碳中和的經濟衝擊

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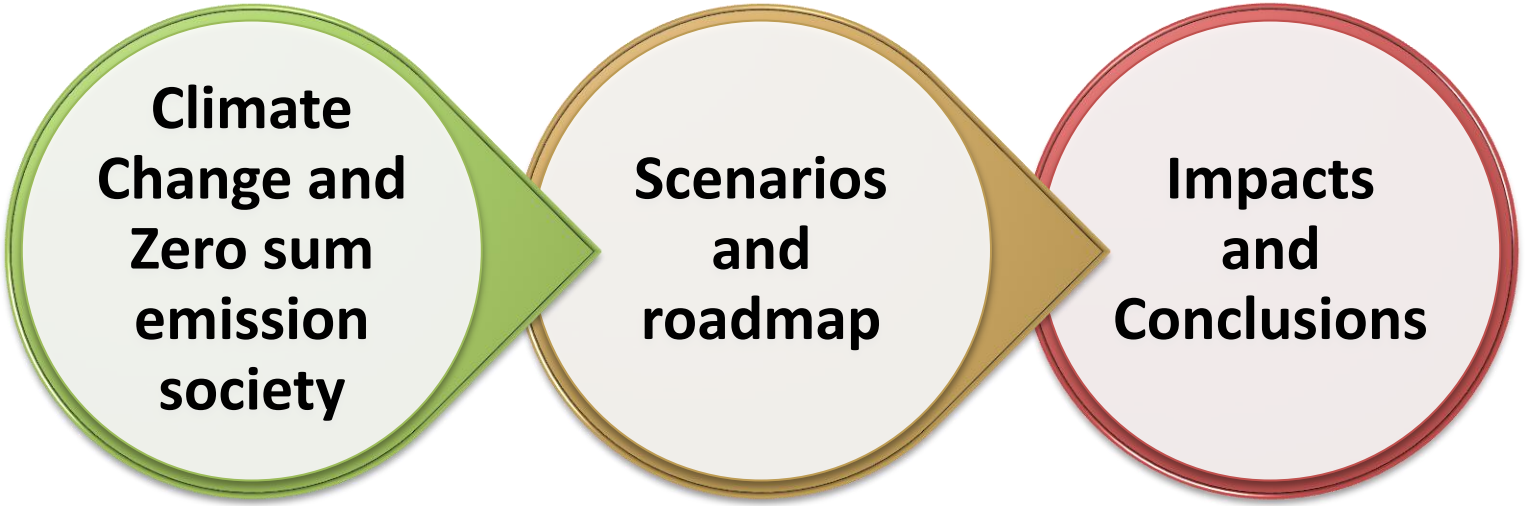
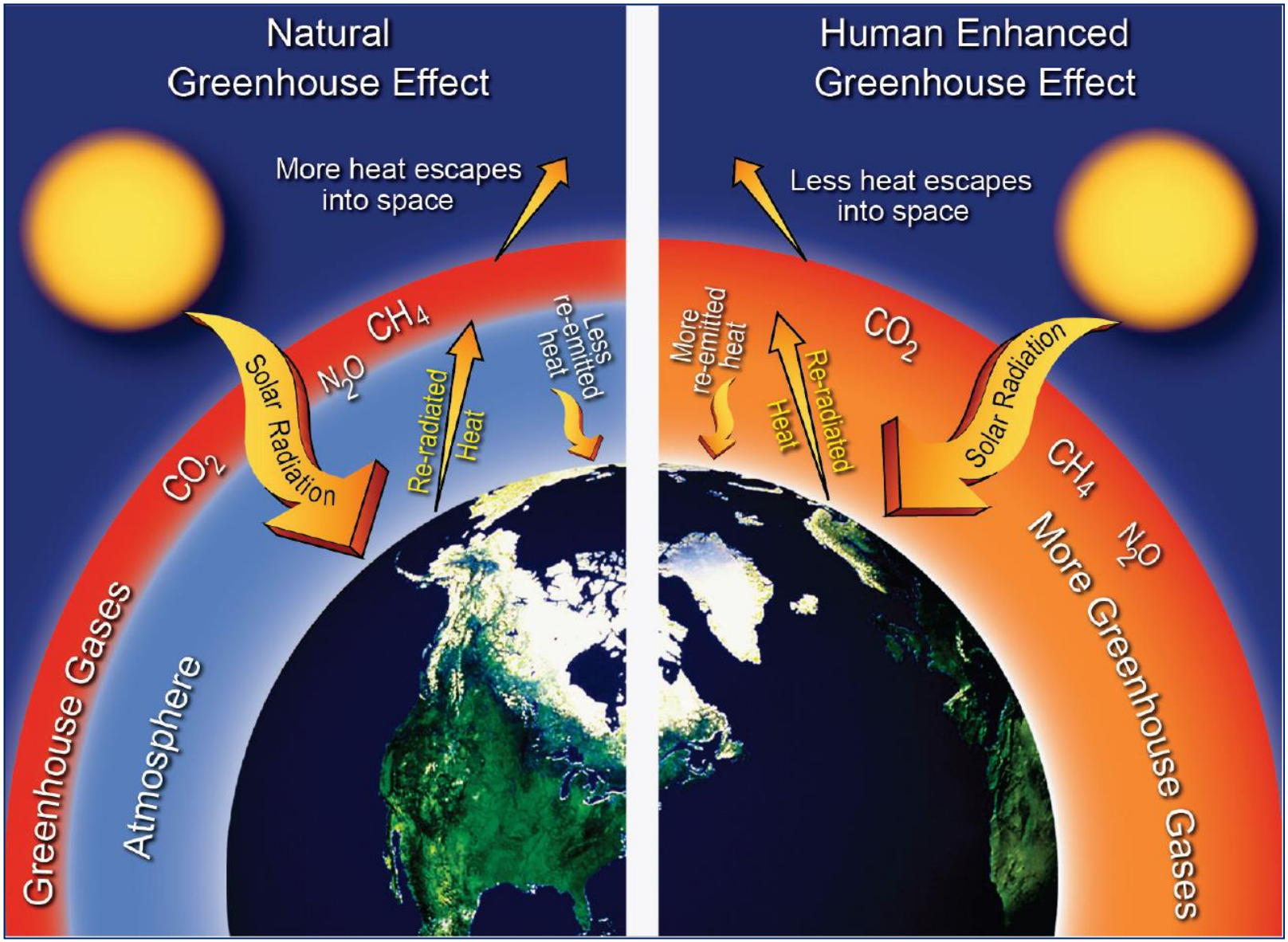
Outline


Climate Change and Zero sum emission society
Scenarios and roadmap
Impacts and Conclusions

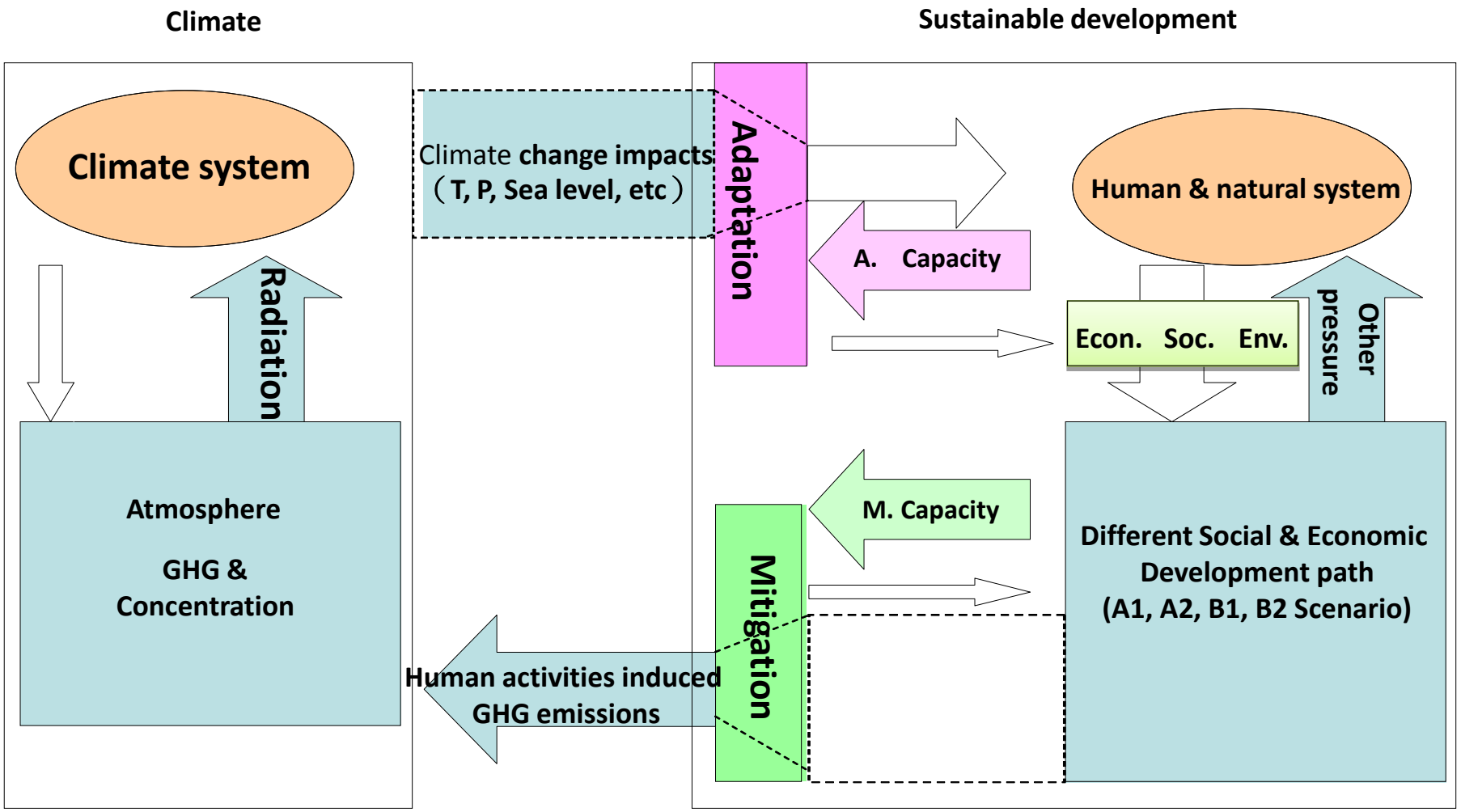


Energy and Heat will be conserved and trapped by GHGs

GHGs and their Global Warming Potential (GWP)

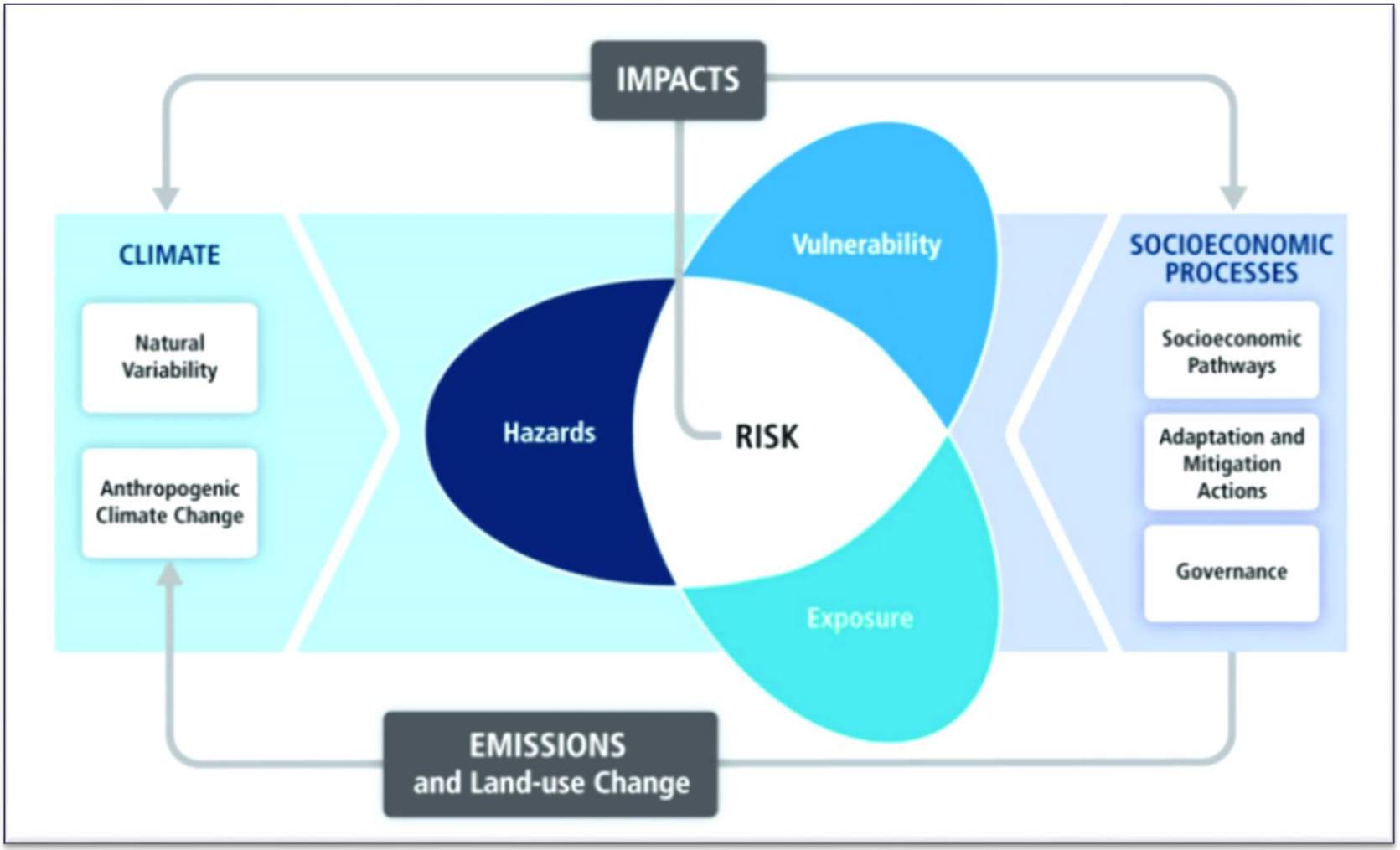
type	二氧化碳 CO_2	甲烷 CH_4	氧化亞氮 N_2O	氫氟碳化合物 (HFCs)	全氟碳化合物 (PFCs)	六氟化硫 (SF_6)	三氟化氮 NF_3
GWP	1	25	298	1430	5700	22800	10800

CC Adaptation and Mitigation



Source：Mohan Munasinghe and Rob Swart, 2005, Primer on Climate Change and Sustainable Development: Facts, Policy Analysis and Applications, Cambridge University Press, Cambridge.

