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An Analysis on Human-Related Unplanned Reactor Trip Events in Korea

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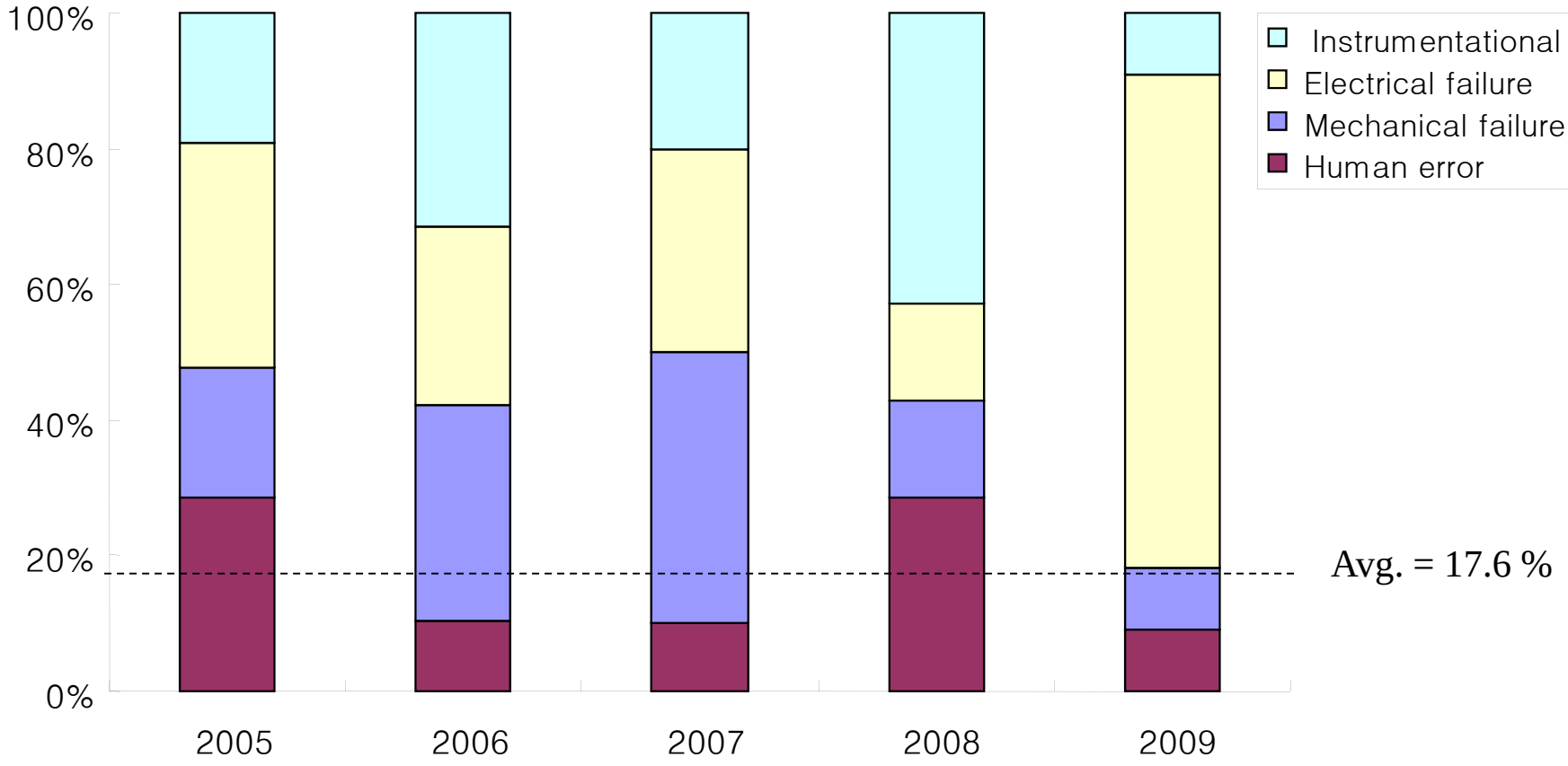
Outline

1. Introduction
2. Classification of Human Errors & Simple Path Model
3. Application to Experience Data
4. Conclusions

1. Introduction

- **Human Errors in NPPs**
  - United States
    - In Boiling Water Reactors (BWRs) for the year 1979
    - 31% (413/1,345) events are identified as human error events
  - Japan
    - NPPs in Japan from 1970 to 1995
    - 22% (193 / 885) events are identified as human error events
  - Republic of Korea
    - NPPs in Rep. of Korea from 2002 to 2006
    - 23% events are identified as human error events

