosa Plastics Corporation, USA
HollyFrontier Corporation
Houston Refining, LP
Hunt Refining Company
Huntsman Corporation
INEOS Olefins & Polymers USA
INVISTA
LyondellBasell Industries
Marathon Petroleum Corporation
Merisol USA LLC
Monroe Energy, LLC
Motiva Enterprises LLC
NALCO Champion
Northern Tier Energy GP, LLC
Olin Chlor Alkali Products
Pasadena Refining System, Inc.
PBF Energy Inc.
Philadelphia Energy Solutions (PES)
Phillips 66
Placid Refining Company
Sasol Chemicals (USA) LLC
Shell Chemical Company
Shell Oil Products US
Silver Eagle Refining, Inc.
Sinclair Oil Corporation
South Hampton Resources, Inc.
Styrolution America LLC
Suncor Energy, Inc.
Tesoro Corporation
The Dow Chemical Company
The Williams Companies
Total Petrochemicals & Refining USA, Inc.
TPC Group
U.S. Oil & Refining Co.
Valero Energy Corporation
Western Refining Company
Westlake Chemical Corporation

TOTAL Refining Petrochemicals vs CONCAWE / AFPM

- Better performance of Petrochemicals compared to Refining
- Number of Tier 1 + Tier 2 Process Safety Events in TOTAL RP :
  - ✓ 149 in 2013
  - ✓ 83 in 2014
  - ✓ 67 in 2015



Benchmark with GBG/API data

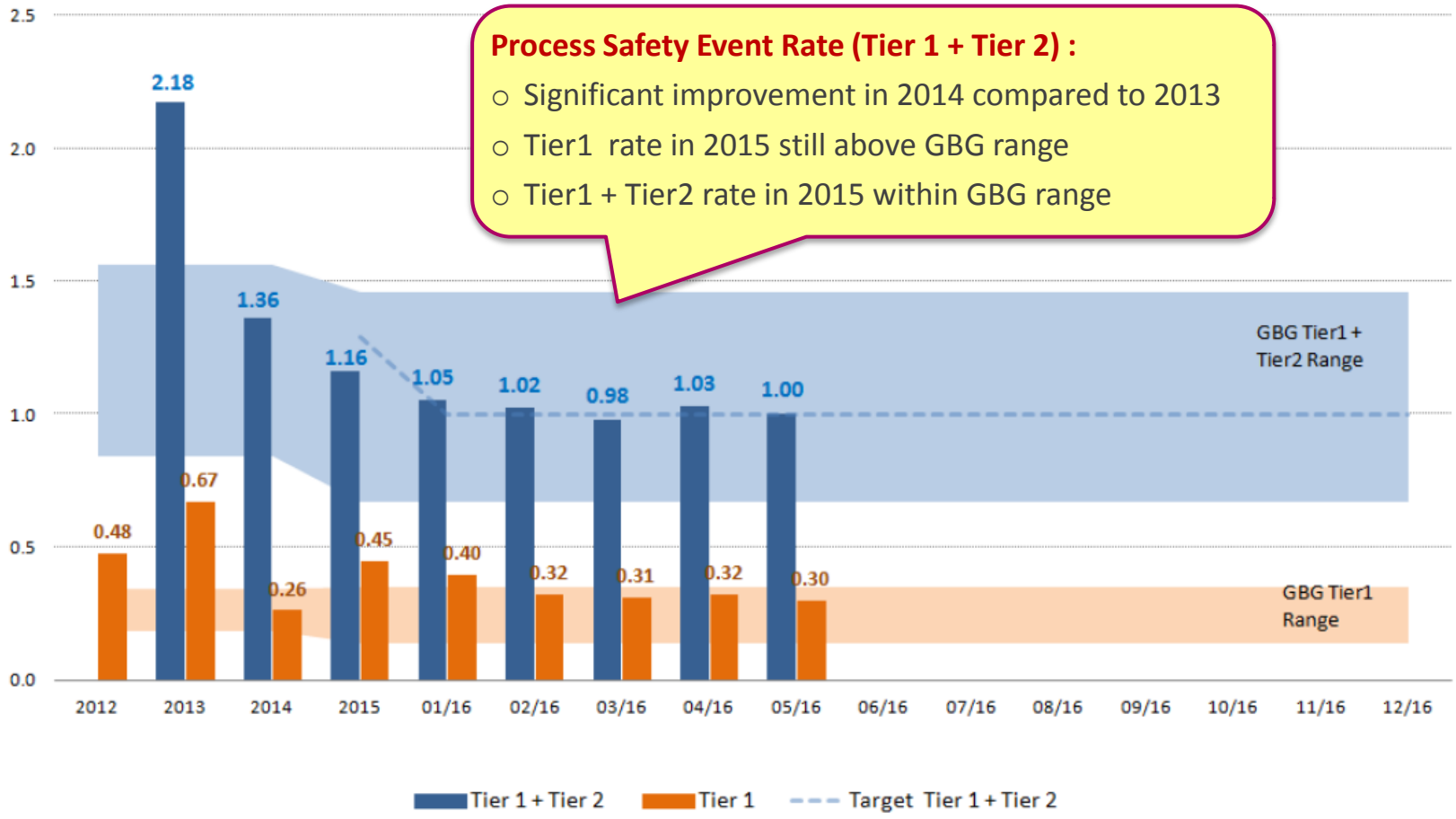
TOTAL Refining & Chemicals vs GBG (Global Benchmarking Group)

GBG 2012/2014 :
Tier 1 Average Rate Range: 0,19-0,346
Tier 1 + Tier 2 Average Rate Range: 0,84- 1,56

GBG 2013/2015:
Tier 1 Average Rate Range: 0,14-0,353
Tier 1 + Tier 2 Average Rate Range: 0,67- 1,46

Process Safety Event Rate (Tier 1 + Tier 2) :

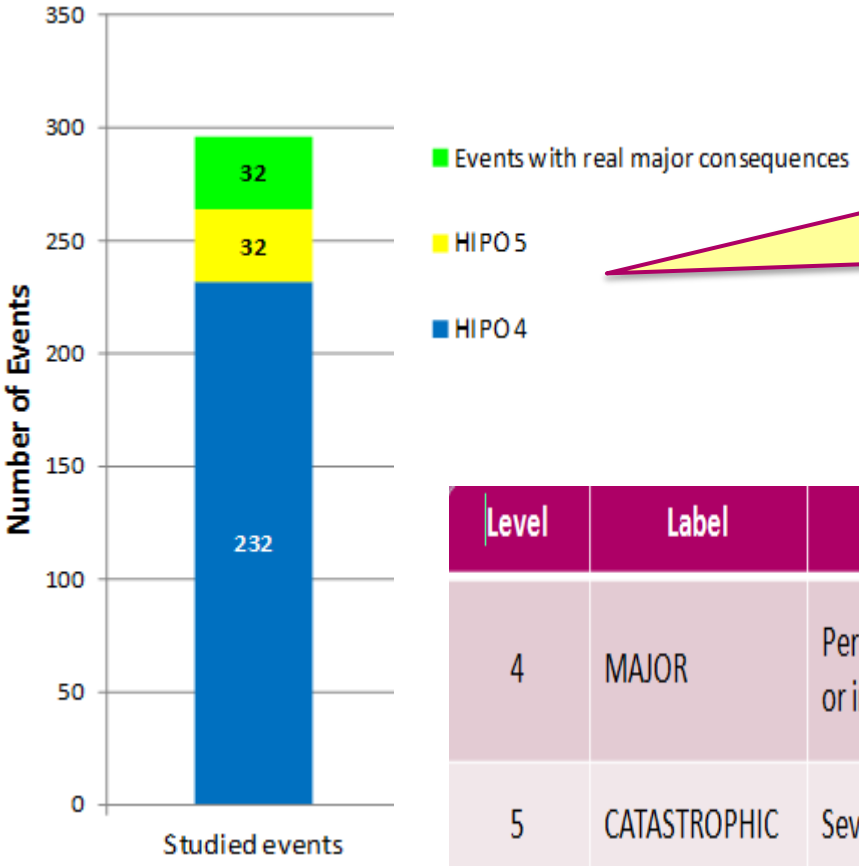
- Significant improvement in 2014 compared to 2013
- Tier1 rate in 2015 still above GBG range
- Tier1 + Tier2 rate in 2015 within GBG range



Analysis of Events

Type of Events

- Events in the period 2012 -2015 with **high potential consequences (HIPO)** and events with **real significant consequences (Real)** were analyzed
- In total **296** such events were recorded in 2012-2015



A « High Potential Event » (HIPO) is an accident or incident which might have given rise to at least a level 4 accident that was just avoided

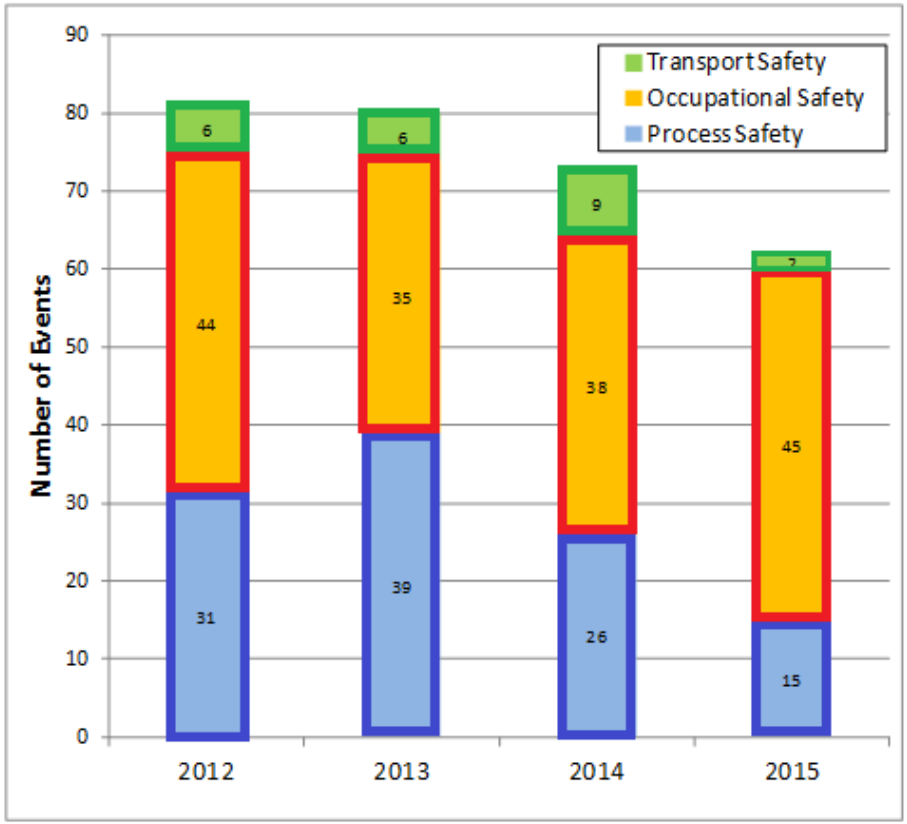
- 28% of the 296 studied events are LOPC events
- 89% of these events are HIPO events