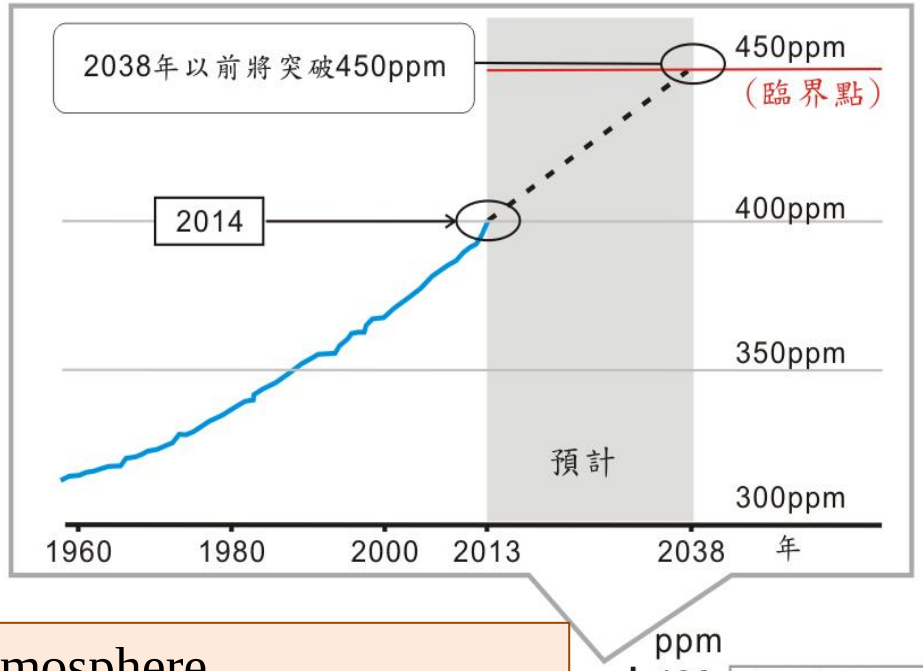
IPCC CONCEPT OF CC RISK MANAGEMENT



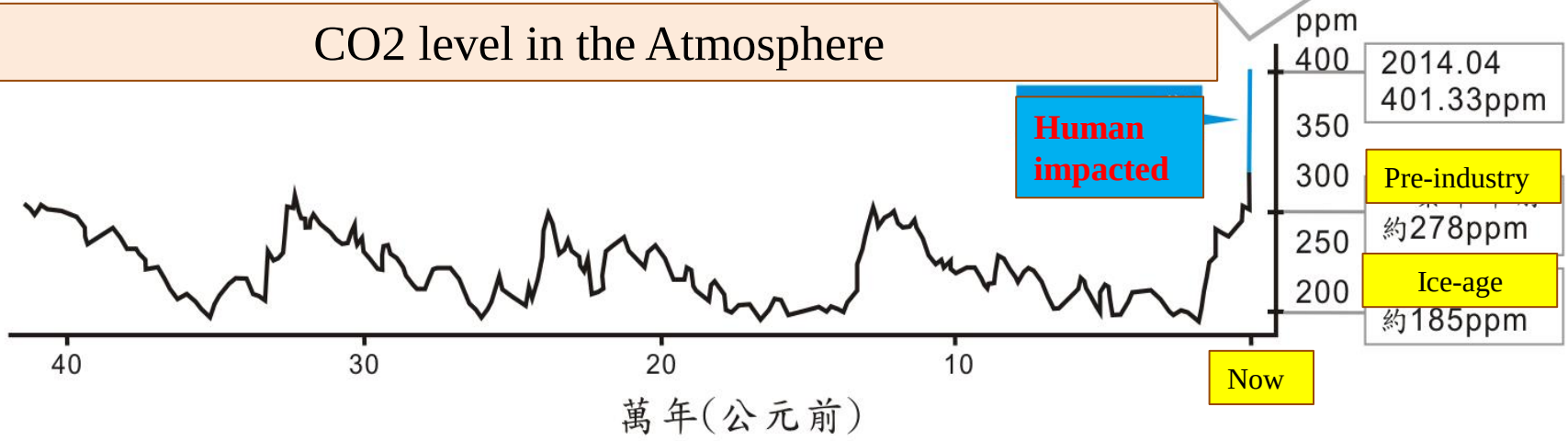
Extreme Climate Events will be Normal in the future

資料來源：汪中和(2014)，「2014我國電業氣候變遷調適研討會」。

GHGs reached 400ppm in 2014 and will break 450 ppm by 2038!

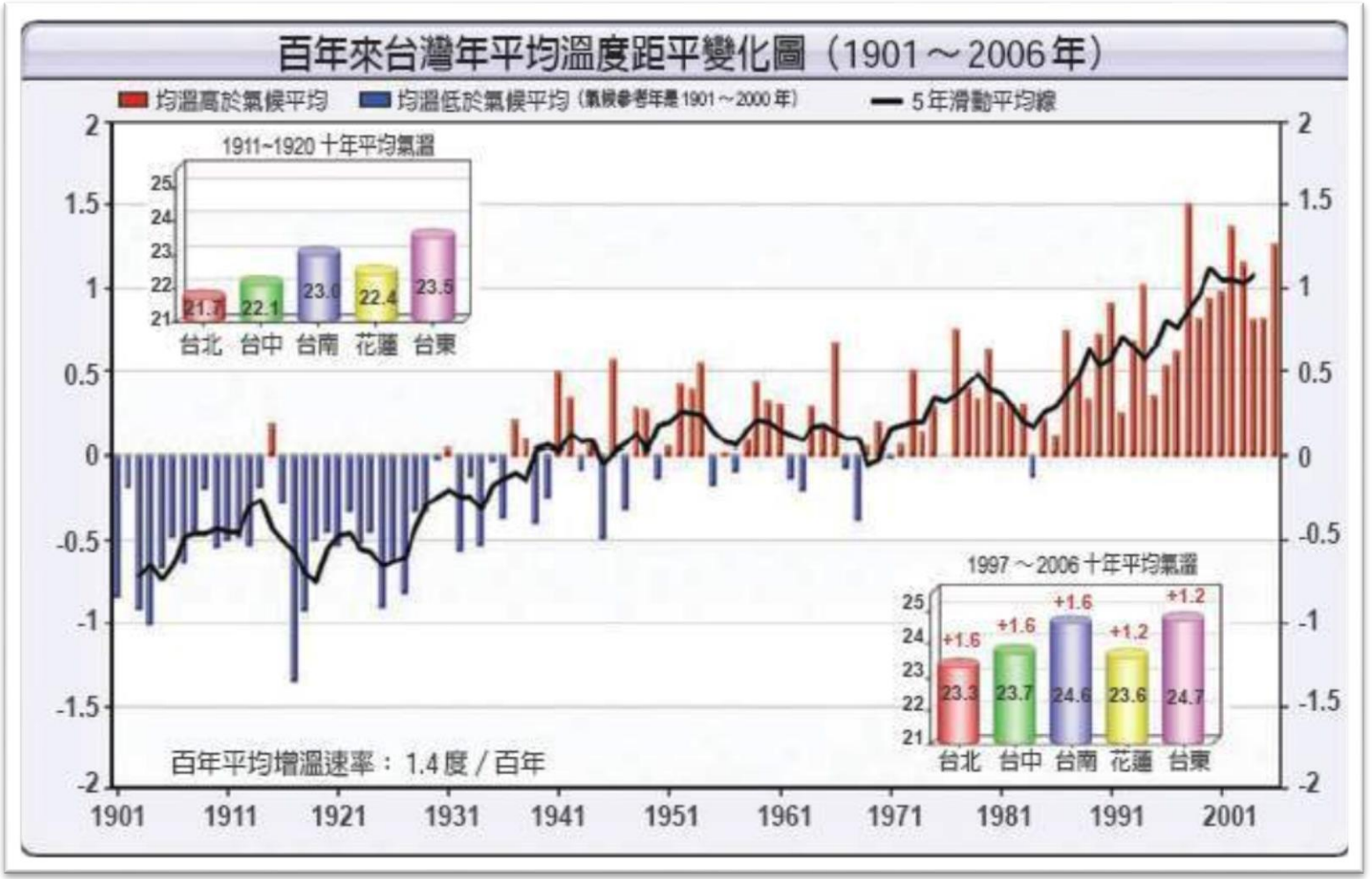


CO2 level in the Atmosphere



10000 years before now

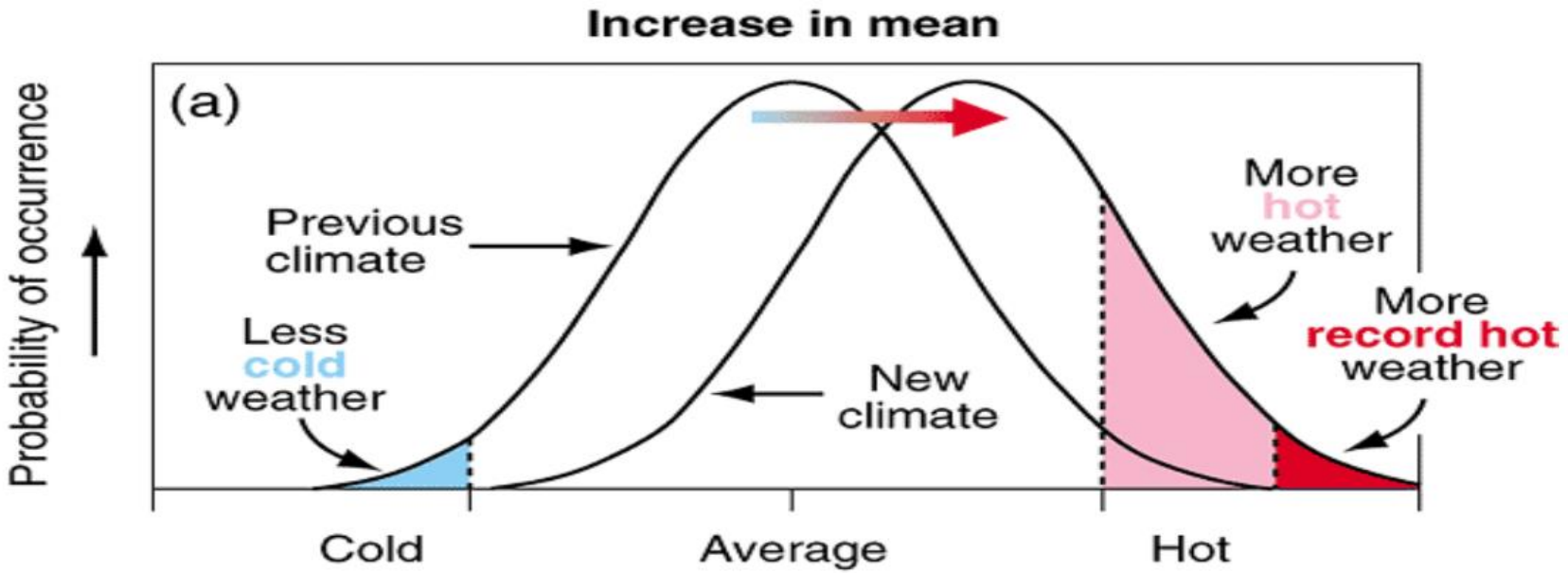
100 yrs-trend of Taiwan Average (Temperature)