1. Introduction



Percentages of unplanned reactor trip causes

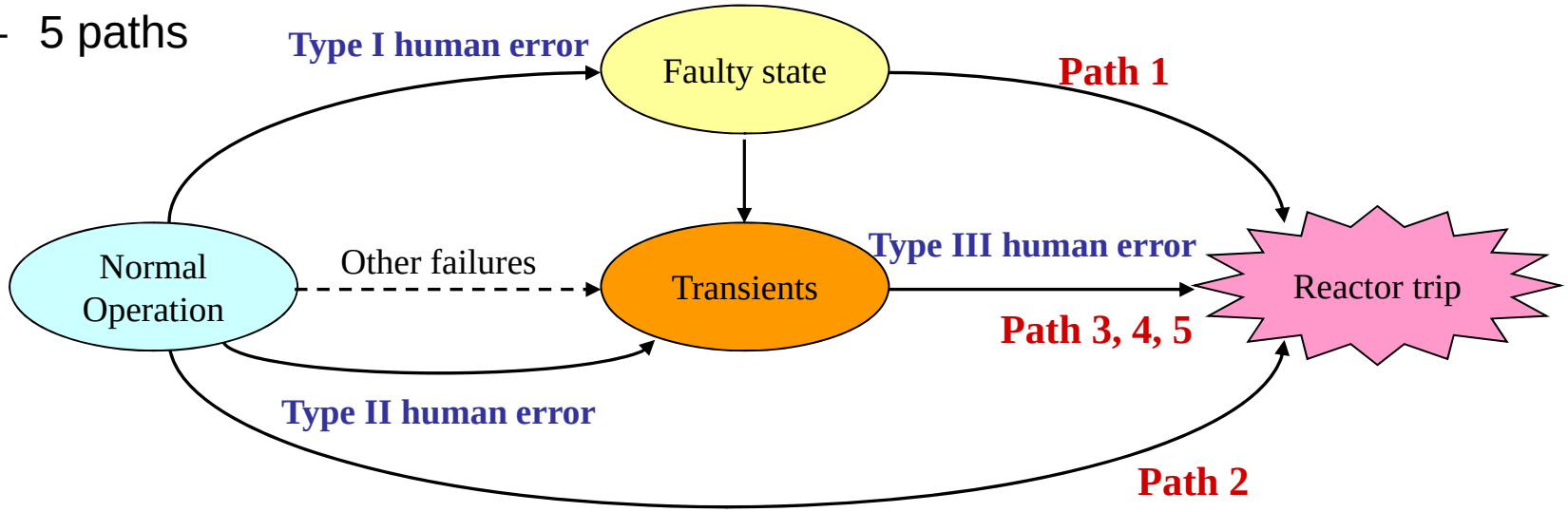
Data source: Operational Performance Information System for NPPs by KINS

2. Classification of Human Errors

- **Three types of human errors (HEs)**
  - Type I : Pre-transient or pre-reactor-trip HEs
    - Maintenance
    - Setting
    - Procedure
    - Design/implementation/manufacturing/installation
  - Type II : Transient-inducing or reactor-trip-inducing HEs
    - Test
    - Maintenance
    - Operation
  - Type III : Post-transient HEs
    - Response to a transient

2. Classification of Human Errors

- Simple path model for human-induced unplanned reactor trips (Kim and Park, 2010)
  - 4 states and 7 transients
  - 5 paths



- ❖ **Path 1: Immediate reactor trip due to Type I HEs**
- ❖ **Path 2: Immediate reactor trip due to Type II HEs**
- ❖ **Path 3: Failure in management of transient state caused by Type I HE**
- ❖ **Path 4: Failure in management of transient state caused by Type II HE**
- ❖ **Path 5: Failure in management of transient state caused by other failures**