Level	Label	Health & Safety	Environment
4	MAJOR	Permanent disability, death or injuries to the population	Significant external pollution. Implementation of external emergency plan. Emissions into the environment of 10 t of toxic product.
5	CATASTROPHIC	Several deaths	Major pollution with long-term environmental consequences outside the site

Characterization of Events (domain)

TOTAL RC data :

Analysis of 296 HIPO events and events with real major consequences in the period 2012-2015

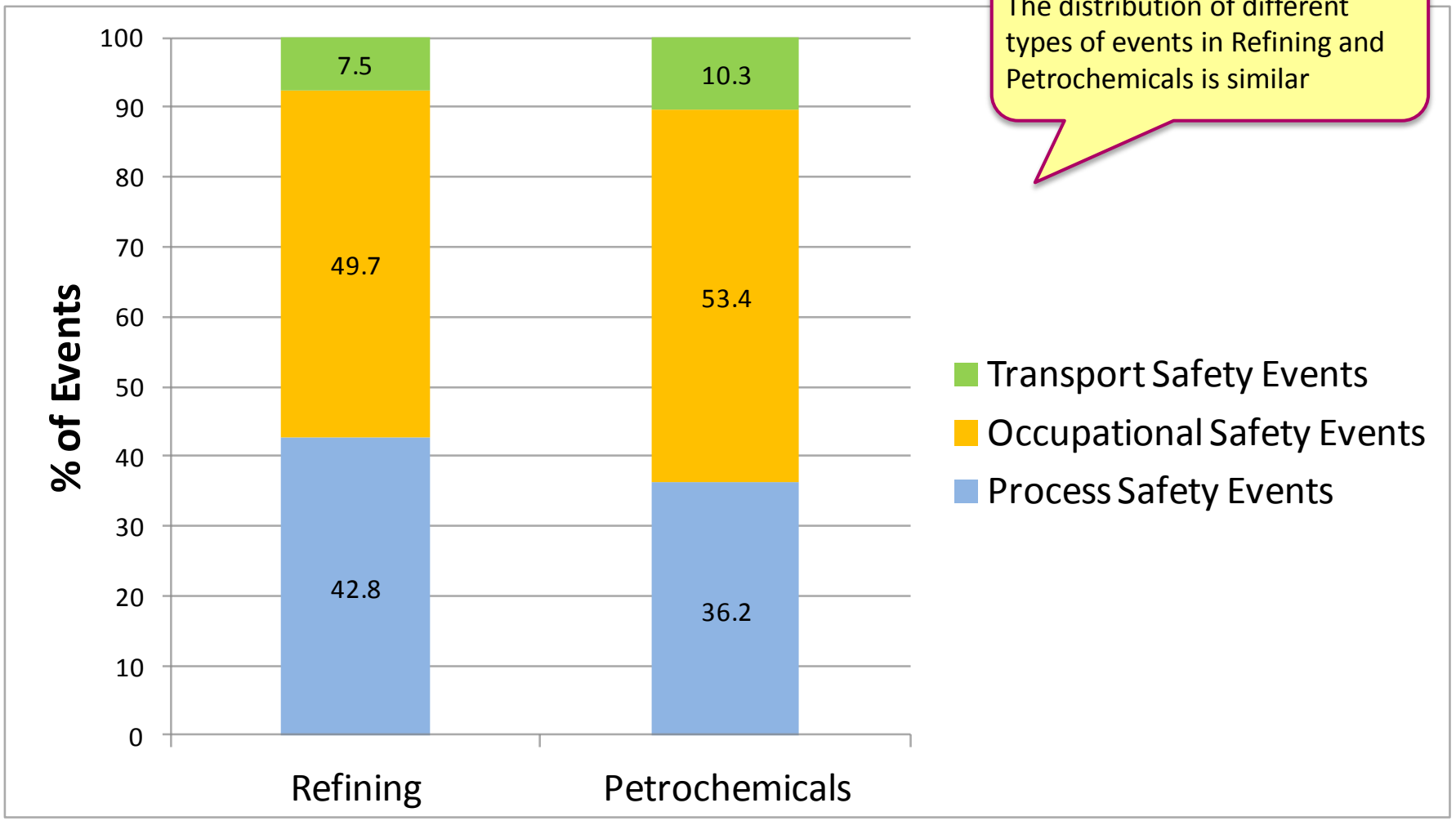


- 54.7% of the 296 studied HIPO events are in the domain of **Occupational Safety**

Type of Events per Sector

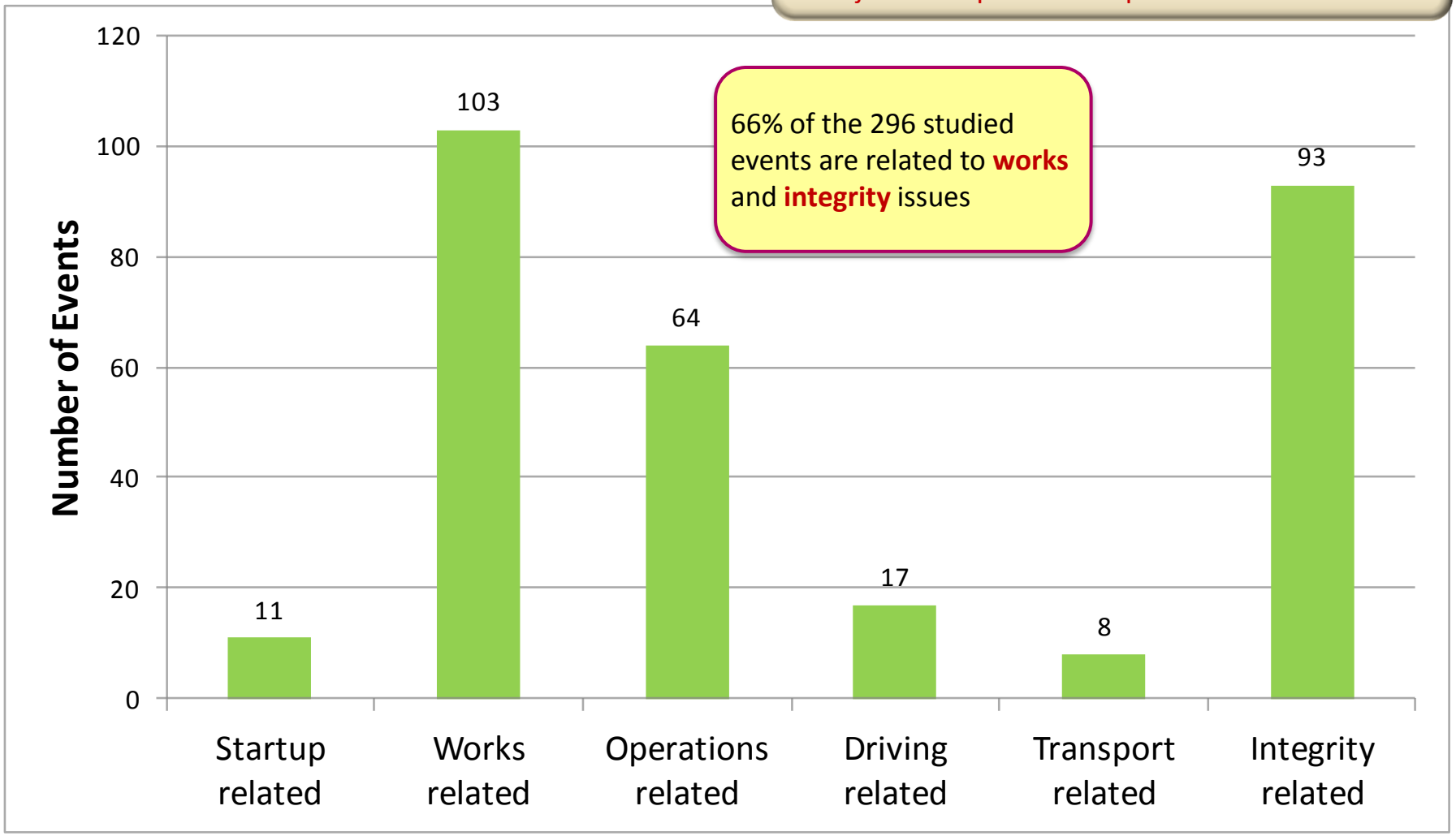
TOTAL RC data :
Analysis of 296 HIPO events and events with real major consequences in the period 2012-2015

The distribution of different types of events in Refining and Petrochemicals is similar



Characterization of Events (nature of activity)

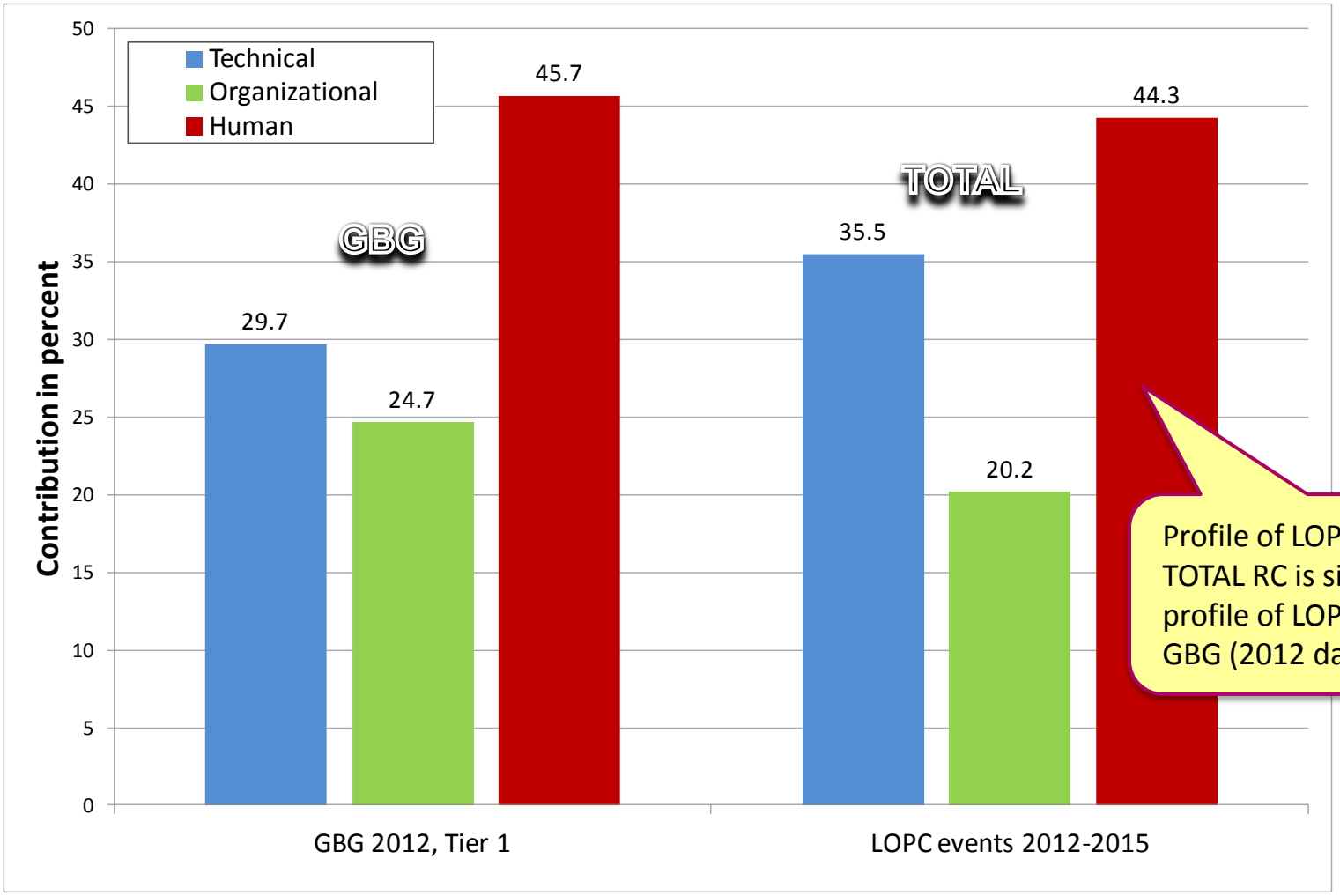
TOTAL RC data :
Analysis of 296 HIPO events and events with real major consequences the period 2012-2015



