Analyzing the Effects of CO2e Pricing on Global Natural Gas Markets

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Outline

- The World Gas Model (WGM)
- Scenario Assumptions
- CO2 Pricing Comparisons Used in This Study
- Comparison Results
- Conclusion

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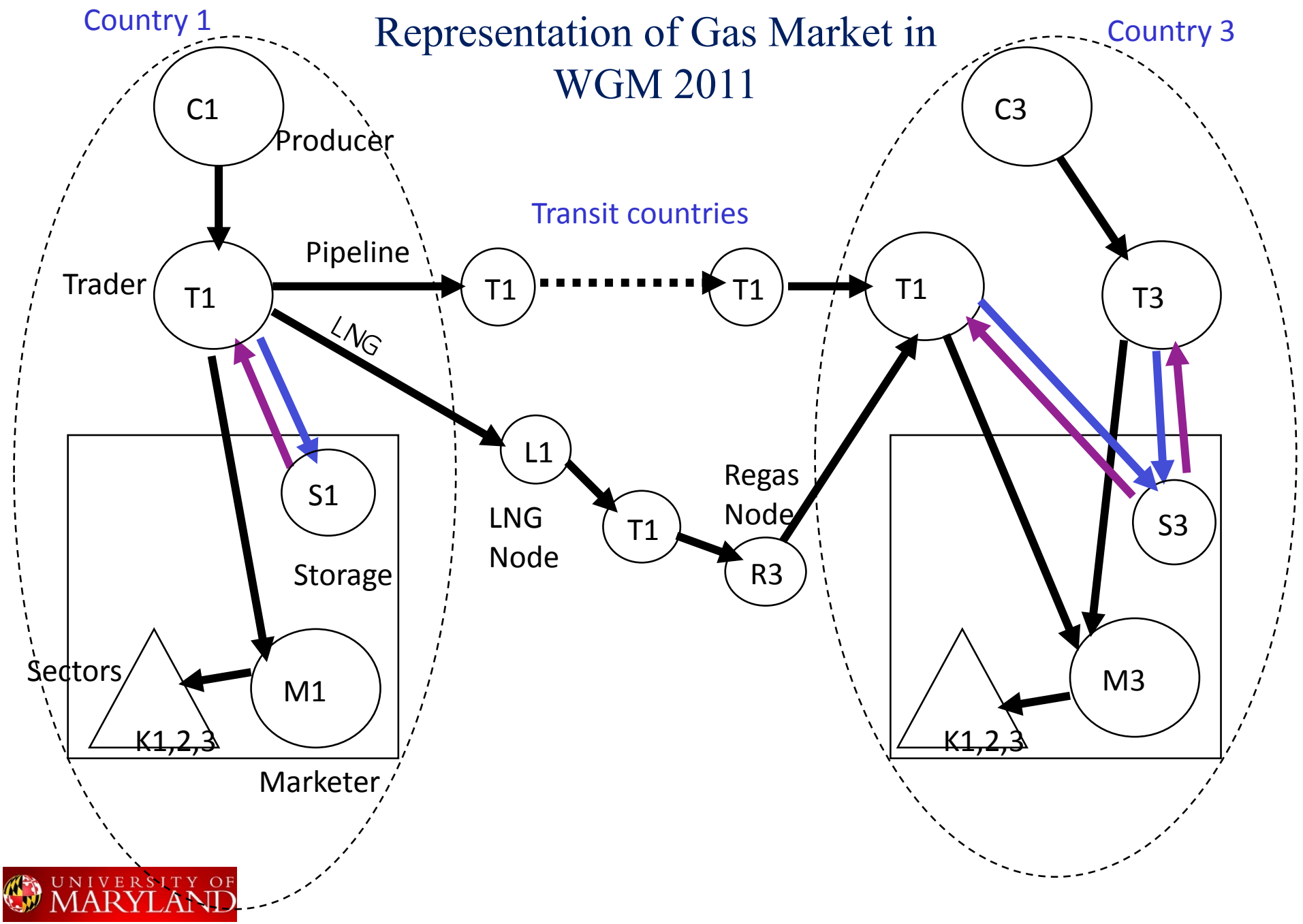
World Gas Model (WGM)