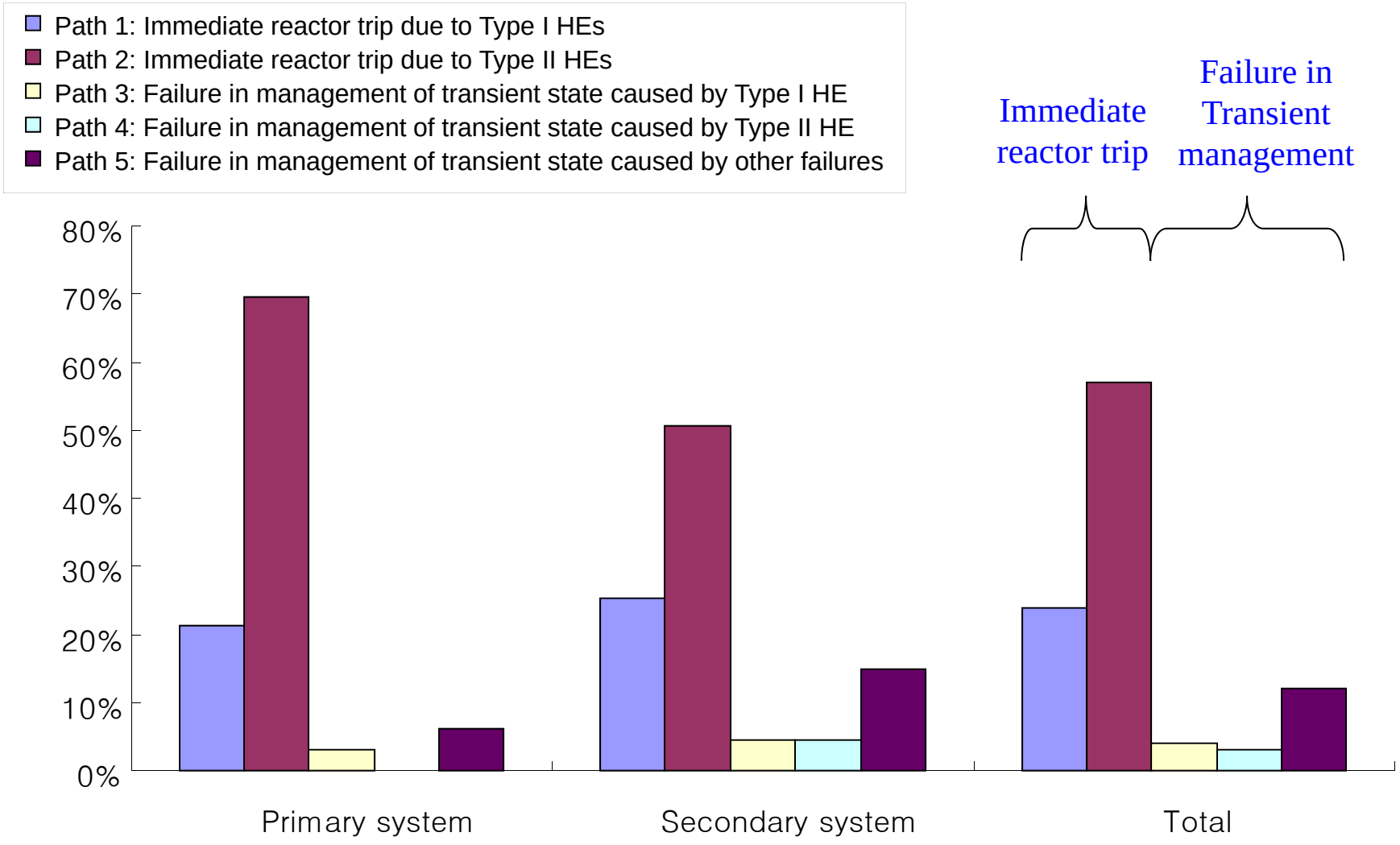
3. Application to Experience Data

- **Experience Data**
  - 100 Unplanned reactor trip events
  - PWRs and PHWRs in Republic of Korea
  - From 1986 to 2006 (by Operational Performance Information System of KINS)

Unit | Time | Title | Rx Power, Generator output etc. | Event Summary | HE Type | Trip Condition