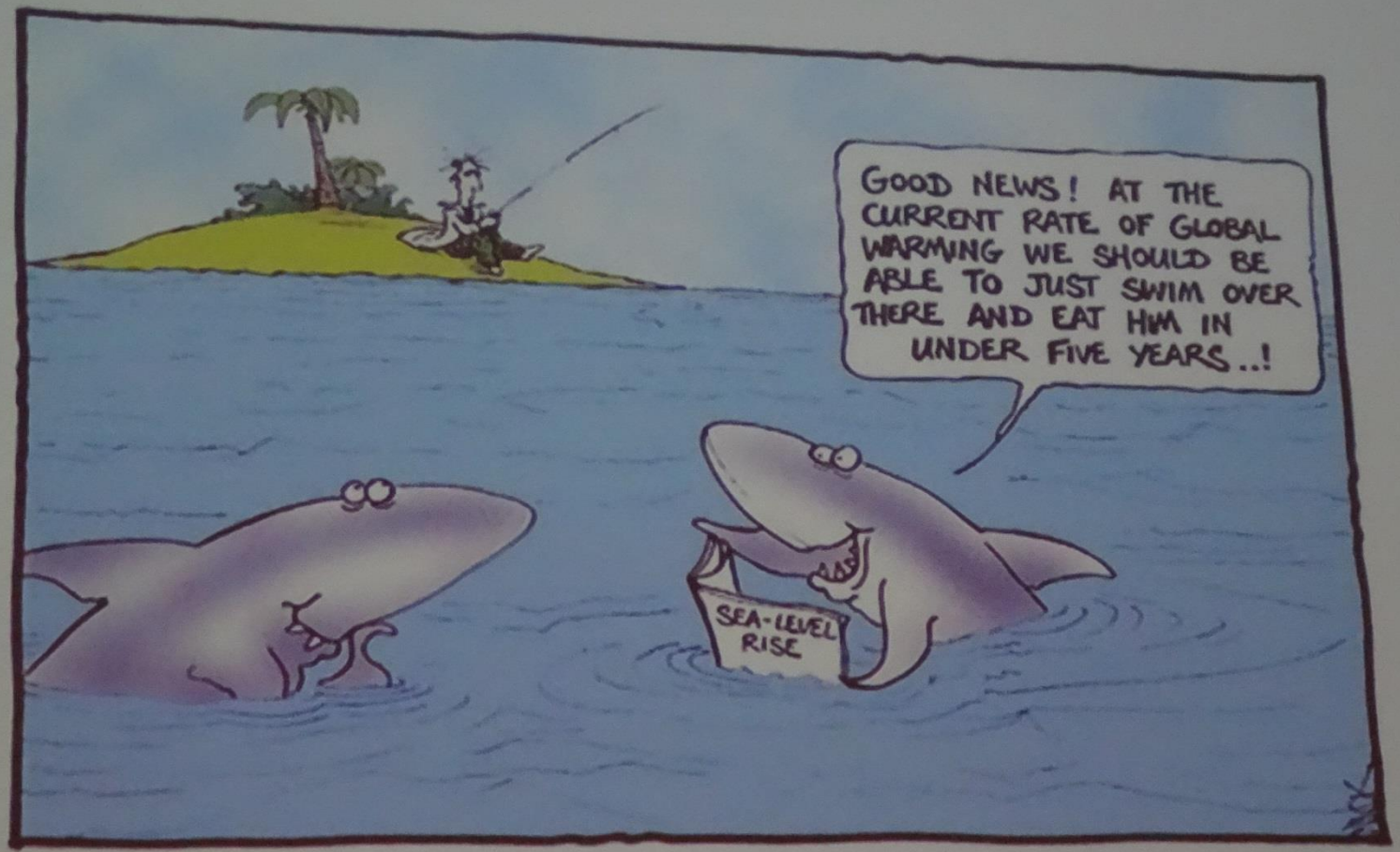
資料來源：百年來台灣氣候的變化　中央氣象局預報中心陳雲蘭　科學發展2008 年4 月， 424 期。

The shift of risk pattern under climate change (e.g., temperature)

Small increases in means can cause large increases in extremes



機會(Opportunity)

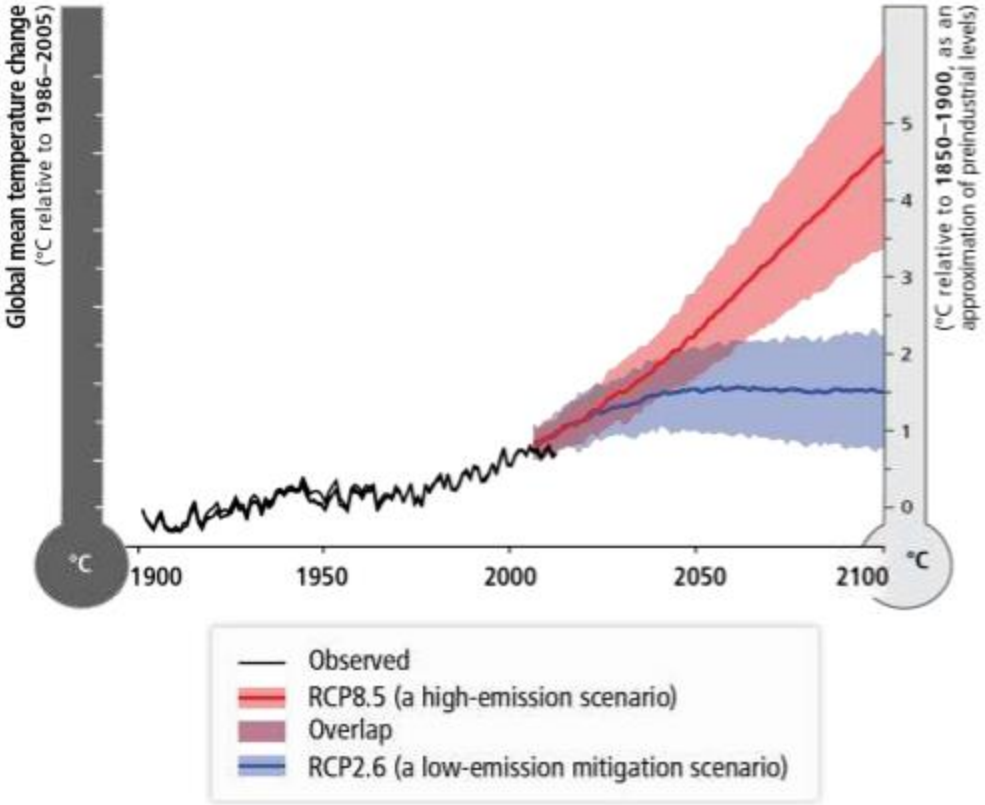


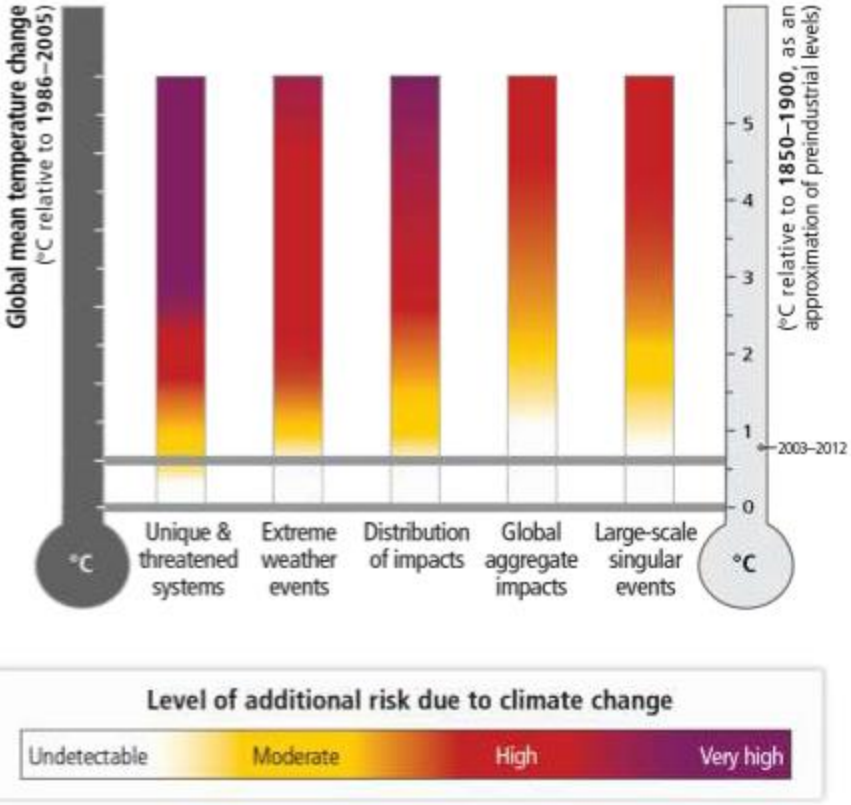
資料來源：NCCARF(2014)，Australia。

IPCC 5th Assessment Report
Reasons for Concern

ipcc
INTERGOVERNMENTAL PANEL ON climate change

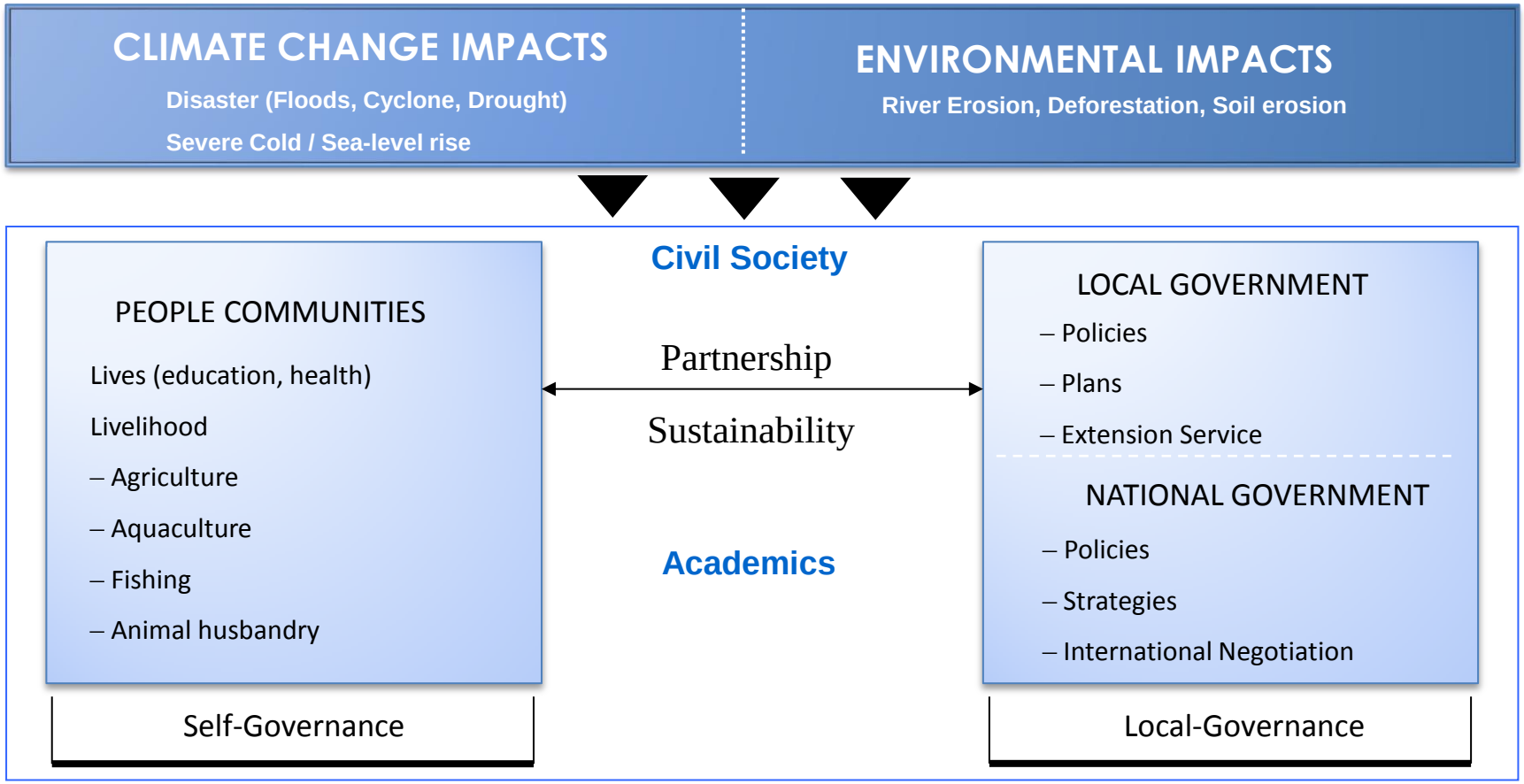
Alternative climate futures entail very different risks