66% of the 296 studied events are related to **works** and **integrity** issues

Benchmarking with GBG data (LOPC)

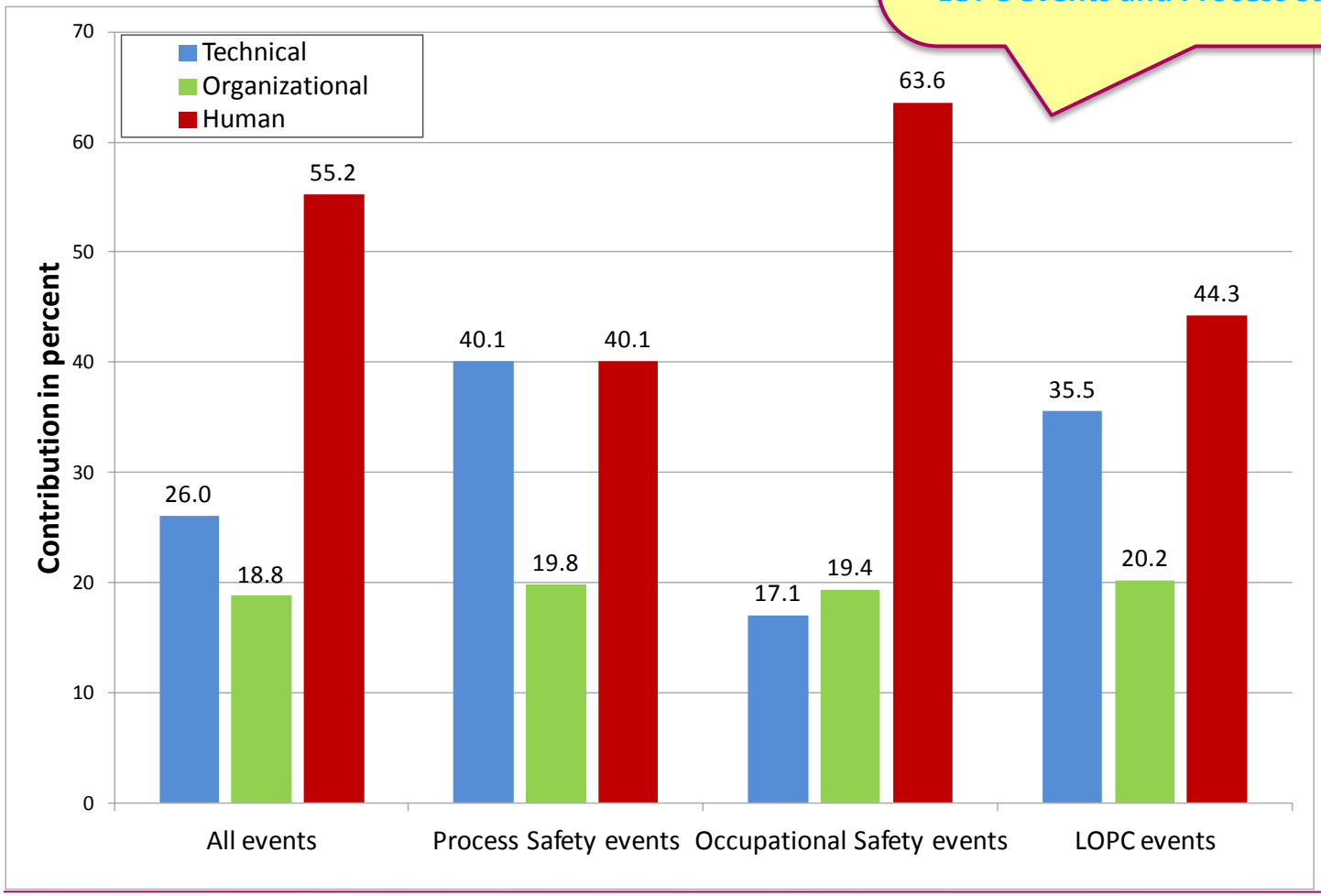
GBG data :
Refining Industry **2012**
Analysis of 70 LOPC events
TOTAL RC data :
Analysis of 82 LOPC HIPO events (excl. fires/explosions) in **2012-2015**



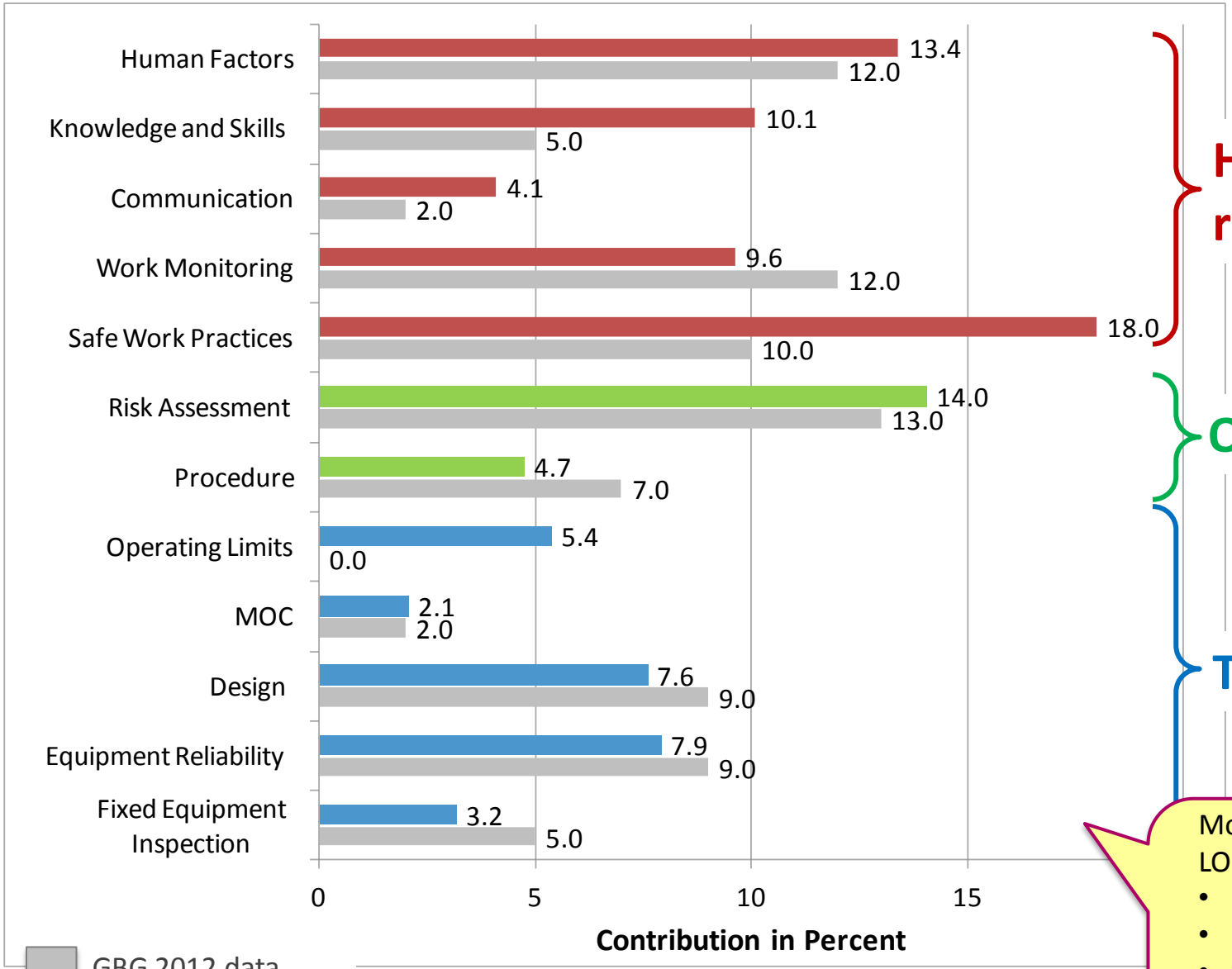
Profile of LOPC events in TOTAL RC is similar to the profile of LOPC events in GBG (2012 data)

Causes for Categories of Events

- Organizational causes have the same contribution for all types of events (LOPC, Process Safety, Occupational Safety)
- **Human related causes** are the most important, irrespective of the category of events
- **Technical related causes are more important for LOPC events and Process Safety events**