- Production/Consumption Nodes: 41 (Groups of countries, countries, regions)
- Covers over 95% of worldwide consumption (2005)
- 12 periods: 2005-2060 (report to 2050)
- Typical decision variables
  - Operating levels (e.g., production, storage injection)
  - Investment levels (e.g., pipeline, liquefaction capacity)
- Other
  - Market power aspects (traders in pipeline and LNG markets)
  - LNG contracts database
  - Seasonality of demand: each year a low and high demand period
  - Environmental policy consideration: Carbon costs for supply chains
- Computational aspects
  - Large-scale complementarity problem (optimization conditions for all players + market-clearing conditions)
  - ~66,000 vars. Solves in ~95 mins (2GB, 1.2 GHz)

Representation of Gas Market in WGM 2011



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JGCRI Scenarios and Data Used

JGCRI provided five scenarios:

- 450 CO2wDelay Case
- 650 Case
- 650 NoCCS
- 650 NoCCSNoNuclear
- 20-20-20

- JGCRI also provided:
  - List of countries that fall in specific regions defined for GCAM analysis
  - Production data
  - Consumption data
  - Prices for natural gas
  - Conversion factors
  - Inflation rates
  - Carbon prices

GCAM450ppm with Delay Scenario

Assumptions

- Action by the developed world in the first time period.
- Brazil, Russia, India, and China enter in 2035 and see approximately 50% of the market CO2 price in their first year of participation.
- The remainder of non-Annex one (developing world) enters in 2050 and see approximately 50% of market CO2 price in their first year of participation.

GCAM-Based CO2 Prices ($2005/ton) for GCAM450ppm with Delay Scenario

Region	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060
AFRICA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	130.80	261.60
ASPACIF	0.00	6.07	12.13	18.20	24.72	31.24	37.76	64.52	91.29	118.05	212.75	307.45
CHINA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.58	131.17	196.75	267.39	338.02
EUROPE	0.00	15.16	30.33	45.49	61.79	78.09	94.39	128.51	162.63	196.75	267.39	338.02
FRSVTUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.58	131.17	196.75	267.39	338.02
MIDEAST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	130.80	261.60
NRTH_AM	0.00	15.16	30.33	45.49	61.79	78.09	94.39	128.51	162.63	196.75	267.39	338.02
STH_AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.58	131.17	196.75	267.39	338.02

- GCAM provided CO2 prices from 2005-2095 in 15-year intervals
- We used GCAM data from 2005-2065
- We used linear interpolation to get data for 5-year increments

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EU 20/20/20Policies

- Based on the EU 20/20/20 policy
  - Adapted to cover all regions and all periods
- Component Policies:
  - GHG emissions reduction target (GHG)
    - Relative to 30 years prior
  - Energy efficiency increase (EE)
    - Relative to baseline
  - Renewable energy target (RES)
    - Fraction of total final energy
  - Renewable transportation energy target (TE)
    - Fraction of total transportation final energy

Assumptions for 20-20-20 Cases

	2020	2035	2050	2065	2080	2095
E. Europe W. Europe	GHG (20%) EE (20%) RES (20%) TE (10%)	GHG (50%) EE (50%) RES (50%) TE (25%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)
Australia/NZ Canada China Japan USA		GHG (20%) EE (20%) RES (20%) TE (10%)	GHG (50%) EE (50%) RES (50%) TE (25%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)
FSU India L. America			GHG (20%) EE (20%) RES (20%) TE (10%)	GHG (50%) EE (50%) RES (50%) TE (25%)	GHG (80%) EE (80%) RES (80%) TE (50%)	GHG (80%) EE (80%) RES (80%) TE (50%)
Africa Mid. East Korea S.E. Asia				GHG (20%) EE (20%) RES (20%) TE (10%)	GHG (50%) EE (50%) RES (50%) TE (25%)	GHG (80%) EE (80%) RES (80%) TE (50%)

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GCAM-Based CO_2 Prices ($2005/ton) for 20-20-20 Cases

Region	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
AFRICA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ASPACIF	0.00	0.00	0.00	0.00	0.53	1.24	1.59	9.84	20.85	26.35
CHINA	0.00	0.00	0.00	0.00	11.19	26.12	33.58	38.04	43.98	46.95
EUROPE	0.00	6.87	16.03	20.61	25.63	32.32	35.66	39.95	45.66	48.52
FRSVTUN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.48	71.12	91.44
MIDEAST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRTH_AM	0.00	0.00	0.00	0.00	10.52	24.54	31.55	42.87	57.97	65.51
STH_AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.63	132.13	169.88