WGII Summary for Policymakers

Key elements of local adaptation and their linkages to human security

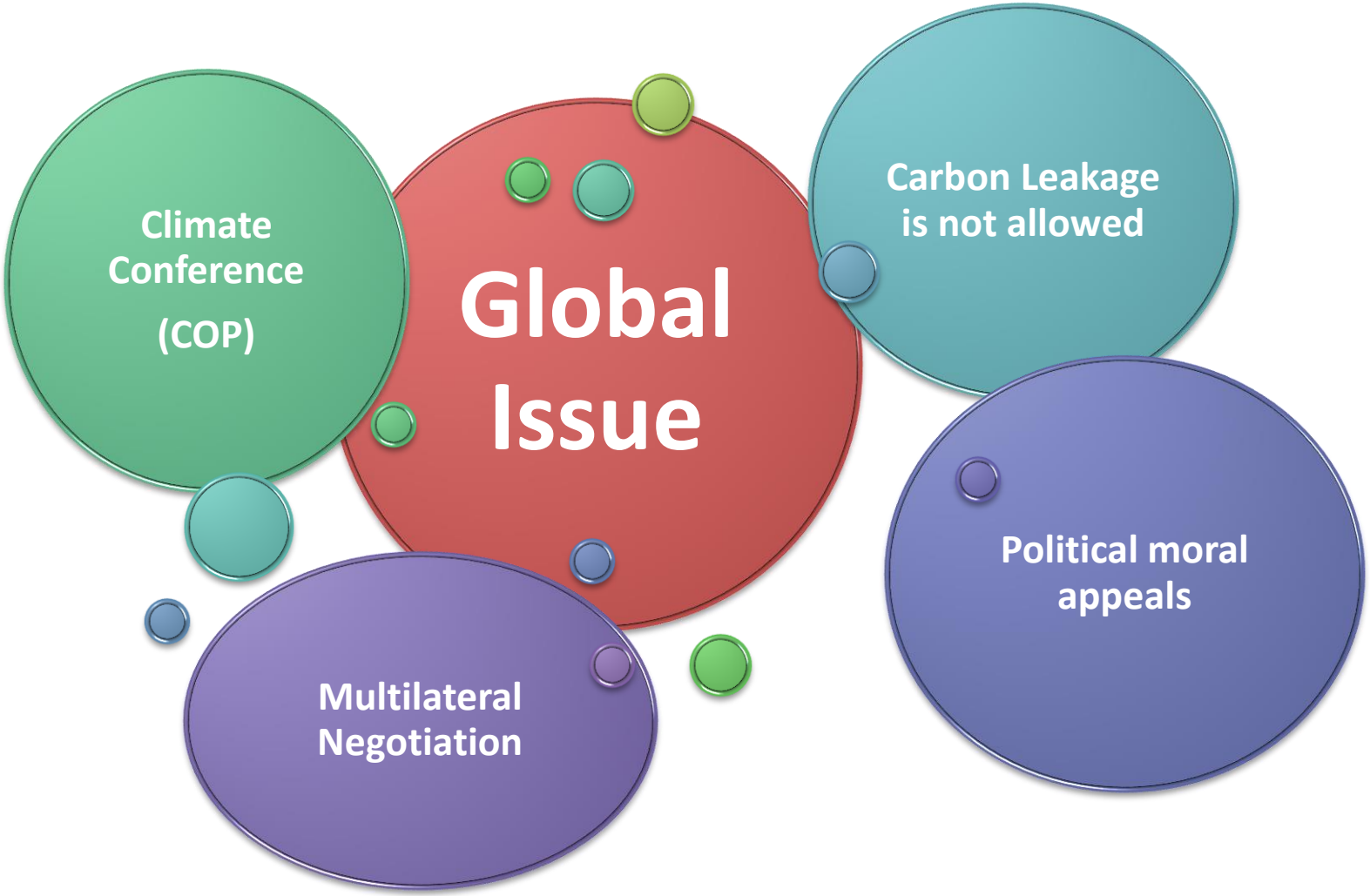


HUMAN SECURITY (PEOPLE AND COMMUNITY DIMENTION)

Livelihood Security	Environmental Security	Social Security	Self-Security	Information Security
Life-Style	Resource Management	Choices	Freedom	Right Information

Source: Kyoto University Graduate school of Global Environmental Studies.

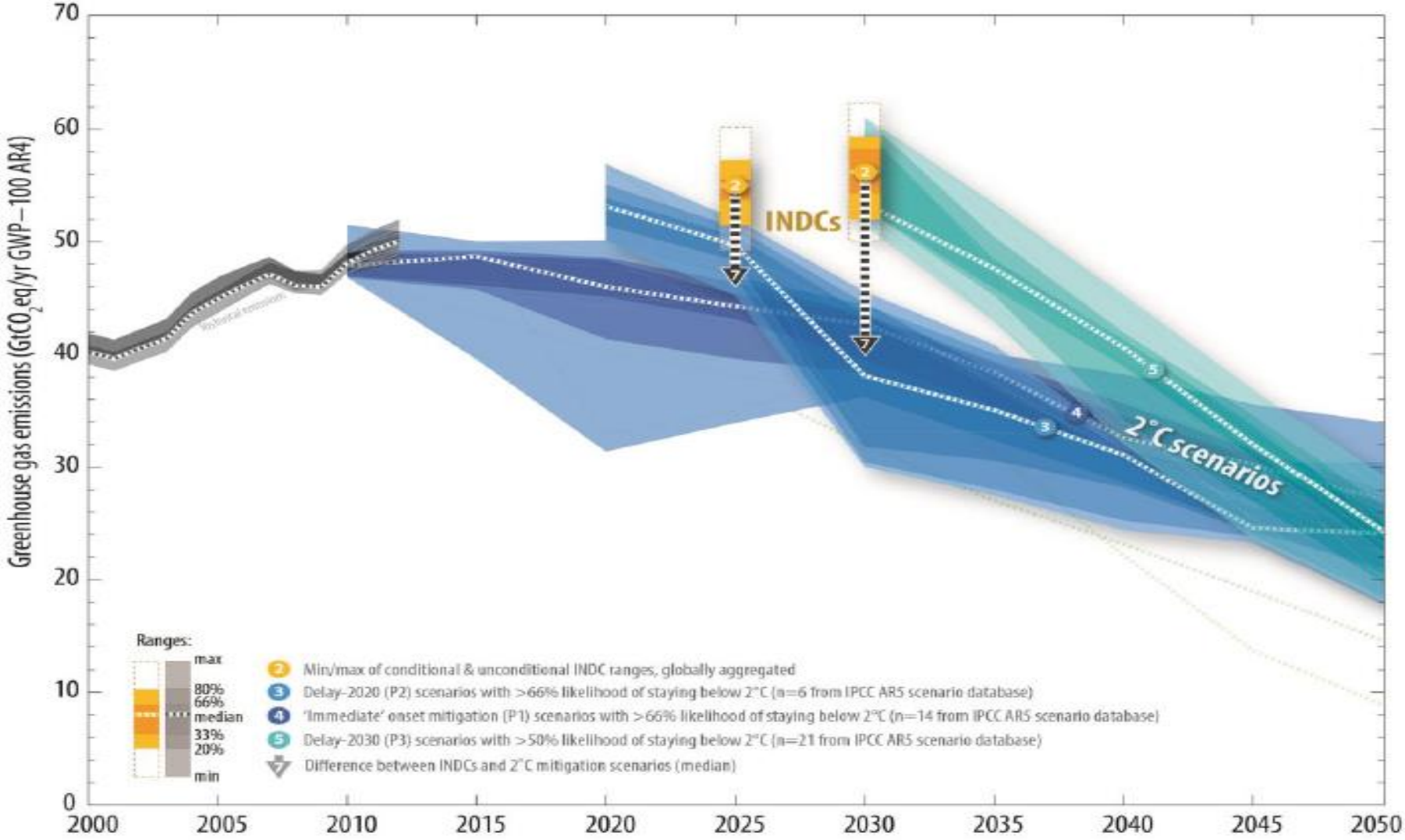
Economics of Climate Change Mitigation



Prisoner's dilemma

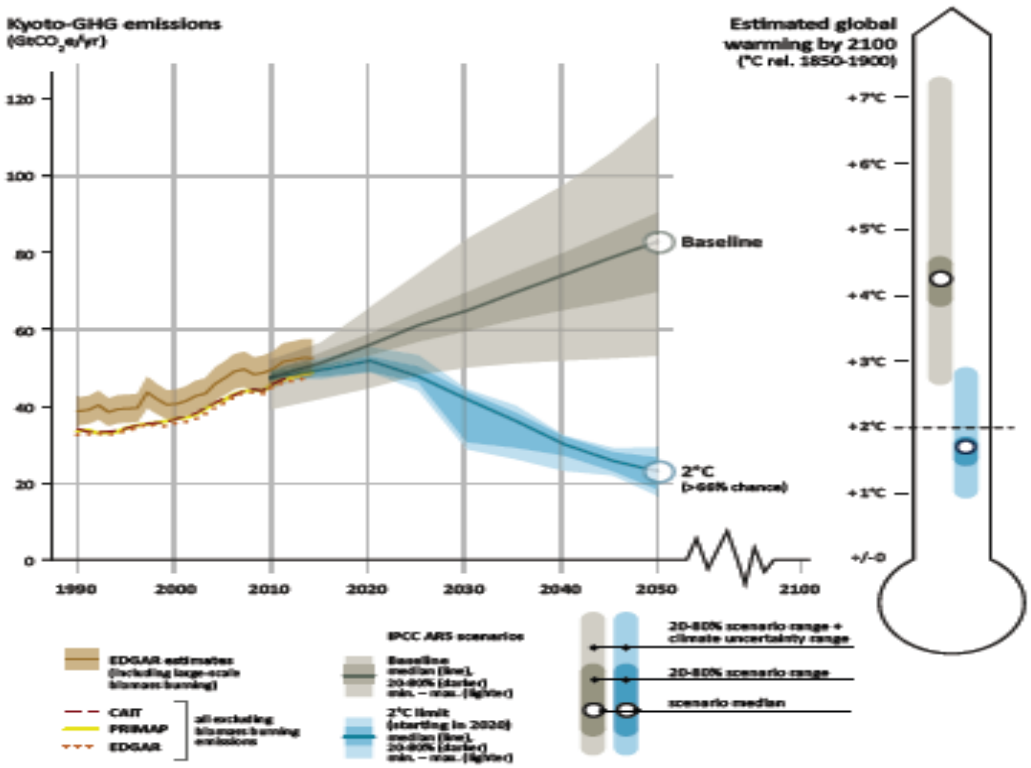
Free rider and prisoner's dilemma are the basic roots of international climate talks

GHG Emission Path under INDCs and the Gap from +2℃ Scenario

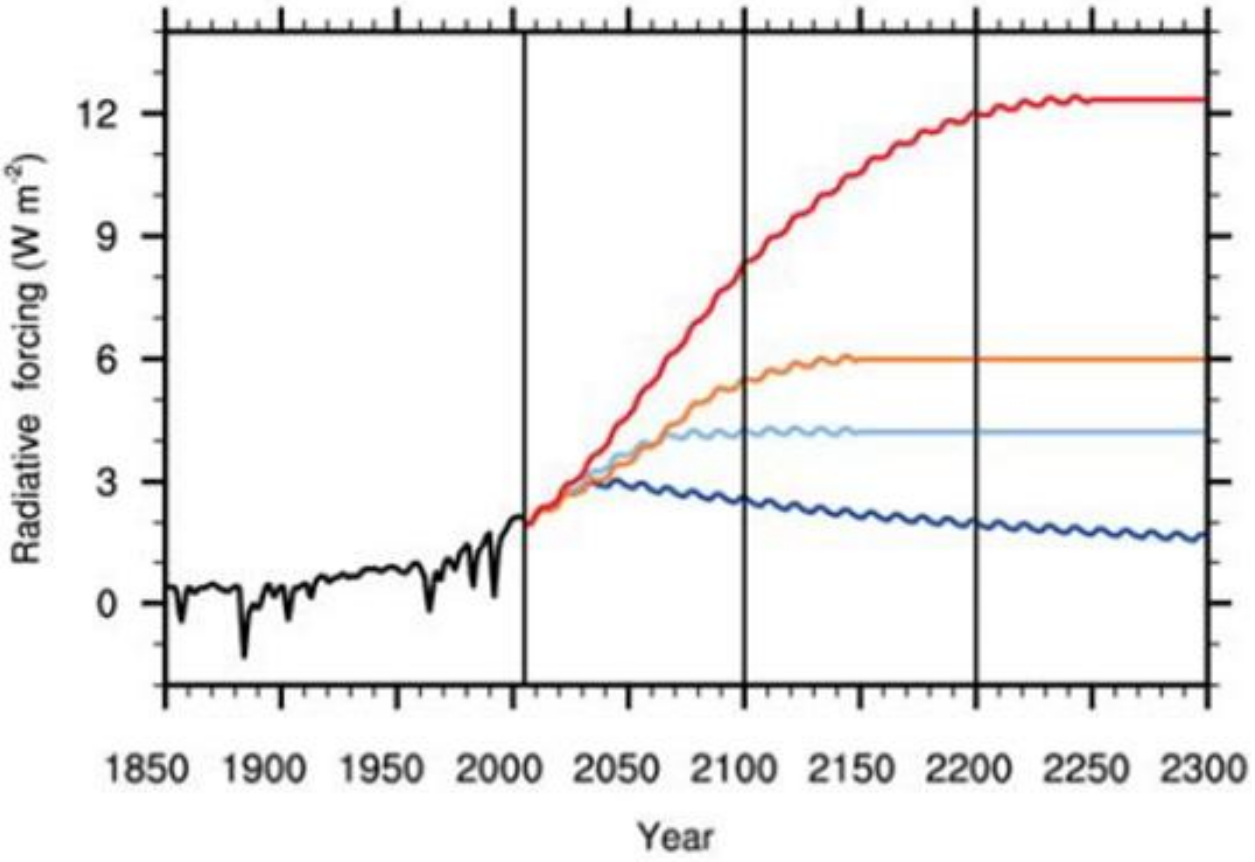


CO_2 GAP to the Emission Target

- 為了達到在本世紀末把全球氣溫上升幅度控制在2℃的目標，全球在2030年的碳排放量需要減少至420億噸，亦即，必須在2014年的水準上降低20.3%。
- 如果INDC減量方案能夠全面且無條件地實施，則至2030年將全球氣溫上升控制在2℃的目標所需排放量的差距為140億噸，至2025年的差距則為70億噸。這意味著全面實施無條件的INDC減量排放方案，在2030年產生的排放水準將使全球到2100年時的平均溫度上升幅度控制在約3.5℃。這與2℃攝氏度的目標還有很大的差距。