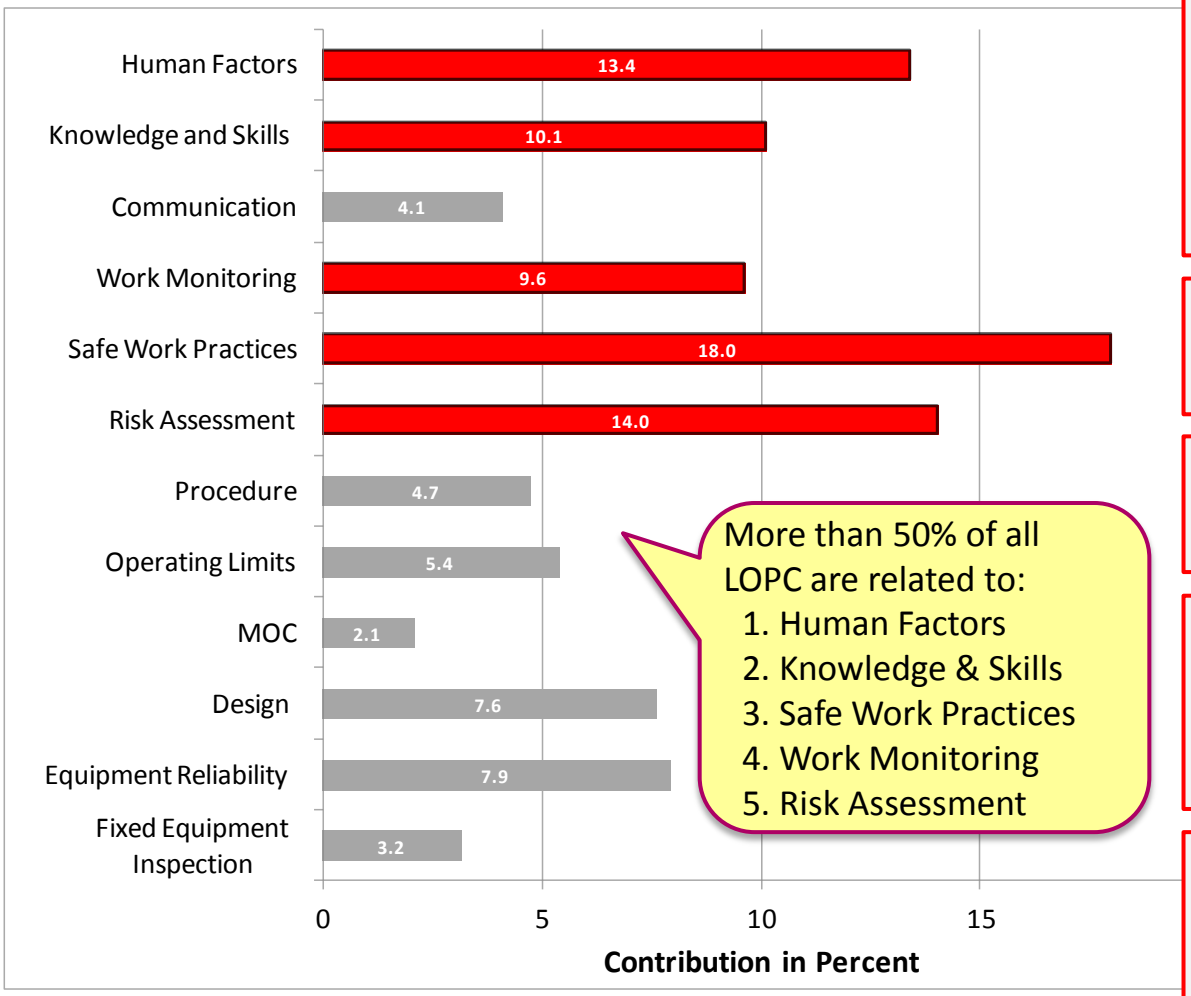
Analysis of TOTAL RC data (LOPC, 2012-2015)



More than 50% of all LOPC are related to:

- Human Factors
- Knowledge & Skills
- Safe Work Practices
- Work Monitoring
- Risk Assessment

Analysis of TOTAL RC data (LOPC, 2012-2015)



Human Factors
- Complacency (lack of focus)
- Normalization of deviation ("bypass is tolerated")
- Lack of presence of management in the field
- Expectations of management are sub-standard
- Inadequate application of work permit process
- Inadequate application of Golden Rules

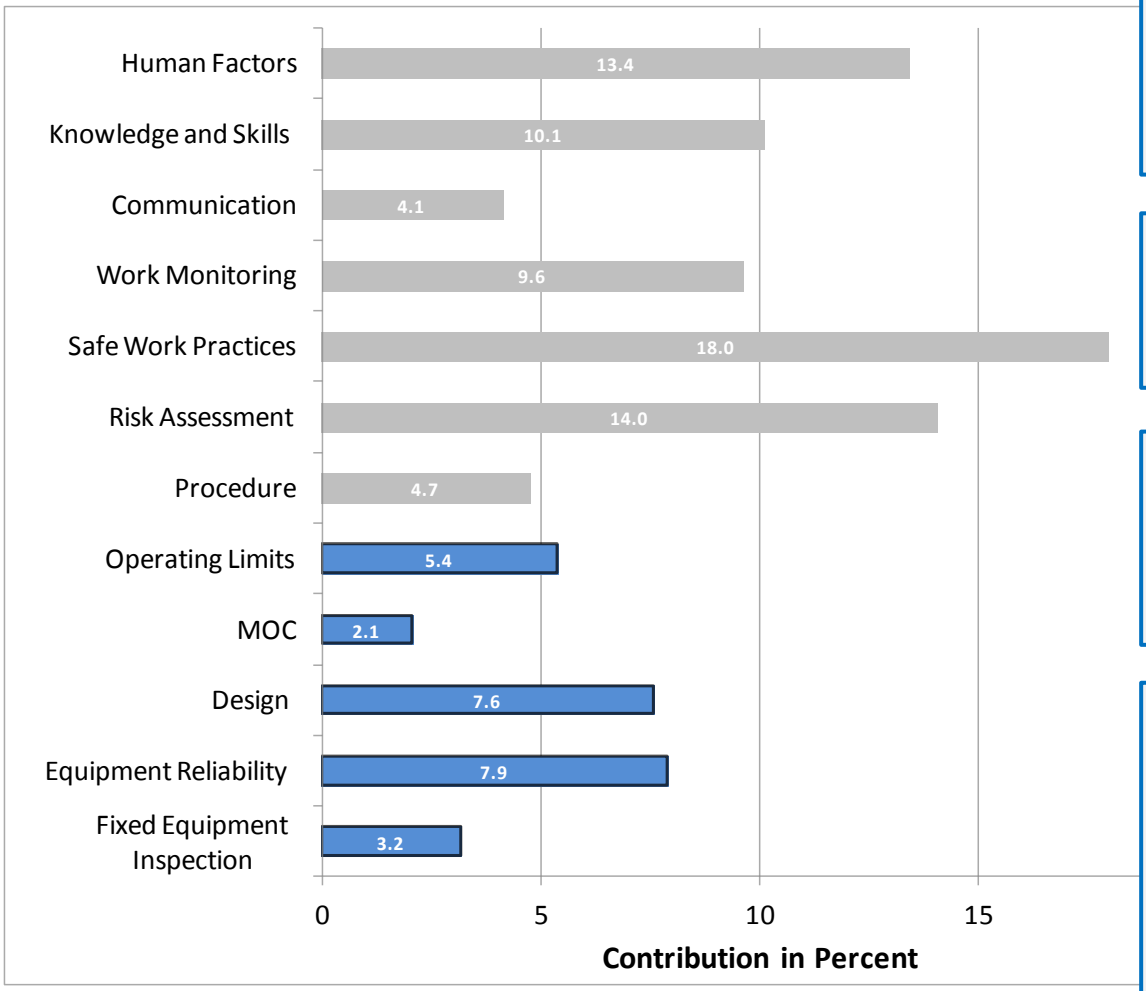
Knowledge & Skills
- Lack of experience
- Lack of skills

Work Monitoring
- Insufficient oversight of contractor work
- Lack of competence of the supervisor

Risk Assessment
- Insufficient quality of risk analysis and risk assessment
- Inadequate application of outcome of risk assessment

Safe Work Practices
- Lack of information or wrong information
- Improper delegation of high risk work
- Poor communication with contractor
- Lack of clear instruction
- No visit in the field
- Poor preparation of equipment for handover

Analysis of TOTAL RC data (LOPC, 2012-2015)



Operating Limits

- Operating window is not clearly and formally defined
- Operating window is not known by all operational people
- An excursion outside the operating window is not immediately and formally reported to site management

MOC

- An efficient and well documented MOC program is not in place and not well monitored

Design / Equipment Reliability

- Lack of use of applicable specifications in the design
- No full compliance with standards and good practices

Fixed Equipment Inspection

- Insufficient experienced and well trained technical staff
- Safety critical items not well defined nor well managed
- No comprehensive documentation of degradation mechanisms
- Insufficient monitoring of the inspection program
- Findings and associated action plan of the inspection programs are not accepted

Action Plans

Action Plans

- The analysis on the previous slides indicate the importance of HIPO and REX knowledge
- Factual evidence of efforts that need to be done to decrease HIPO and REX : human factor , knowledge, skills, risk assessment quality, etc …
- More specifically, a number of desired behaviors need to be developed in order to avoid the majority of HIPO events and event with real major consequences

1 High-Risk Situations
2 Traffic
3 Body Mechanics and Tools
4 Protective Equipment
5 Work Permits
6 Lifting Operations
7 Powered Systems
8 Confined Spaces
9 Excavation Work
10 Work at Height
11 Change Management
12 Simultaneous Operations or Co-Activities

- This study was helpful to prioritize safety actions

Action Plan for HSE Corporate (Safety Division) in Line with Findings of Analysis

Support

1. Develop and organize process safety training of process safety teams on sites
2. Improve process safety culture at operational level (operators, engineers, …)
3. Assure assistance to new projects according to TOTAL HSE/INDUSTRY guidelines
4. Assure quality of analysis of HIPO events, LOPC events and important accidents/incidents

Verify

5. Verify the use of mandatory rules and methods in our LBUs
6. Improve the efficiency of the RC HSE REX process (COREX, follow up of important REX, KPI,…)
7. Continue the development & follow-up of conformity programs (storage of LPG/Flam. Liq, …)
8. Prepare a mapping of major process safety risks and verify that these risks are managed

Define

9. Develop the Safety Culture program in RC
10. Continue the development of the technical integrity program (method, network, audits)
11. Continue the development and implementation of TOTAL referential, guides, audits, training
12. Implement REACH regulation and integrate product safety management

BACK UP

LOPC

- A loss of primary containment (LOPC) = accidental, sudden and uncontrolled loss of combustible, flammable, explosive, corrosive, toxic products or products dangerous to the environment whatever steps are taken to confine or collect them or to protect the environment.
- The products to which this indicator relates are those identified in API 754.
- Examples:
  - Leaks or releases of liquid and/or gas hydrocarbons or flammable or toxic materials occurring on site from a closed circuit:
    - Either directly into the atmosphere (Ex: burst of a pipe, of a seal, rupture of pump seals)
    - Or in a collection network (drain network or gutters).
    - Or in a secondary containment (storage tank, service station separator).
  - Opening of pressure relief valves (PRV) to the atmosphere giving way either to liquid carry over, or to discharge to a potential unsafe location, or to a shelter in place or to a public protective measure (road closure)
  - Break of rupture disks