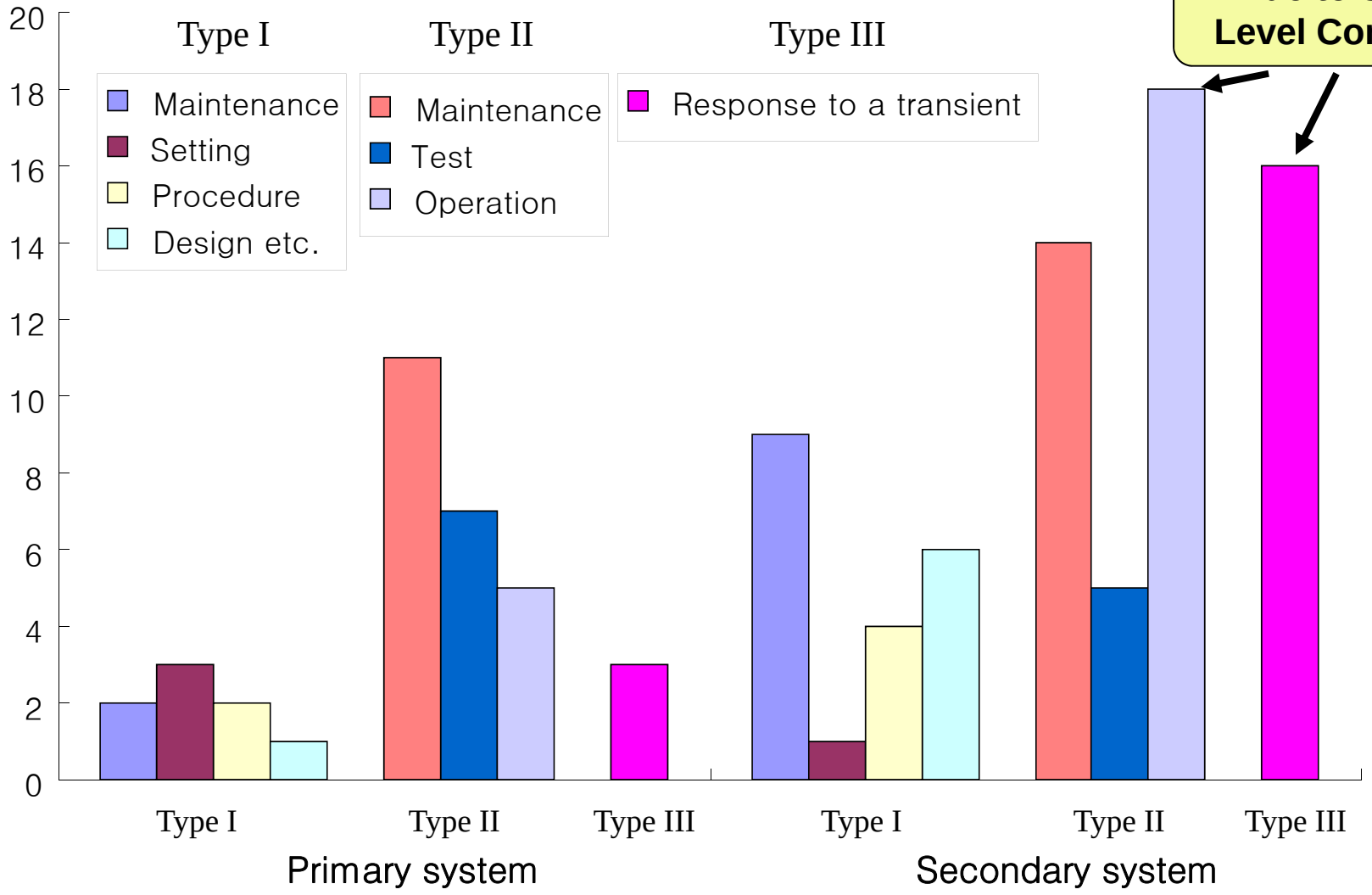
호 기	발생일자	사건제목	Rx출력	전기출력	고장계통	고장원인	정지유형	작업종류	사건요약	인적오류유형	비고	발전소상태	정지조건
고리2호기	1986-02-26 16:31	노외 핵계측 계통 시험을 수행하던 중 시험자의 부주의로 인한 OP 델타 T 신호가 발생되어 원자로 및 터빈발전기 정지	100 %	653 Mwe	1	인적	자동	보수/시험	원자로출력 100%, 발전기출력 653MWe로 정상운전중 '86.2.26 16시 20분경 원자로 보호계통 시험함(Rx Protection Sys Process Rack)에서 "노외 핵계측 계통 출력영역" 의 정기 시험(Surveilance Test)을 행하고 있었으며, 출력영역 N-42 계열의 시험완료 후 N-43 계열의 시험을 위해 시험 선택스위치를 '시험위치'로 놓는 순간 'OPΔT' 신호가 발생되어 16:31 원자로가 정지되었음. 정지된 후 원자로 보호함에서 확인한 결과 출력영역 N-42 계열시험을 마친 다음, **시험선택 스위치가 '정상위치'로 복구시키지 않은 상태로 존재하던중 출력영역 N-43 계열의 시험 선택스위치 전환**시 2/4 채널 정지 논리회로 형성되어 원자로 정지신호 발생함. 원자로 고장정지후 확인점검결과 원자로 안전성에 미친 영향은 없음. 동 사건의 교훈으로 시험 절차서내에 계열별 시험 완료 후 다중 점검(발전과장, QA) 사항을 반영하고, 매월 시험 실시전 시험실시자에게 별도의 교육을 실시토록 후속 조치함. 고장원인이 시험잘못으로 판명되었고 모든 운전변수를 재검토, 정상화시킨후 2.26 18:45 원자로임계에 도달하였고 2.27 05:30 계통병입을 실시함.	II	시험	정상운전	OPΔT