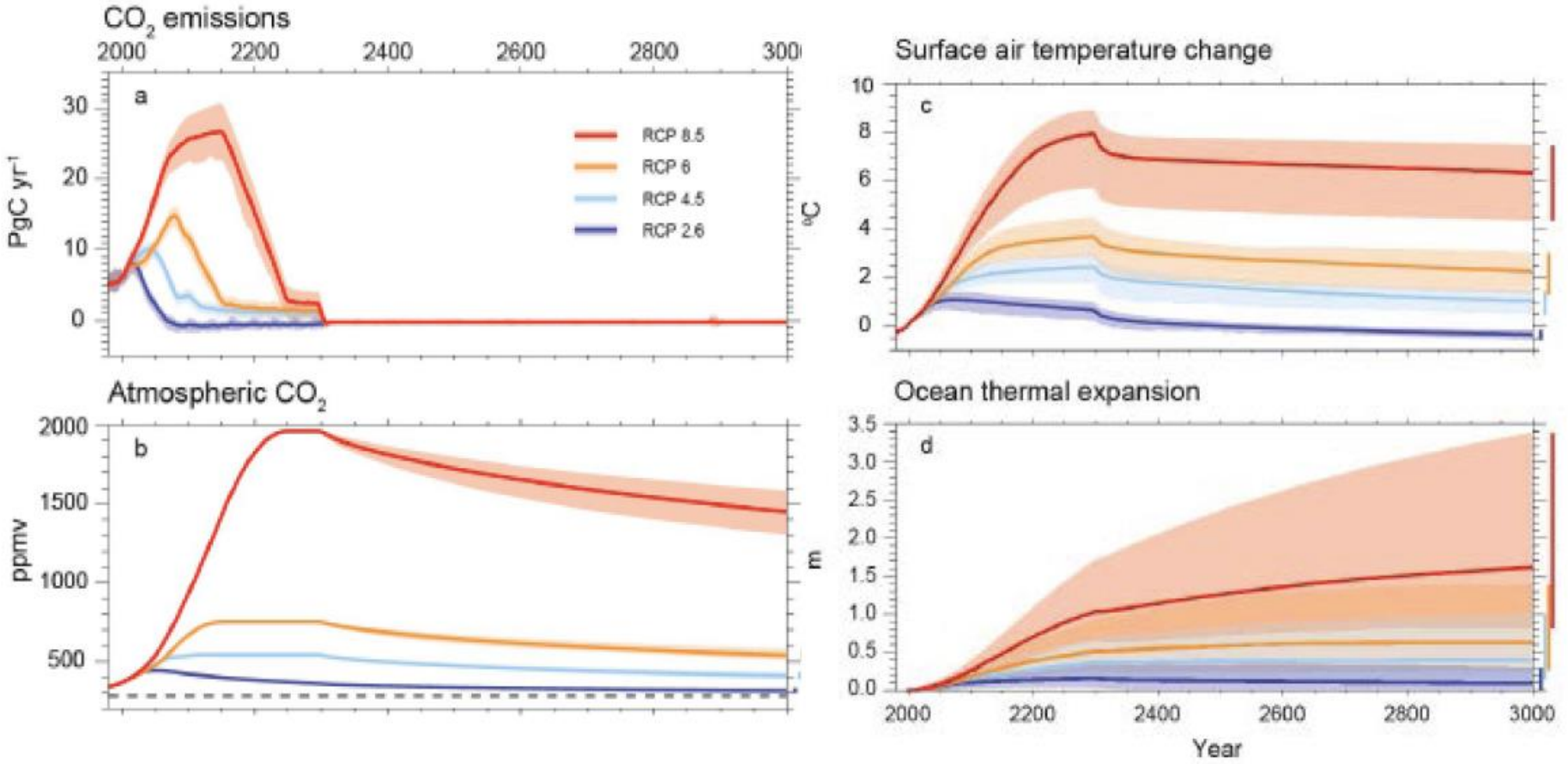


IPCC New Scenarios in AR5 Representative Concentration Pathways

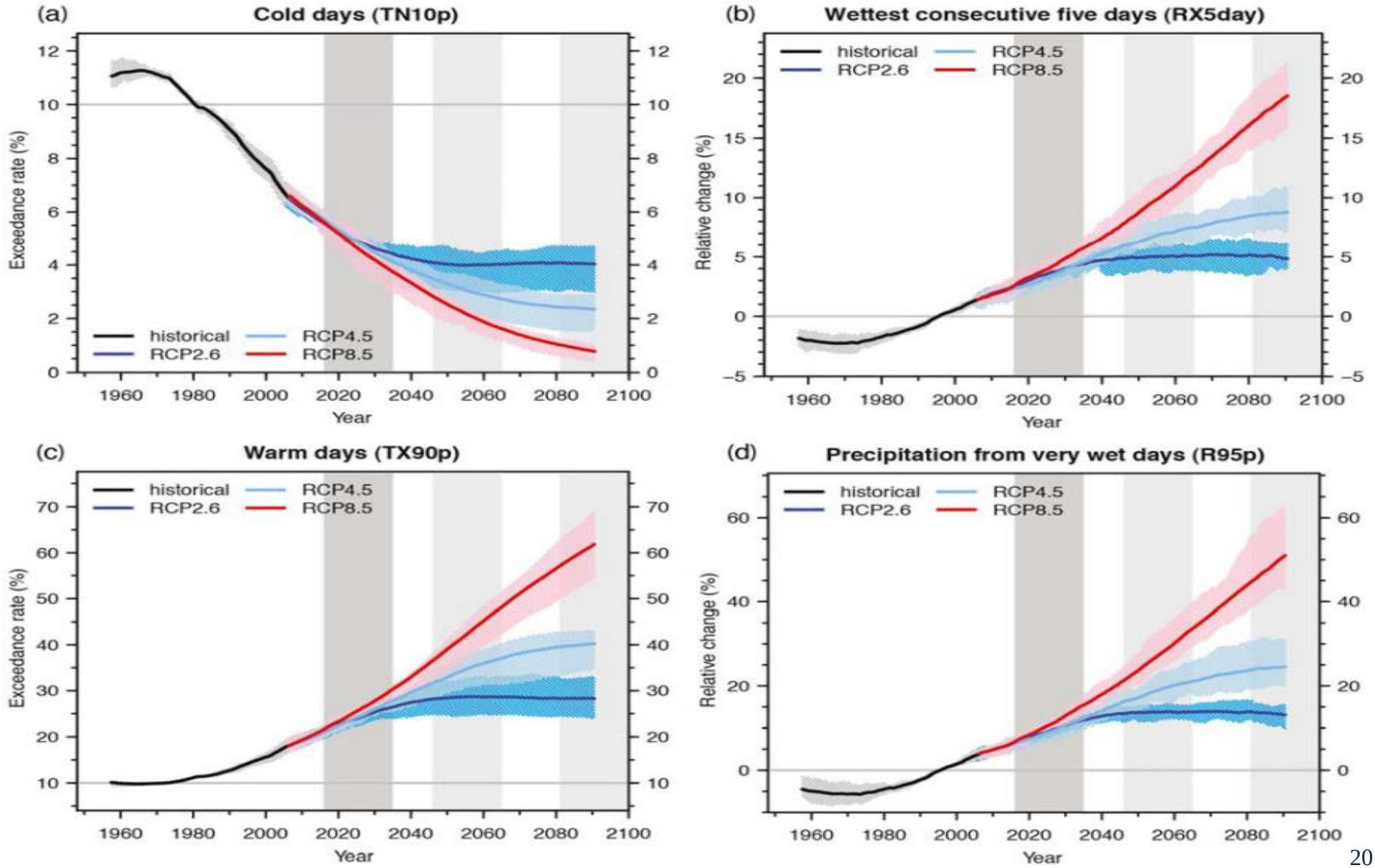


- **RCP8.5**
  Rising
- **RCP6.0**
  Stabilization after 2100
- **RCP4.5**
  Stabilization after 2100
- **RCP2.6**
  Peak and decline

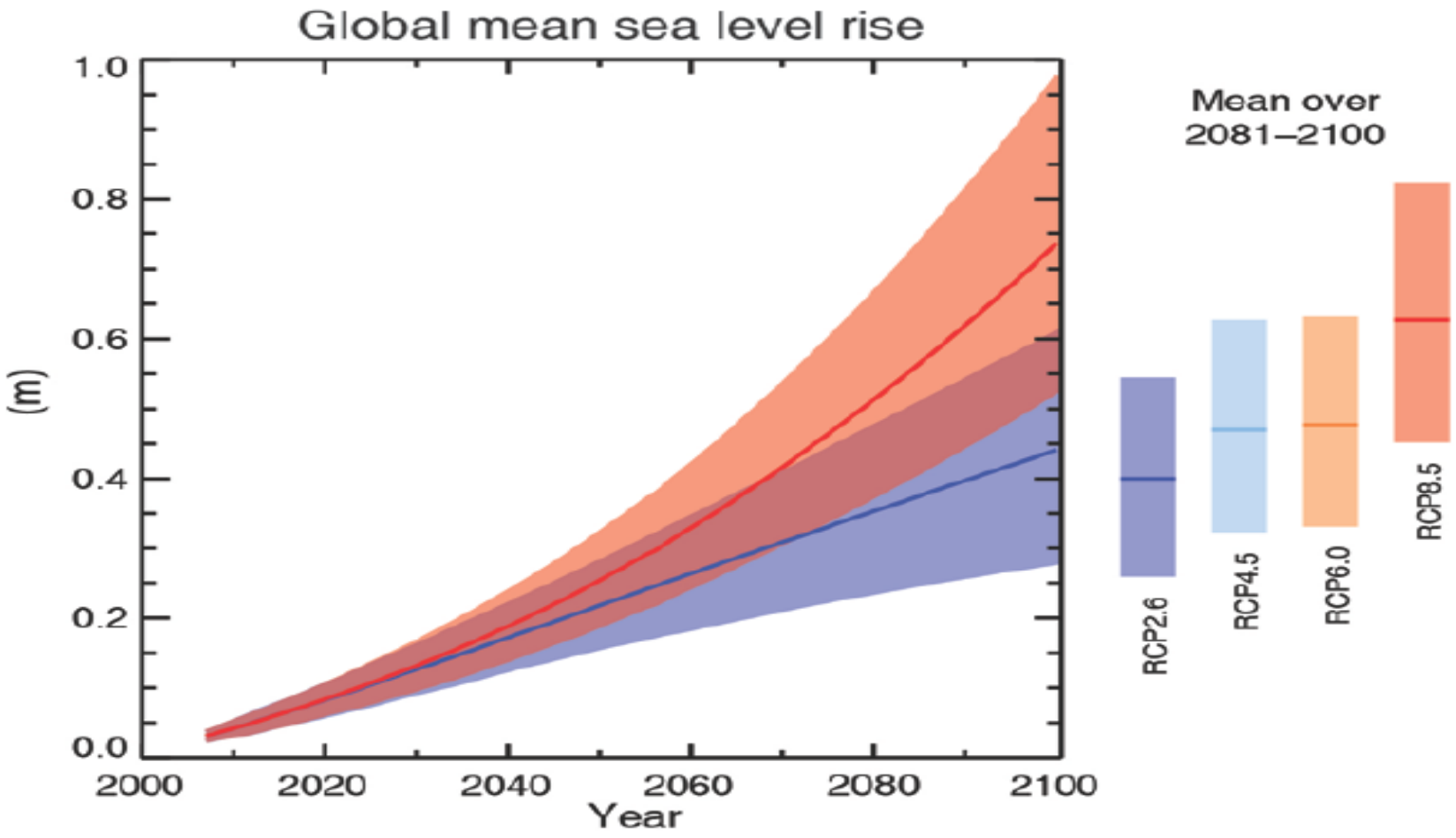
Multi-century climate change commitment based on past, present and future emissions of CO_2