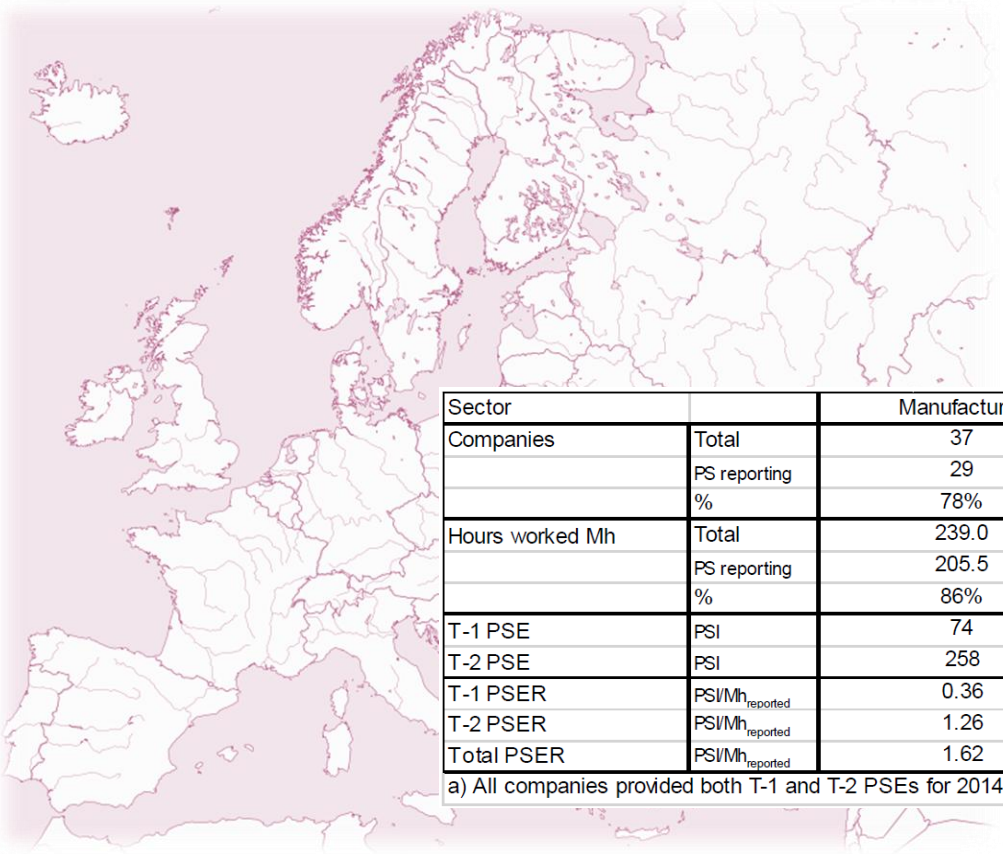
Thresholds for reporting

IBP- FP	Products	Tier 1		Tier 2		Tier 3	
		Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
	Flammable gas, incl H2, LPG, Fuel gas	>500	>250	50- 500	25- 250	<50	<25
IBP<35°C- FP<23°C	C5 cut/Pentan/Light reformate/…	>500	>250	50- 500	25- 250	<50	<25
IBP>35°C- FP<23°C	Light crude/Gasolines/Light naphta/Benzen/ Toluen/Light Aros/ETBE/MTBE/MEK/DEA	>1000	>500	100- 1000	50- 500	<100	<50
IBP>35°C- 23<FP<60°C	Kerosene/Heavy crude/Styrene/EthylBenzene Diesel/Furfurol/Sulfur/…	>2000	>1000	100- 2000	50- 1000	<100	<50
FP>60°C- Product released at Temp<FP	Home heating oil/Basestock /Heavy FO/Lube			>1000	>500	<1000	<500
FP>60°C- Product released at Temp >FP	ATRES/Fuel/VACRES/…	>2000	>1000	100- 2000	50- 1000	<100	<50
	Phenol/H2O2 (<70%)	>1000	>500	100- 1000	50- 500	<100	<50
	Acids and bases	>2000	>1000	100- 2000	50- 1000	<100	<50
	H2S, Chlorin, SO3, Oleum	>25	>12,5	2,5- 25	>1,2	<2,5	<1,2
	SO2, HF, anhydrous HCL, Methyl mercaptan	>100	>50	10- 100	>5	<10	<5
	Ammonia, CO	>200	>100	20- 200	>10	<20	<10

- Values in kg/h
- The thresholds in Kg/h are corresponding to the quantity released in any one hour period

CONCAWE

- Benchmark study in 2014 was performed by CONCAWE (downstream oil & gas in Europe) on safety performance of European refineries
- The study includes feedback from 37 CONCAWE members and represents about 98% of European refining capacity (EU-28, Norway and Switzerland)

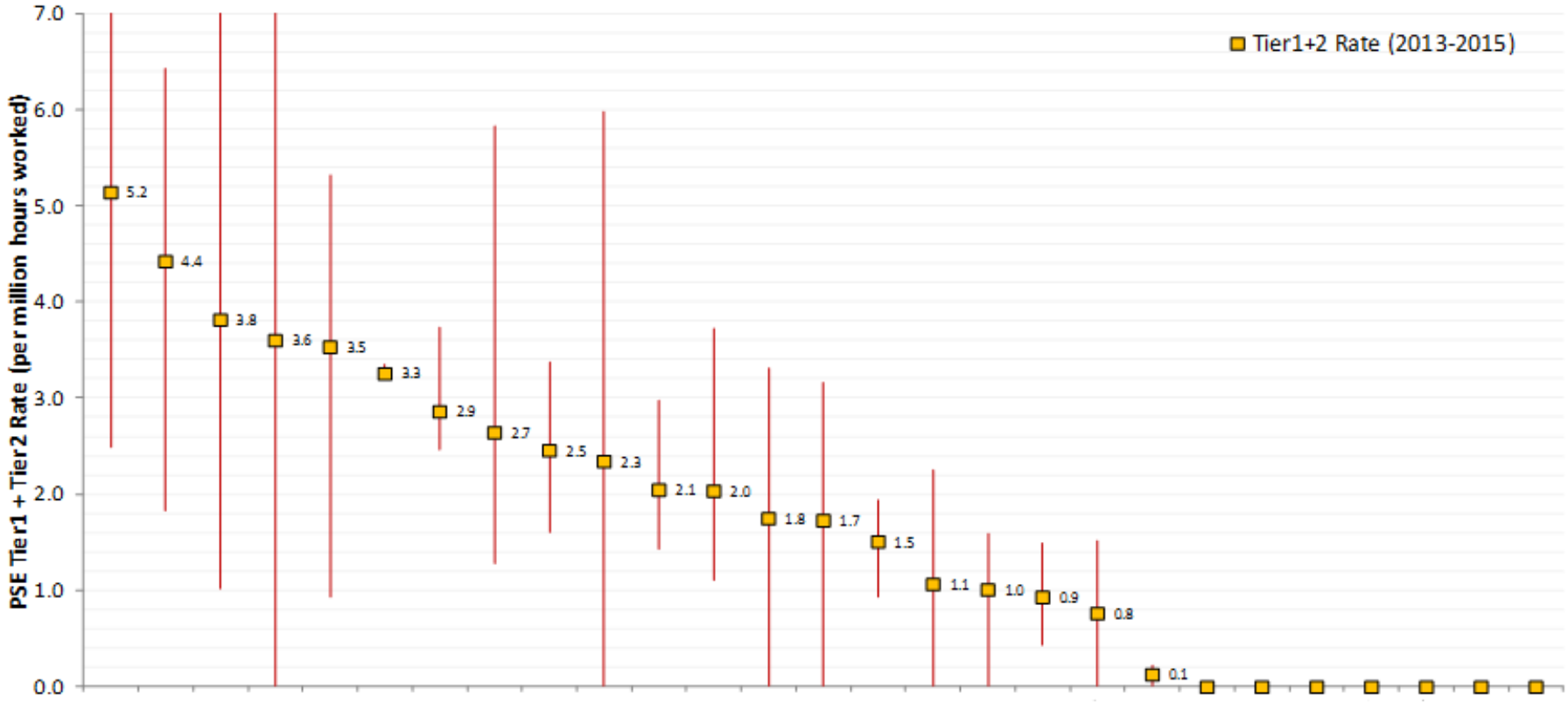


Sector		Manufacturing	Marketing	Both Sectors
Companies	Total	37	24	23
	PS reporting	29	16	15
	%	78%	67%	65%
Hours worked Mh	Total	239.0	268.7	507.7
	PS reporting	205.5	214.5	419.9
	%	86%	80%	83%
T-1 PSE	PSI	74	8	82
T-2 PSE	PSI	258	55	313
T-1 PSER	$PSI/Mh_{reported}$	0.36	0.04	0.20
T-2 PSER	$PSI/Mh_{reported}$	1.26	0.26	0.75
Total PSER	$PSI/Mh_{reported}$	1.62	0.29	0.94

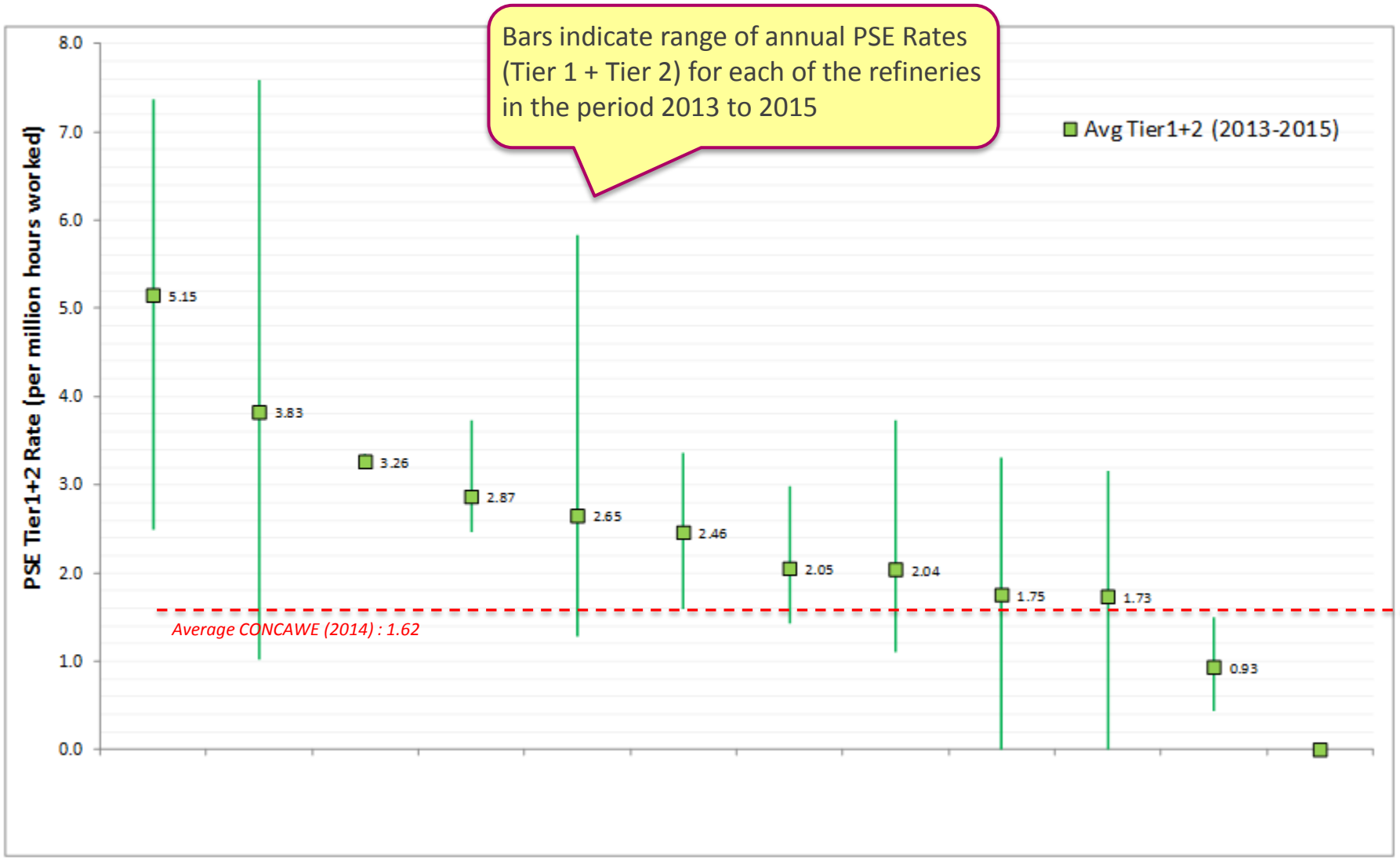
a) All companies provided both T-1 and T-2 PSEs for 2014.