3. Application to Experience Data



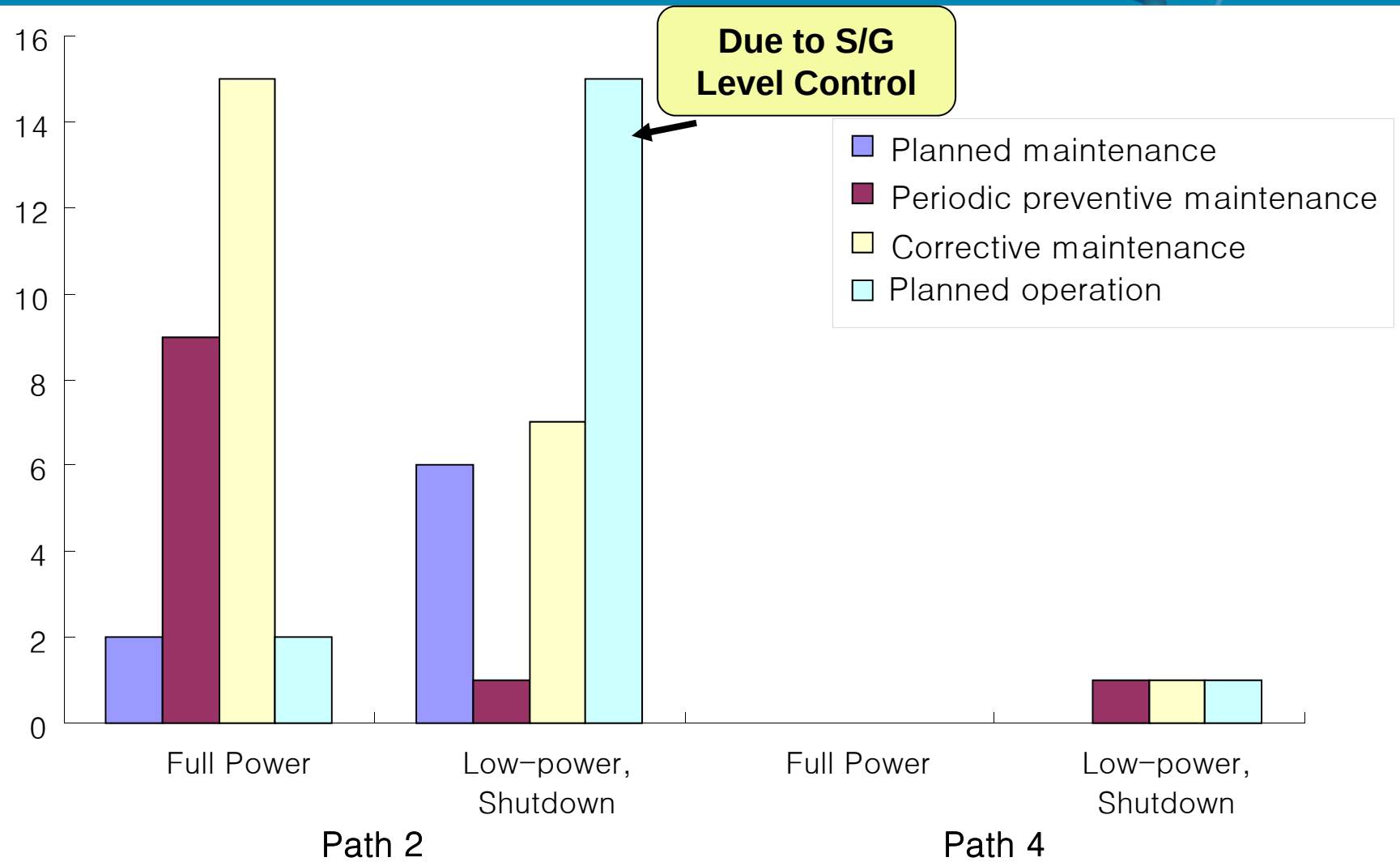
Number of events corresponding to each path

3. Application to Experience Data



Number of events corresponding to tasks of each type of HEs

3. Application to Experience Data



Detailed analysis on Type II human errors

4. Conclusions

- **Application of a Path model**
  - Based on three types of human errors
  - Identify five paths to unplanned reactor trips
- **Application to Experience data**
  - Importance of immediate reactor trips
    - For more than 80% of those events, operators do not have enough time to respond to those events.
  - Identification of cautious tasks
    - Corrective maintenance in the primary system
    - Steam generator level control in the secondary system

Analysis on Human-Related Unplanned Reactor Trip Events in Korea

Thank you for Your Attention

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