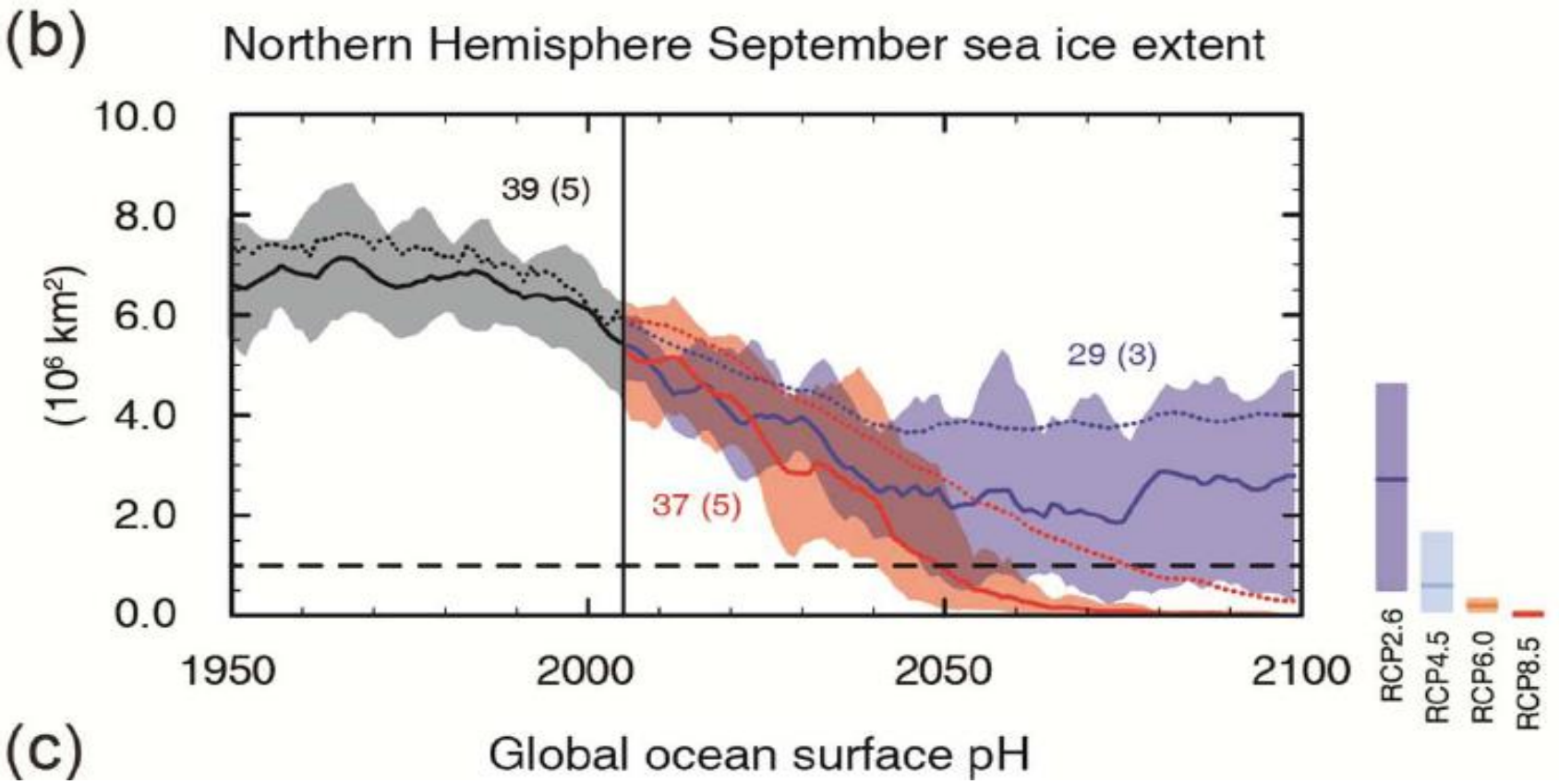
Future changes in temperature extremes in AR5



The rate of sea level rise is very likely to increase



Arctic sea ice cover will continue to shrink and thin



A nearly ice-free Arctic in September by mid-Century is likely for RCP8.5

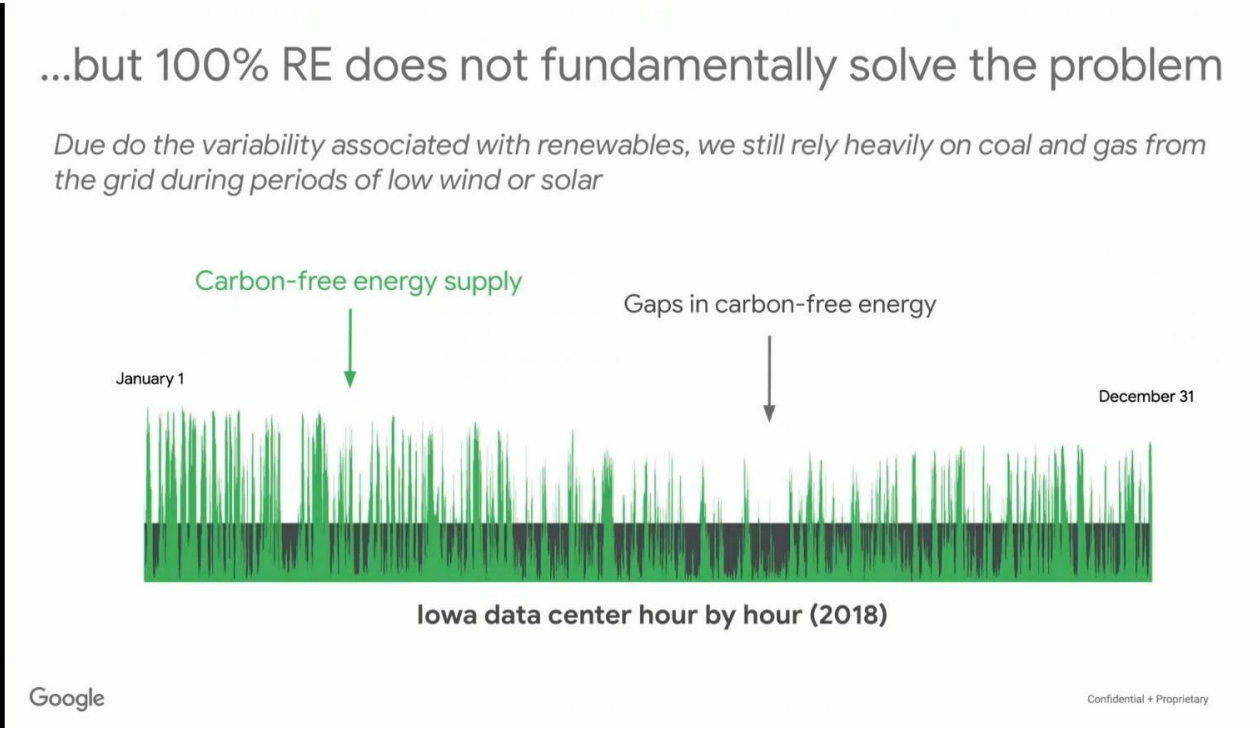
全球碳中和進程的一些重要國家

- 2015年《巴黎協定》承諾，在2050-2100年實現全球「碳中和」目標。
- 2018年美國加州簽署了碳中和令，在2045年前實現電力100%可再生。
- 2019年法國必須將減排速度提高三倍，以實現碳中和目標。
- 2020年奧地利承諾在2040年實現碳中和，2030年實現100%清潔電力。
- 2020年歐盟決定以立法規範歐洲到2050年實現「碳中和」。
- 2020年中國在聯合國大會表示，中國將爭取2060年前實現碳中和。
- 2020年日本宣布將在2050年完全實現碳中和。
- 2020年韓國也表示將在2050年完成碳中和。

碳中和執行過程與推動策略

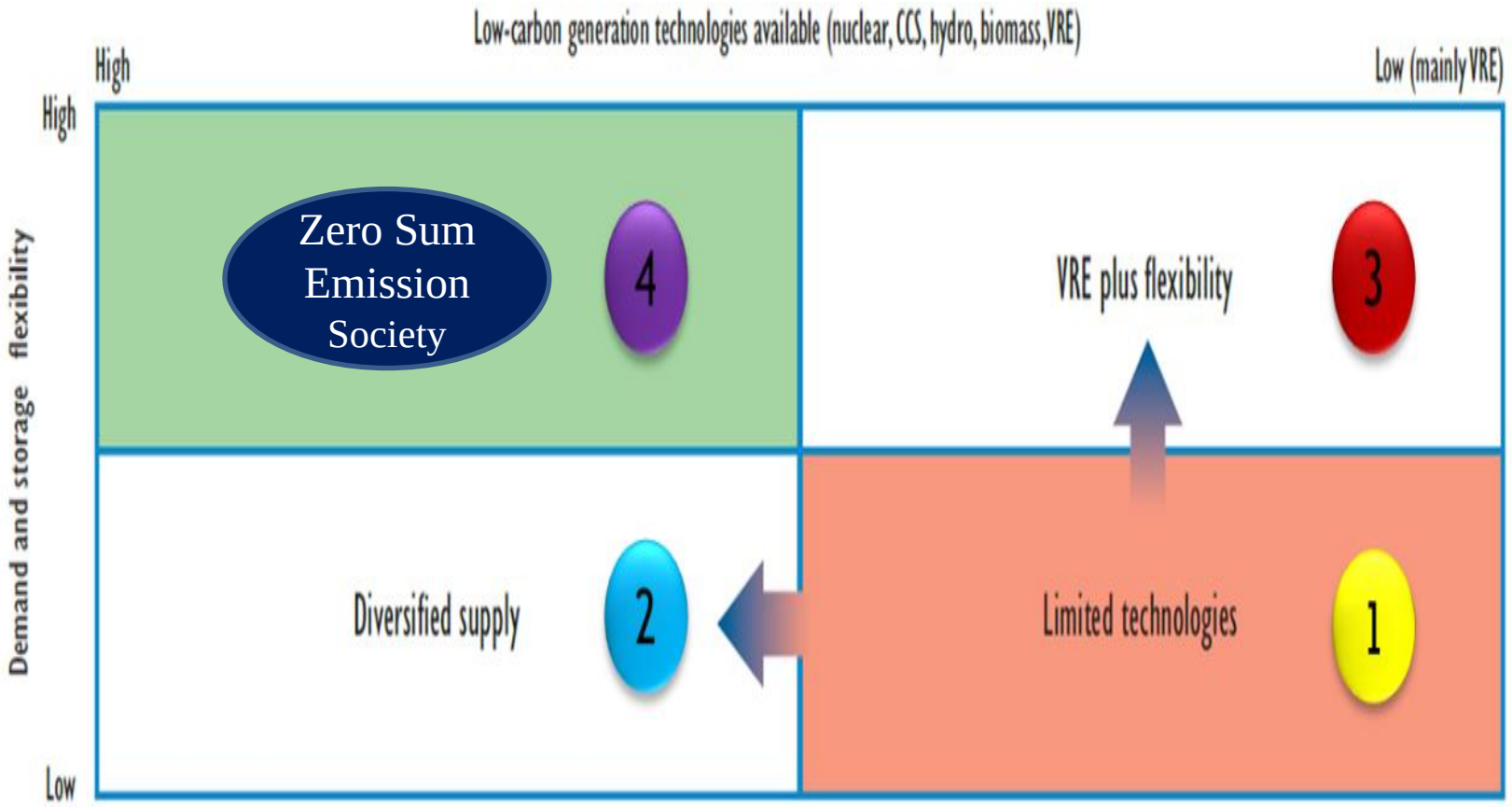
- 承諾：以企業或是國家為單位，宣布碳中和的目標。
- 計算和分析：計算現有的溫室氣體排放，並分析如何將其減量。
- 執行：企業或地方政府，導入相關的環境及能源管理系統。
- 減量：透過內部的改變，達到減少溫室氣體的排放。
- 抵消：透過碳補償機制，藉由減少外部的排放，來抵消自身造成的溫室氣體排放。例如：種樹、碳捕捉。
- 定期評估：定期的評估，並將成果整理發表，來檢討並改進其減少排放的措施。