TOTAL RP sites – Process Safety Event Rate (Tier1+2)

Bars indicate range of annual PSE Rates (Tier 1 + Tier 2) for each of the RP sites in the period 2013 to 2015



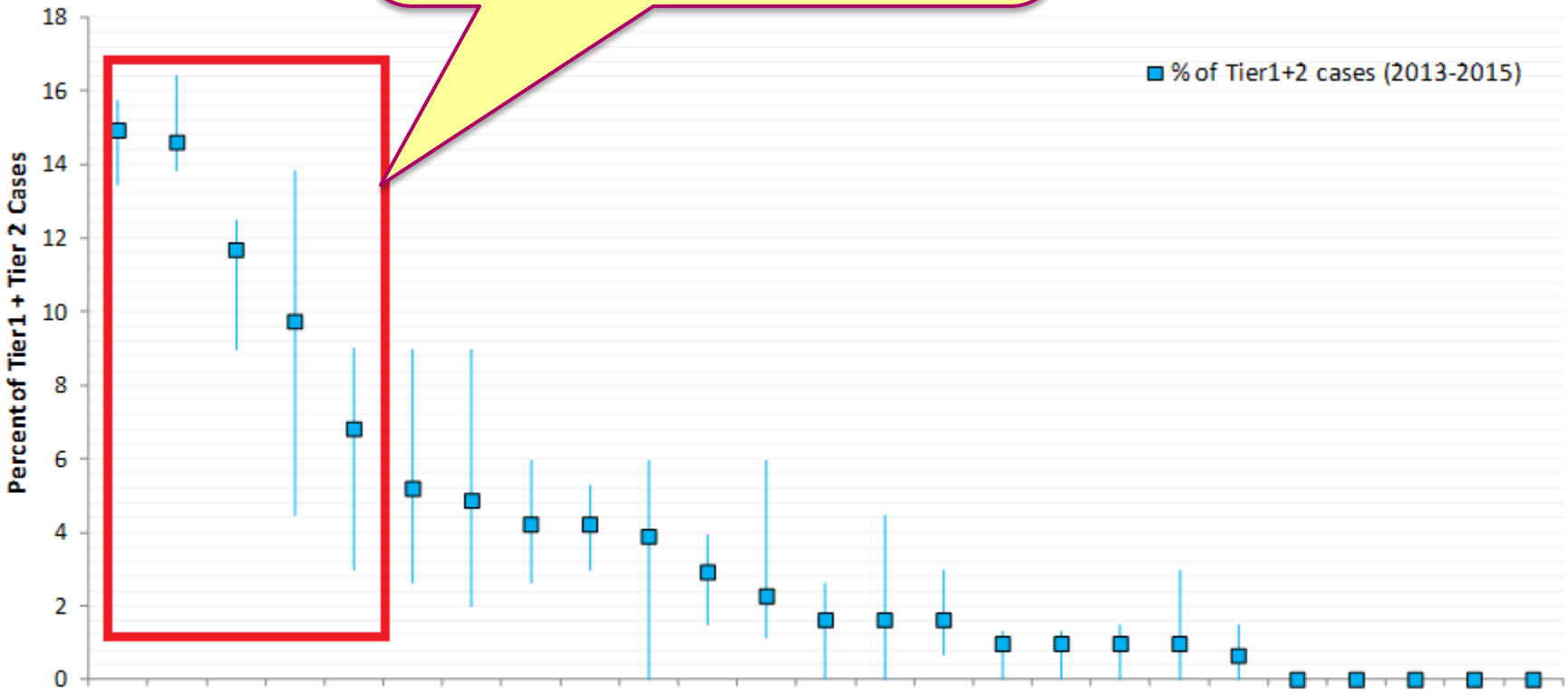
TOTAL Refining – Process Safety Event Rate (Tier1+2)

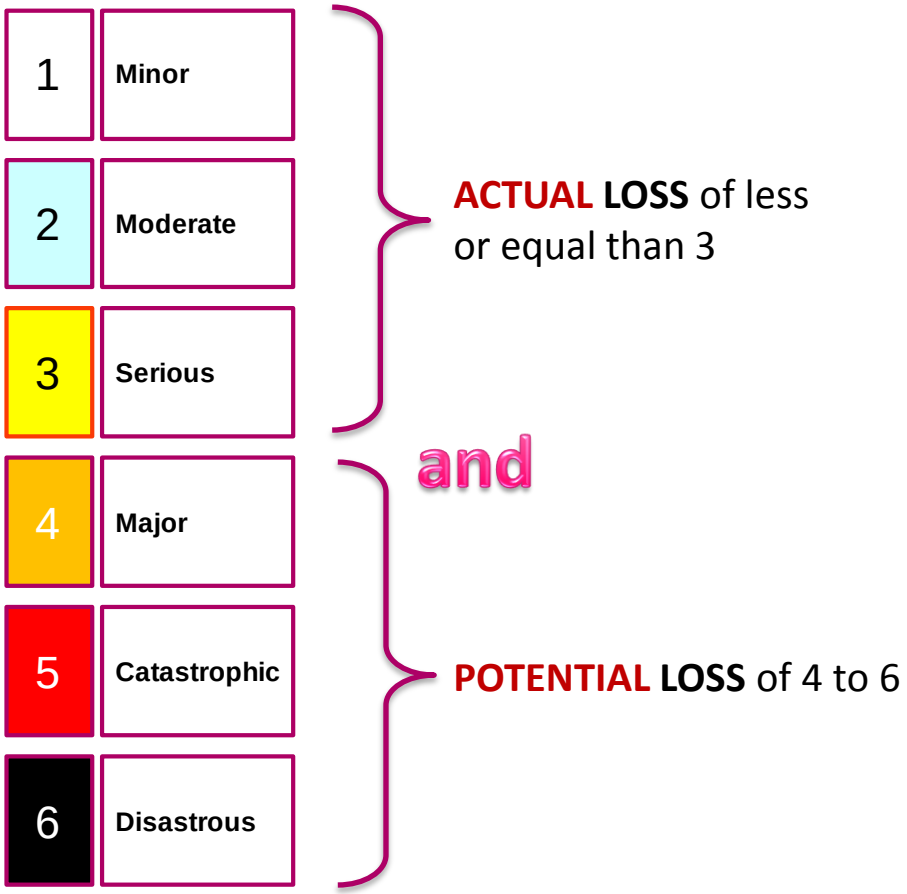


TOTAL RP – Number of Tier1+Tier2 Events

- Bars indicate range of annual percentage of PSE cases (Tier 1 + Tier 2) for each of the sites in the period 2013 to 2015
- About **60 percent** of all Tier1 + Tier 2 PSE cases (period 2013 to 2015) are generated by **5 sites**

TOTAL RC data :
Analysis of 308 Tier 1 + Tier 2 events in the period 2013 to 2015



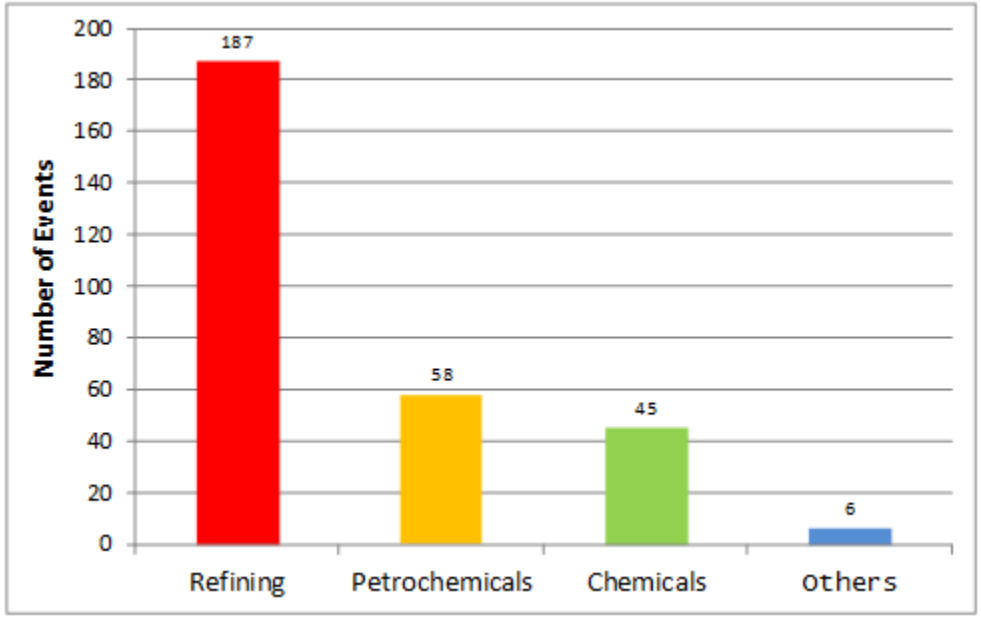


A « High Potential Event » (HIPO) is an accident or incident which might have given rise to at least a level 4 accident that was just avoided:

- Either through the existence of particular favorable circumstances
- Or by the successful use of an ultimately mitigating emergency device
- Or through an unexpected or unforeseen recovery action

Level	Label	Health & Safety	Environment
4	MAJOR	Permanent disability, death or injuries to the population	Significant external pollution. Implementation of external emergency plan. Emissions into the environment of 10 t of toxic product.
5	CATASTROPHIC	Several deaths	Major pollution with long-term environmental consequences outside the site