RE100的省思：
比RE100還要純還要綠的零碳轉型：GOOGLE



零碳電力技術轉型發展之可能情境

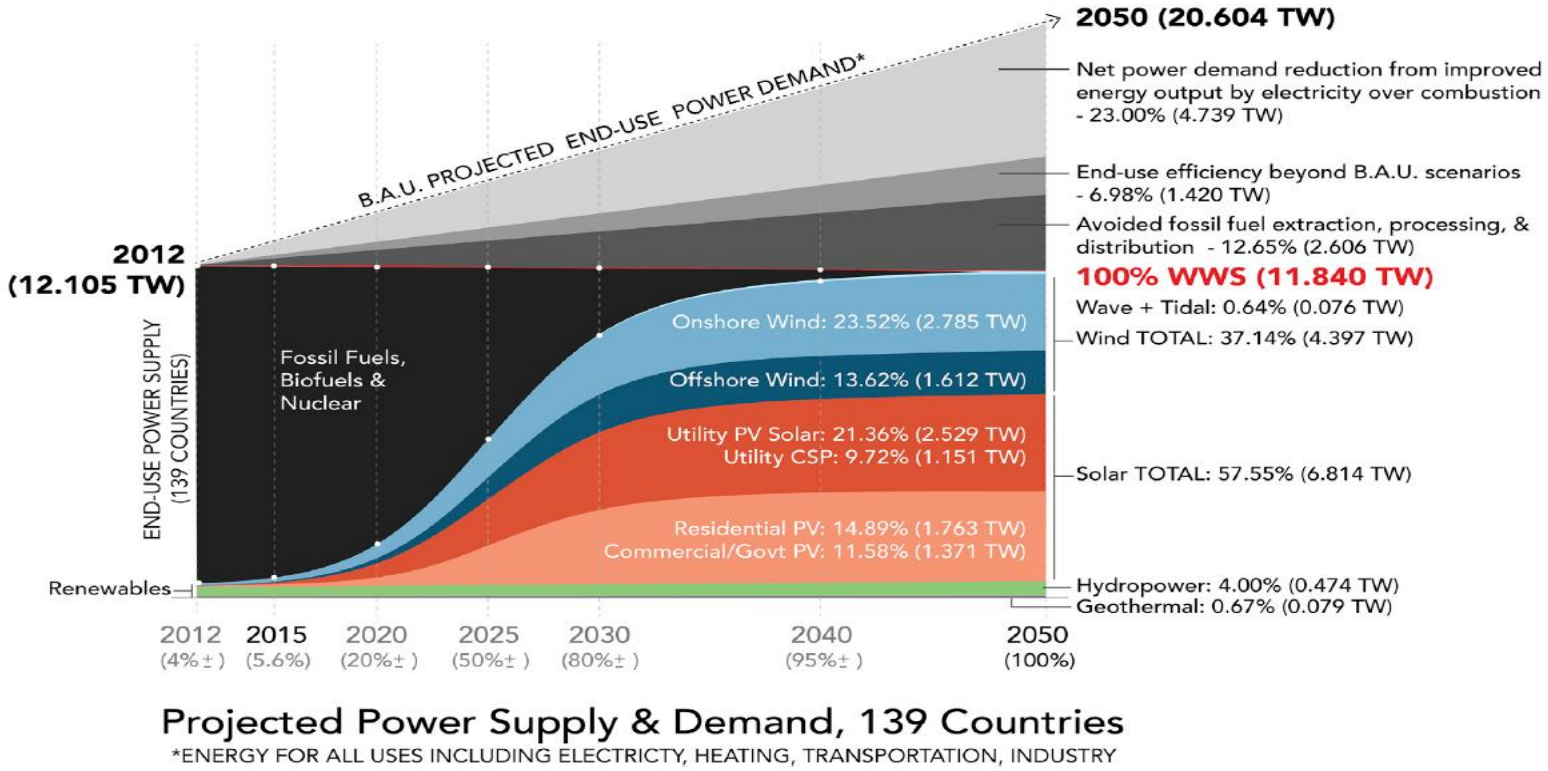
1▸3▸4 VS 1▸2▸4



資料來源：IEA（2016）。

零排社會的情境之路

- 情境A(134)：WWS（風水地）
- 情境B：Nuclear, Coal with CCS, Biofuel/Bioenergy（地火風水）



Source: Jocobson et al (2017). 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. Joule Volume 1, Issue 1, 6 September 2017, Pages 108-121. Elsivier Inc.

BAU與WWS情境下能源需求的差異

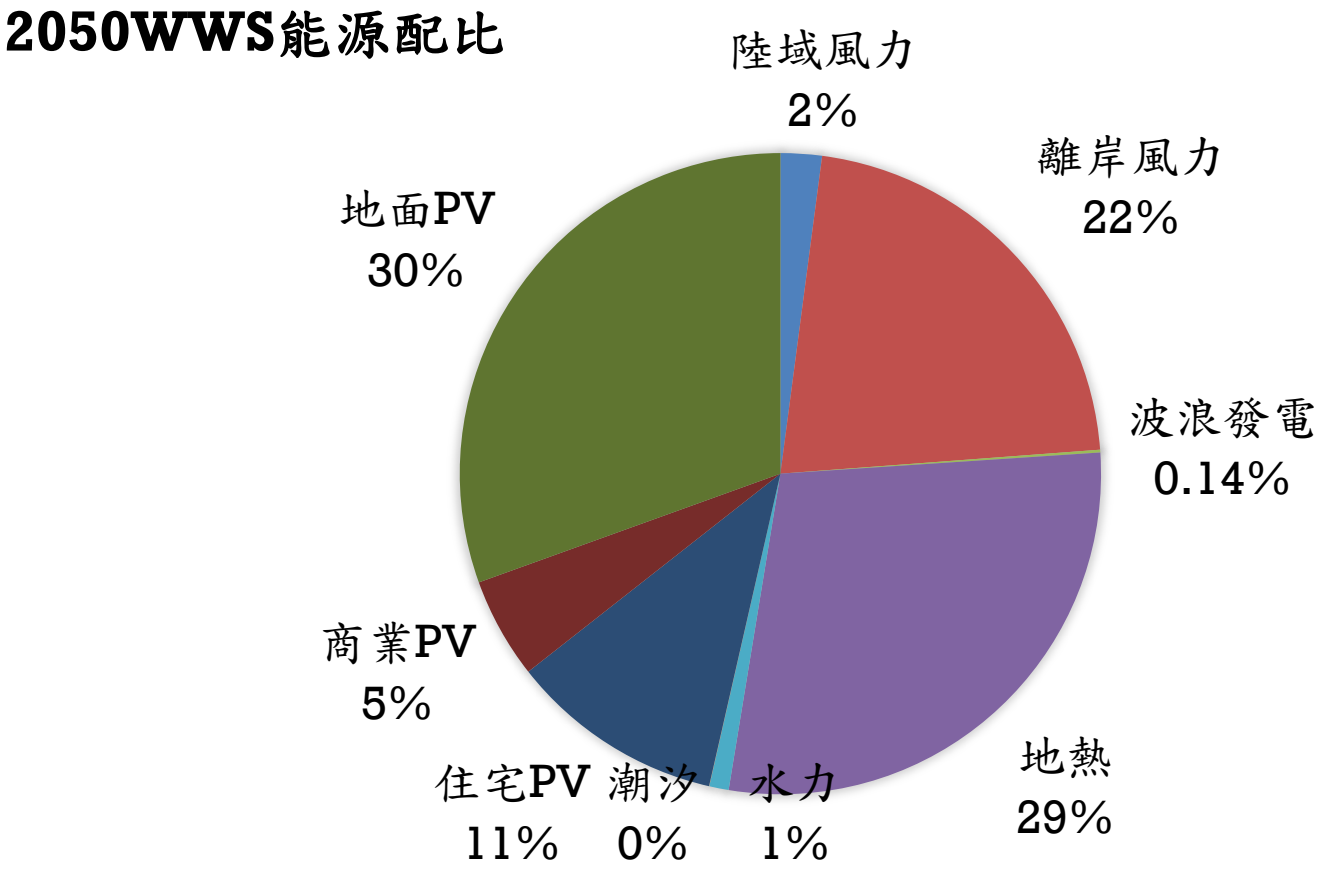
Table 1. 2012 BAU, 2050 BAU, and 2050 100% WWS End-Use Loads (GW) by Sector, Summed Among 139 Countries

Scenario	Total End-Use Load (GW)	Residential % of Total	Commercial % of Total	Industrial % of Total	Transport % of Total	Ag/ Forestry/ Fishing % of Total	Other % of Total	(a) 2050 Change in Load (%) due to Higher Work: Energy Ratio of WWS	(b) 2050 Change in Load (%) due to Eliminating Upstream w/WWS	(c) 2050 Change in Load (%) due to Efficiency Beyond BAU w/WWS	Total 2050 Change in Load (%) w/WWS
BAU 2012	12,100	22.4	8.10	38.7	27.4	2.13	1.37				
BAU 2050	20,600	20.4	8.08	37.3	31.0	1.87	1.34				
WWS 2050	11,800	25.7	11.2	42.1	16.0	2.85	2.15	−23.0	−12.7	−6.89	−42.5

The last column shows the total percent reduction in 2050 BAU end-use load due to switching to WWS, including the effects of reduced energy use due to (a) the higher work to energy ratio of electricity over combustion, (b) eliminating energy industry self-use for the upstream mining, transporting, and/or refining of coal, oil, gas, biofuels, bioenergy, and uranium, and (c) assumed policy-driven increases in end-use energy efficiency beyond those in the BAU case. Supplemental Information Section S3 describes the methodology; Table S6 contains individual country values.

Source: Jocobson et al (2017). 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. Joule Volume 1, Issue 1, 6 September 2017, Pages 108-121. Elsivier Inc.

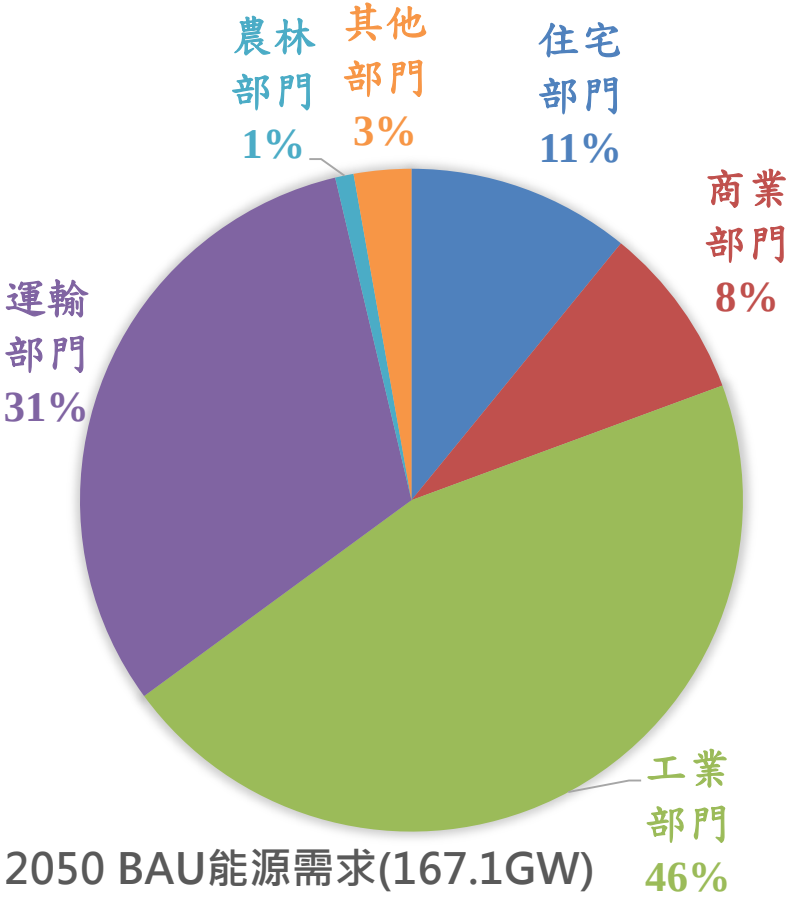
零排社會WWS下 2050台灣的能源供給

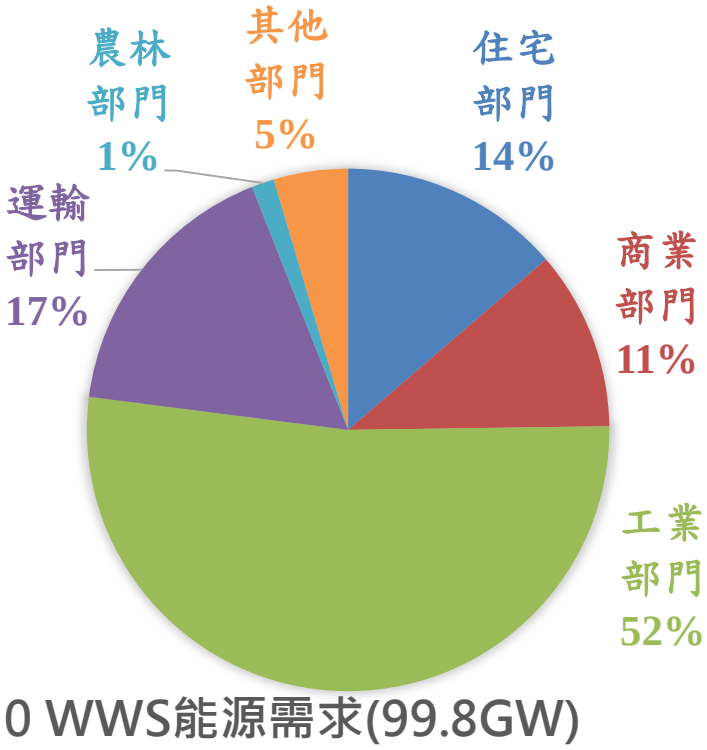


Chinese Taipei	2.08	21.73	0.14	28.64	0.98	0.01	10.83	5.09	30.51	0.00

Source: Jocobson et al (2017). 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. Joule Volume 1, Issue 1, 6 September 2017, Pages 108-121. Elsivier Inc.

零排社會下 2050台灣的能源需求



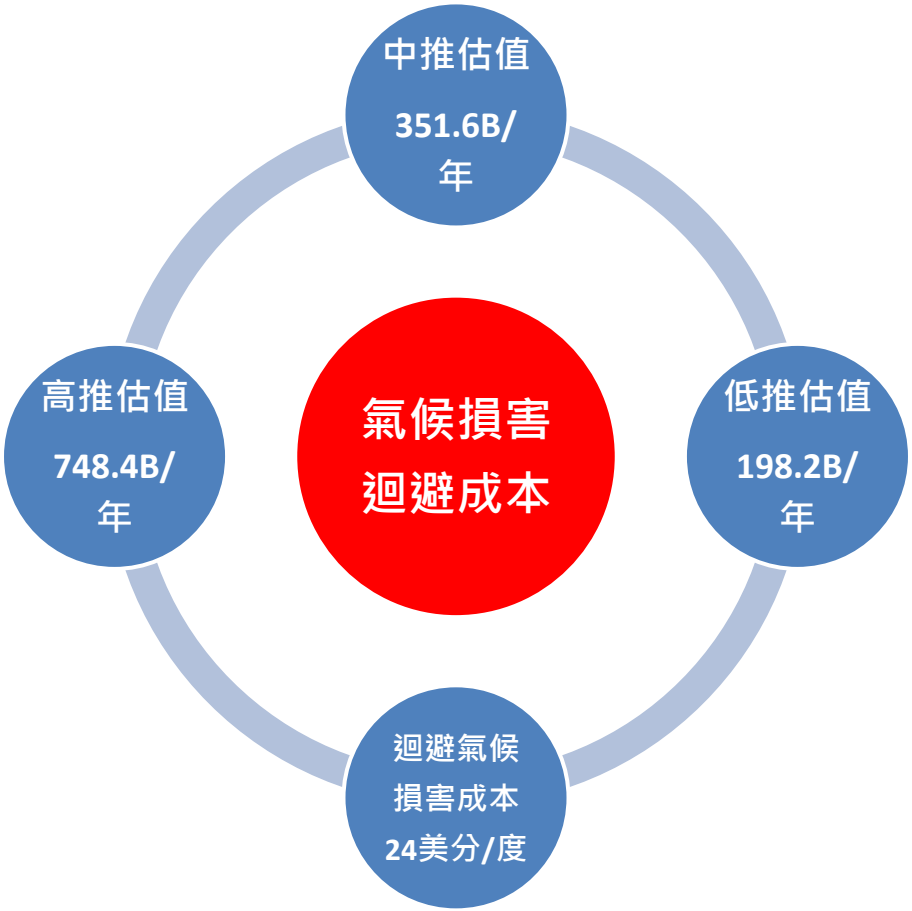


Source: Jocobson et al (2017). 100% Clean and Renewable Wind, Water, and Sunlight All-Sector Energy Roadmaps for 139 Countries of the World. Joule Volume 1, Issue 1, 6 September 2017, Pages 108-121. Elsivier Inc.

2050台灣WWS零碳社會的發電成本

2050台灣WWS零碳社會所迴避的健康成本

2050台灣WWS零碳社會所迴避的氣候損害成本



2050台灣WWS零碳社會所創造的工作機會

WWS下2050受損的產業

Energy sector	Jobs lost in sector	Percent of jobs in sector that are lost
Oil and gas extraction	2,783,000	89
Coal mining	969,000	96
Uranium mining	99,400	100
Support for oil and gas	4,179,000	89
Oil and gas pipeline construction	1,890,000	89
Mining & oil/gas machinery	1,348,000	89
Petroleum refining	689,000	94
Asphalt paving and roofing materials	0	0
Gas stations with stores	1,719,000	30
Other gas stations	407,000	50
Fossil electric power generation utilities	1,021,000	100
Fossil electric power generation non-utilities	184,000	100
Nuclear and other power generation	1,299,000	100
Natural gas distribution	1,306,000	100
Auto oil change shops/other repair	57,300	10
Rail transportation of fossil fuels	634,000	52
Water transportation of fossil fuels	264,600	23
Truck transportation of fossil fuels	836,000	8
Bioenergy except electricity	6,524,000	100
Total current jobs lost	**26,209,000**	
[h]Jobs lost from not growing fossil fuels	**1,535,000**	
All jobs lost	**27,744,000**	
[i]Total labor force	2.87 billion	
Jobs lost as percent of labor force	**0.97%**	

and Delucchi et al. (2017) for detailed calculations and referencing.

IRENA推薦電力轉型之30項創新措施

IRENA：International Renewable Energy Agency

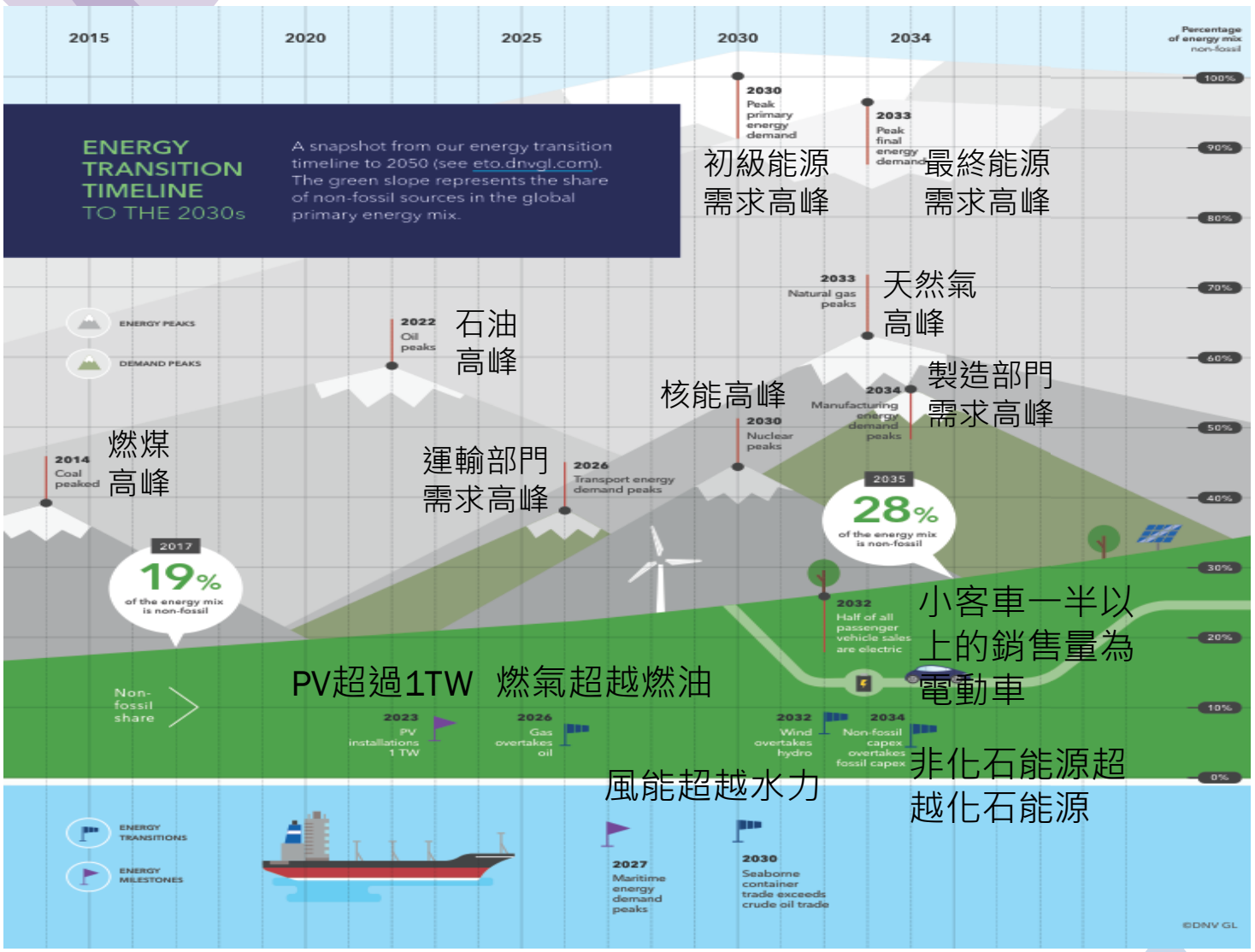
13項

关键技术	商业模式	市场设计	系统运行
1 电力公司规模蓄电池	12 聚合商	17 提高电力市场的时间粒度	25 配电系统运营商未来的角色
2 电表后端电池	13 点对点电力交易	18 提高电力市场的空间粒度	26 输配电系统运营商之间的合作
3 电动车智能充电	14 能源即服务	19 创新辅助服务	27 波动性可再生能源发电的先进预测
4 可再生电力供热	15 社区所有制模式	20 再设计容量市场	28 抽水蓄能的创新运行
5 可再生能源电力制氢	16 先装后付模式	21 区域市场	29 虚拟输电线路
6 物联网		22 峰谷分时电价	30 线路动态容量
7 人工智能和大数据		23 分布式能源市场整合	
8 区块链		24 净计费方案	
9 可再生能源小型电网			
10 超级电网			
11 常规电厂的灵活性			

『能源轉型』必須要在能源技術、商業模式、市場設計和系統營運方面，進行全方位的技術創新。
～IRENA

資料來源：IRENA (2019), Transforming the Energy System.

DNV. GL 2030技術展望：低碳能源系統



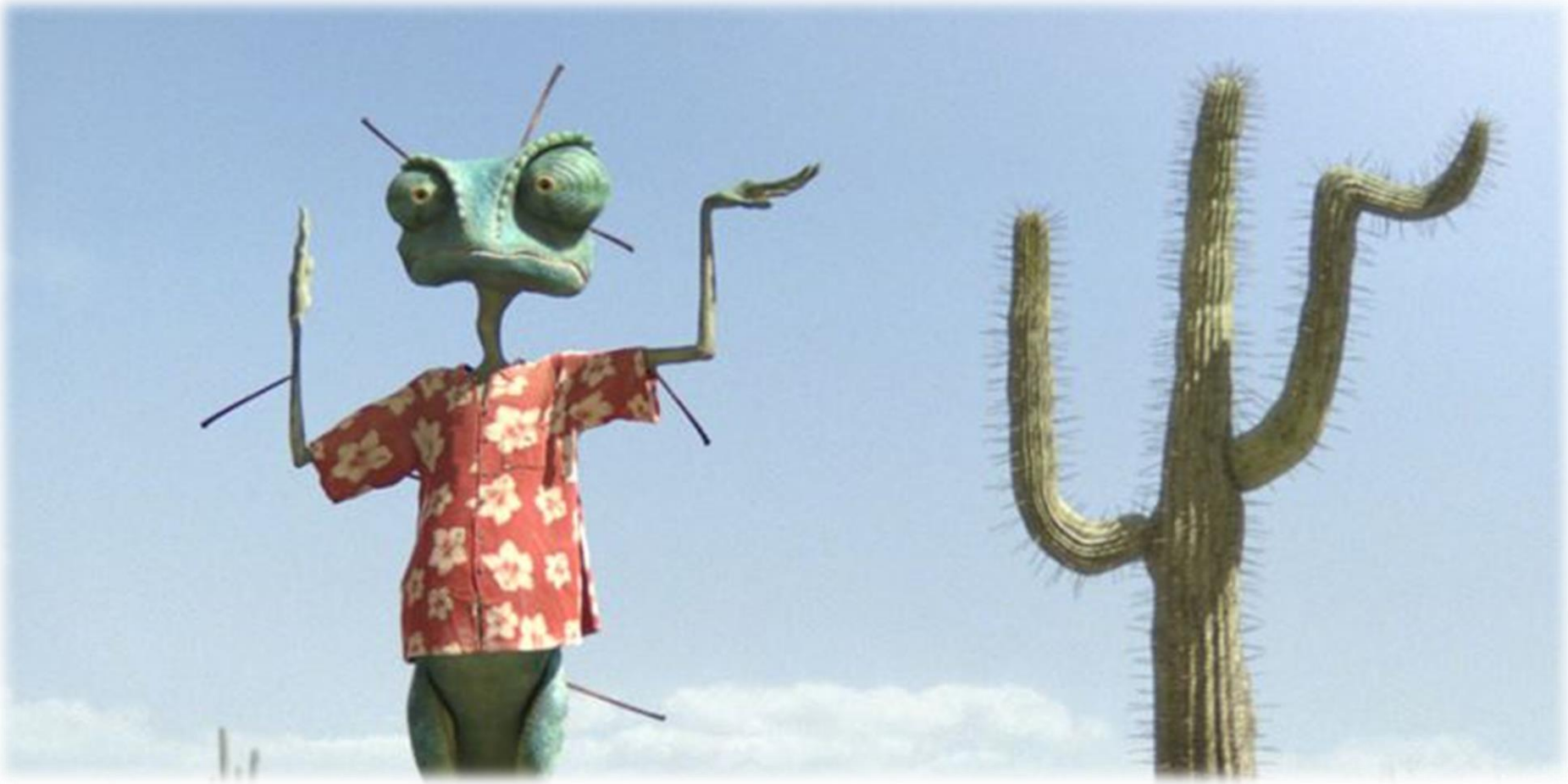
1. 電池儲能
2. 陸域與離岸風電
3. 太陽光電
4. 燃油EOR技術
5. 海洋開採技術
6. 合成燃料
7. 二氧化碳捕獲封存
8. 3D列印技術
9. 智慧控制器
10. **人工智慧**
11. **區塊鏈**
12. **物聯網**
13. 綠色氫能
14. 新的化學儲能系統
15. 小模組核能
16. 超高效熱泵/地熱

資料來源：整理自 DNV(2020), TECHNOLOGY OUTLOOK 2030.

Conclusions

- **Global warming trend is inevitable** no matter GHGs reduction continues or not.
- Climate change impacts will not discriminate in their choice of country, region or species although the magnitude maybe differentiates.
- **It is not the strongest of the species that survives nor the most intelligent…It is the one that is the most adaptable to change. (Darwin)**

ADAPTATION



THANK YOU FOR ATTENTION.