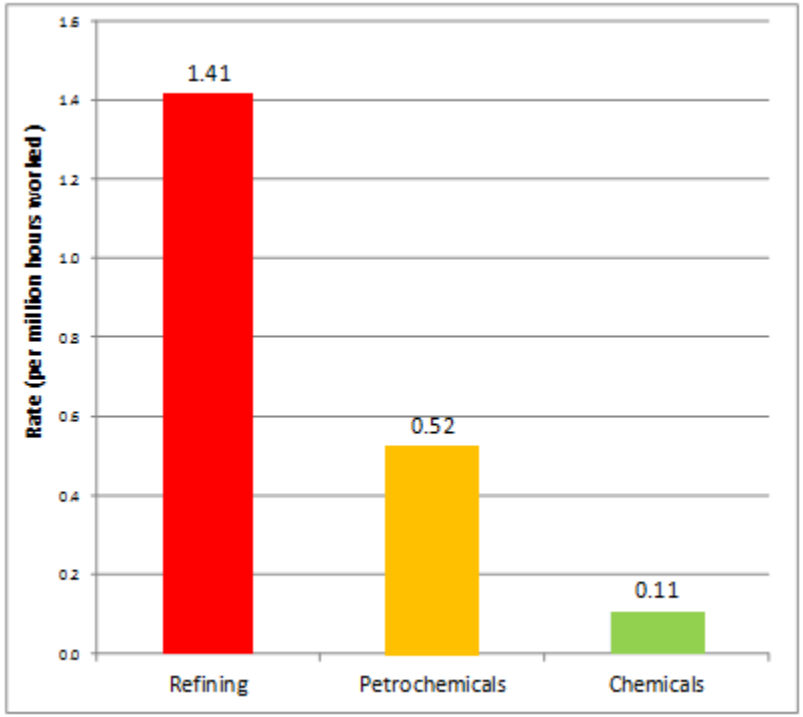
Events per Sector



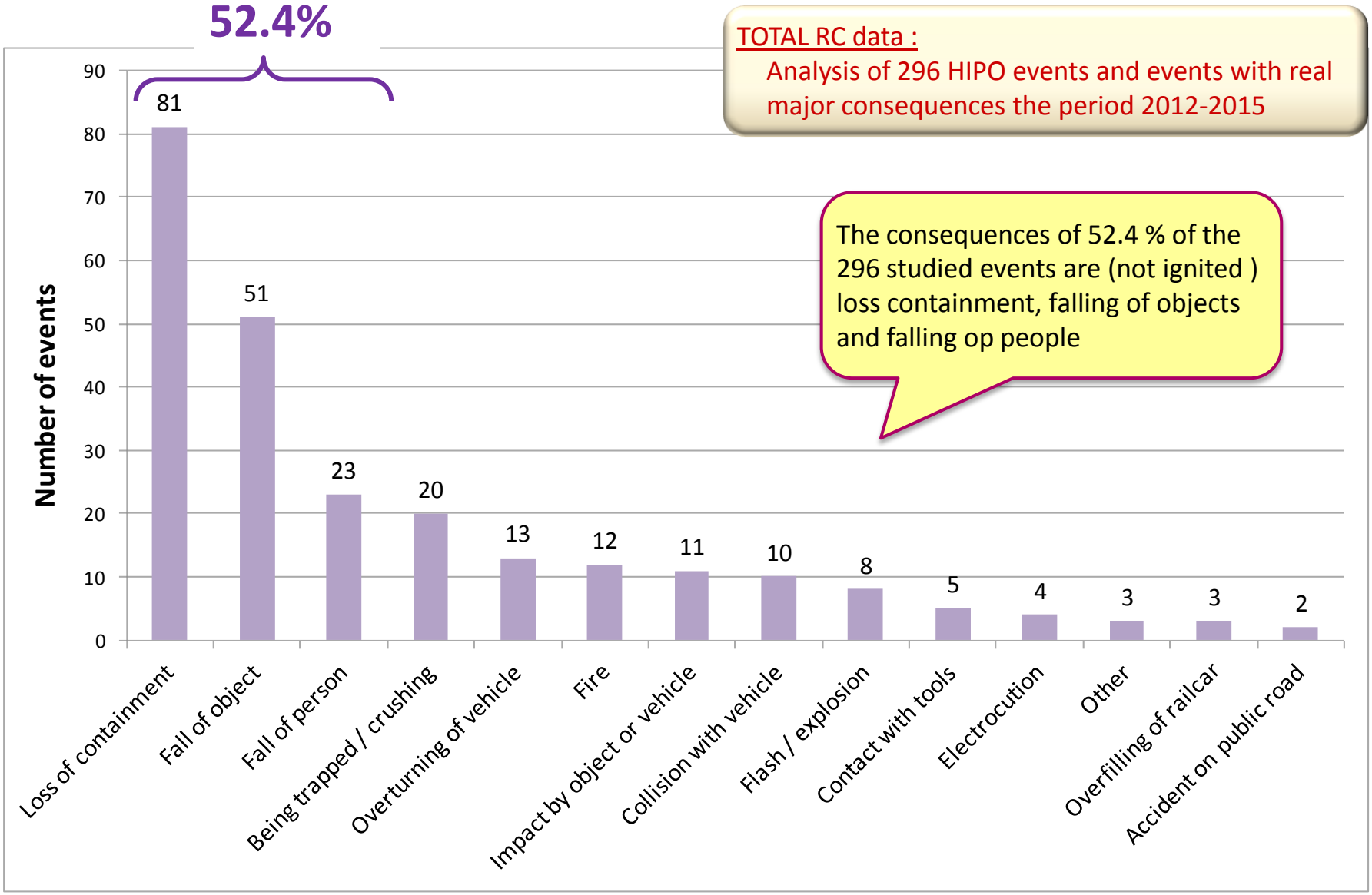
TOTAL RC data :

Analysis of 296 HIPO events and events with real major consequences in the period 2012-2015

Better performance of Petrochemicals and Chemicals sites in comparison to Refining



Characterization of Events (category of consequences)



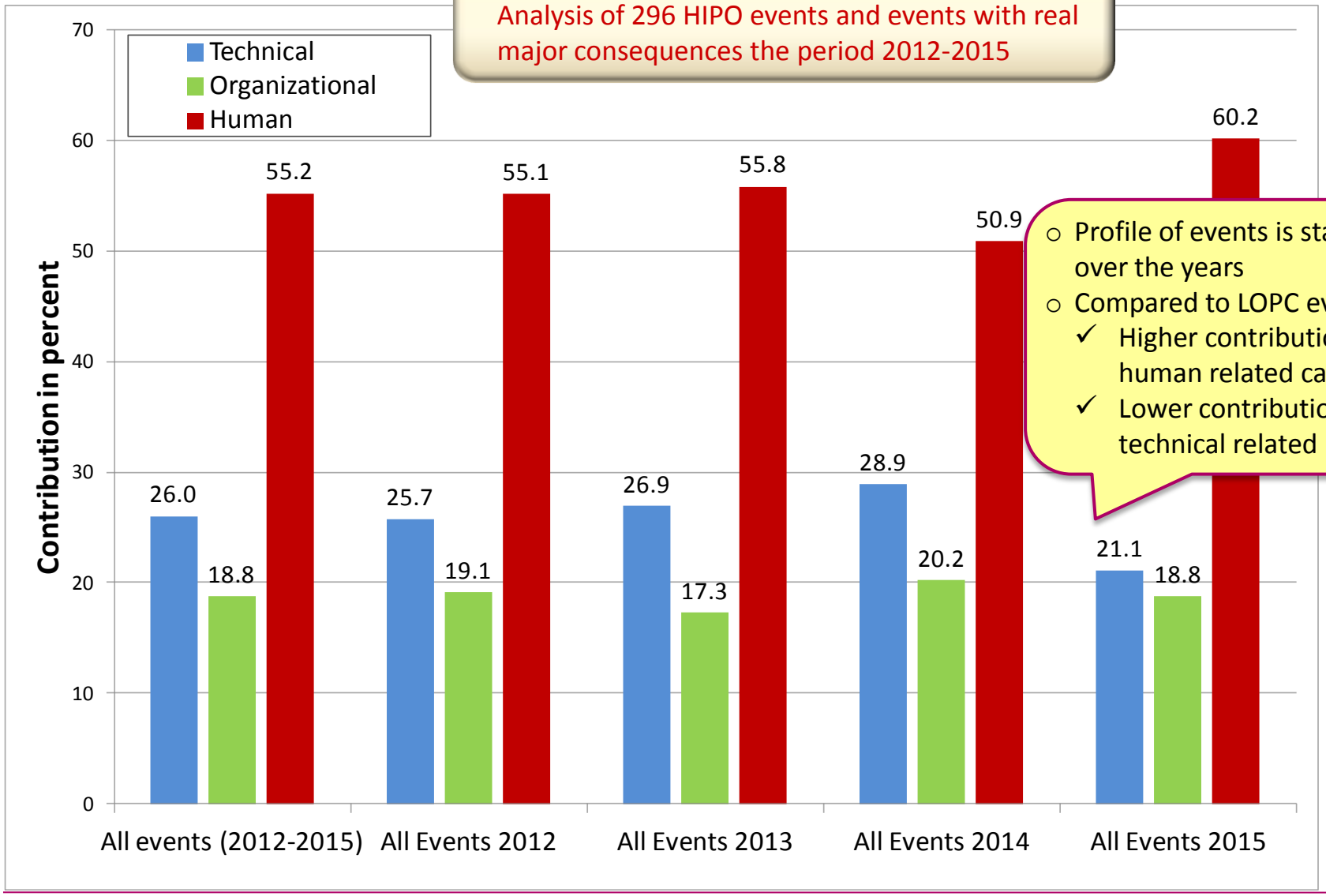
Benchmarking with GBG data (2012)

Classification of accident causes according to API & GBG

Technical cause (sudden failure)	A - Mechanical failure (failure while operating within design enveloppe)	1 - Fixed Equipment Inspection 2 - Equipment Reliability
	B - Process failure (failure because of operation out of design enveloppe)	3 - Design 4 - Change Management 5 - Operating Limits
Organisational cause (inadequate operation)	C - Inadequate operation preparation	6 - Procedures 7 - Risk Assessment
Human related cause	D -Inadequate practices	8 - Safe Work Practices 9 - Work Monitoring 10 - Communication
	E - Other human related cause	11 - Knowledge and Skills 12 - Human Factors
Other	F - Other	13 -Other

Causes for **All Events** (Process Safety + Occupational Safety +Transport Safety)

TOTAL RC data :
Analysis of 296 HIPO events and events with real major consequences the period 2012-2015

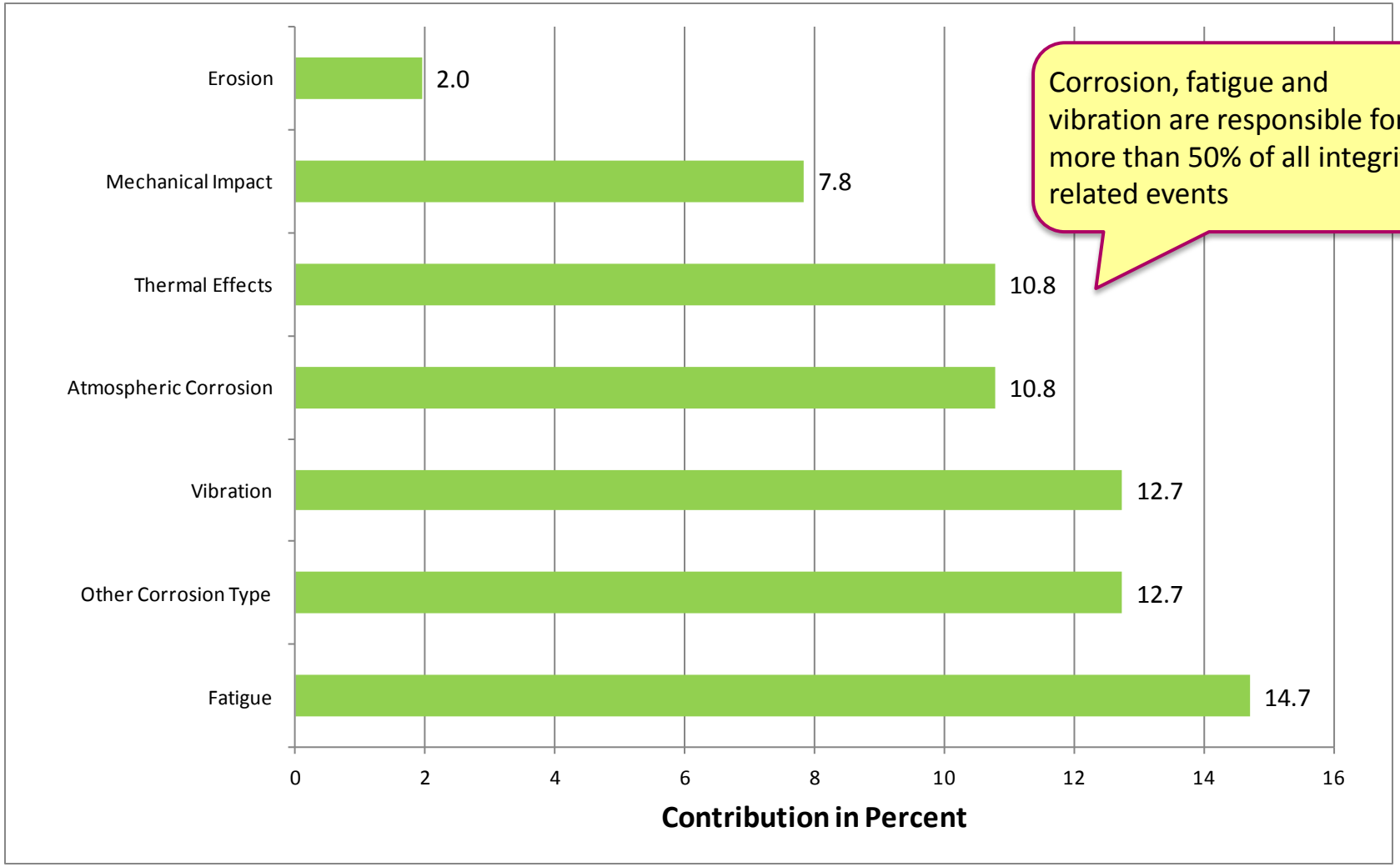


- Profile of events is stable over the years
- Compared to LOPC events:
  - ✓ Higher contribution of human related causes
  - ✓ Lower contribution of technical related issues

Focus on Integrity

Degradation Types

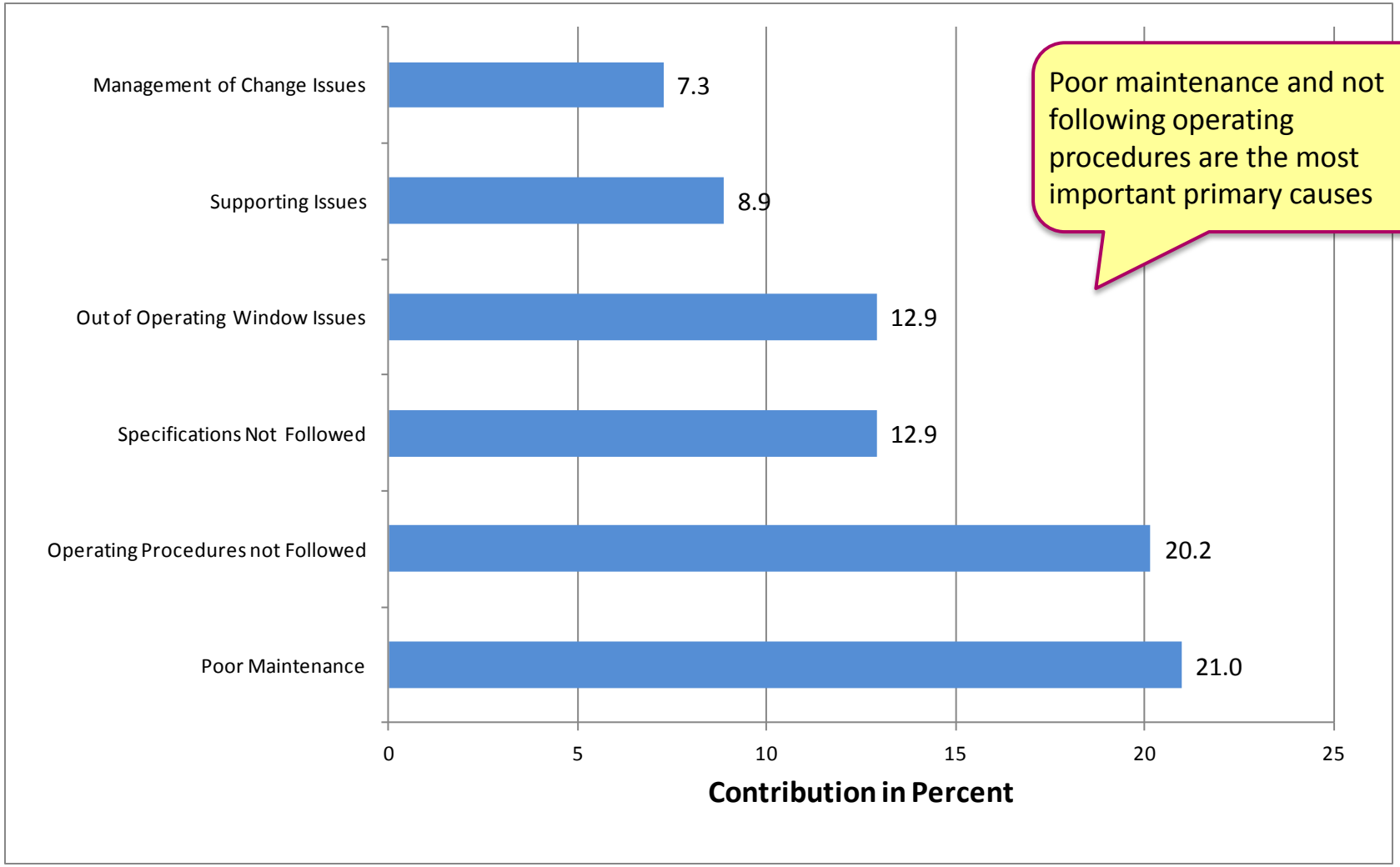
TOTAL RC data :
Analysis of **93 integrity** related HIPO events and events with real major consequences the period 2012-2015



Primary Causes

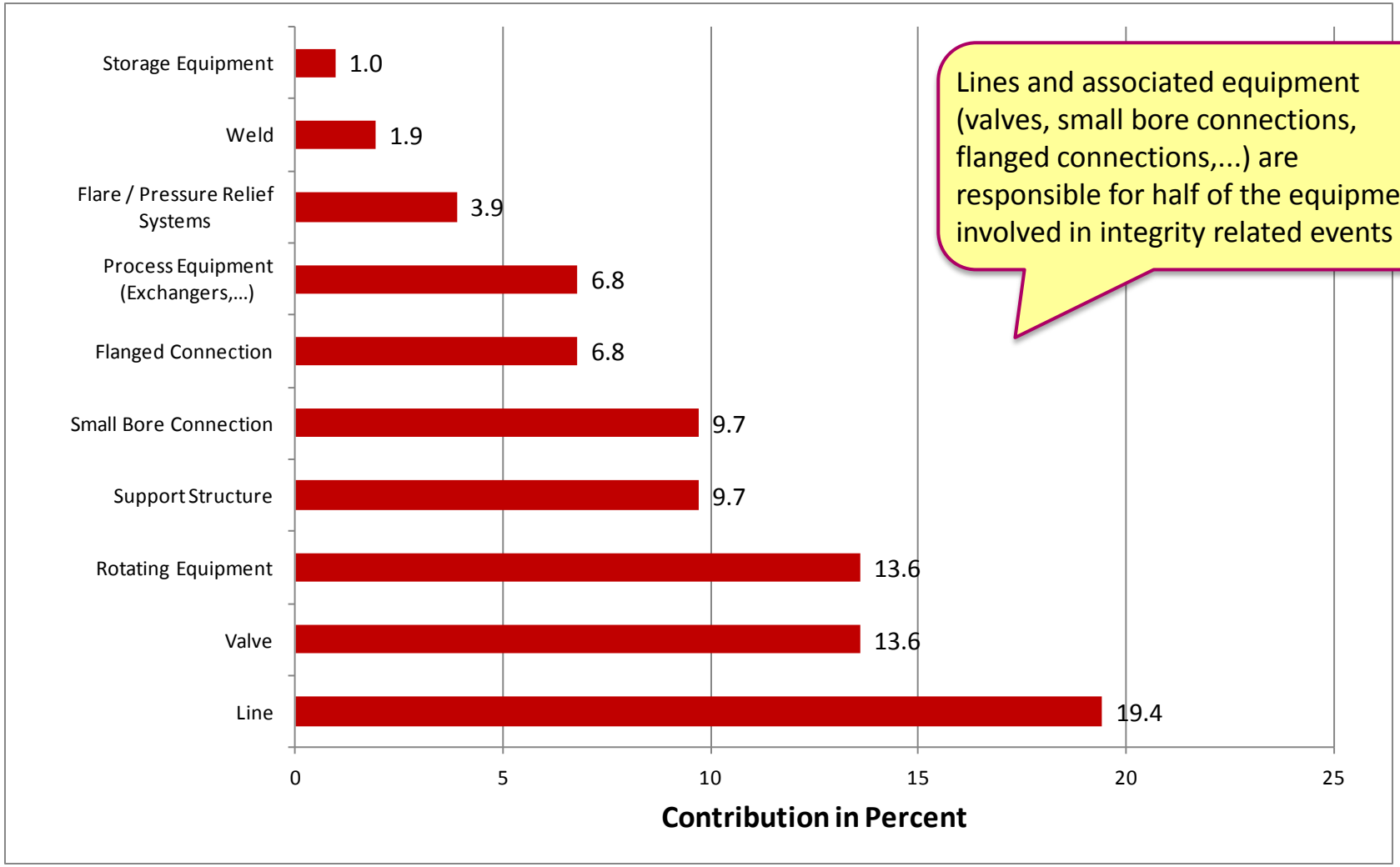
TOTAL RC data :

Analysis of 93 integrity related HIPO events and events with real major consequences the period 2012-2015



Equipment Involved

TOTAL RC data :
Analysis of 93 integrity related HIPO events and events with real major consequences the period 2012-2015



Lines and associated equipment (valves, small bore connections, flanged connections,...) are responsible for half of the equipment involved in integrity related events