- GCAM provided CO2 prices from 2005-2095 in 15-year intervals
- We used GCAM data from 2005-2065
- We used linear interpolation to get data for 5-year increments

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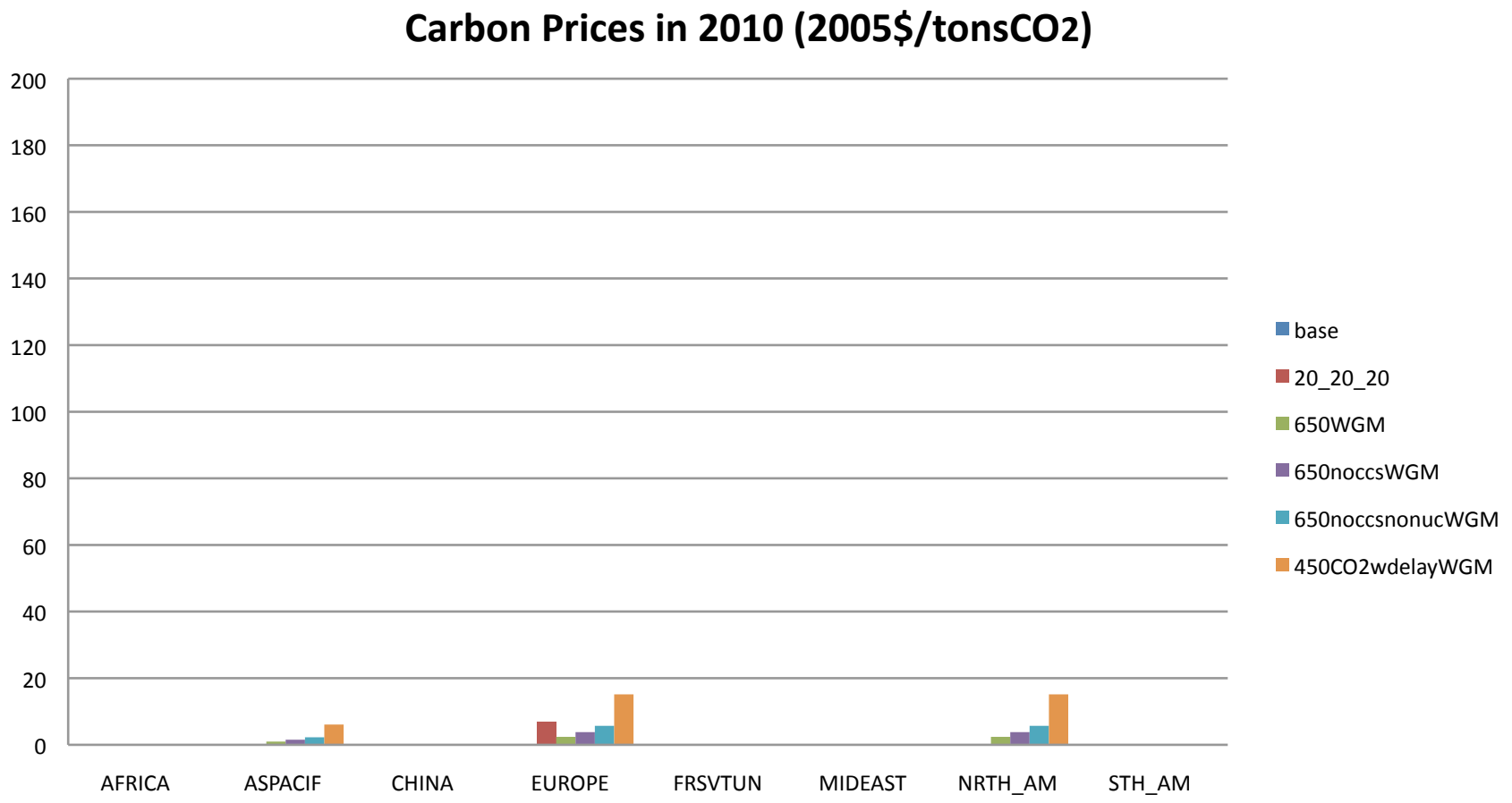
Cases and Description

CASE NAME	ABBREVIATION	DESCRIPTION
Base Case	Reference WGM	Reference Case from WGM
20-20-20	20-20-20	Incorporating GCAM data intoWGM
650WGM	650WGM	Incorporating GCAM data into WGM
650noCCSWGM	650noCCS	Incorporating GCAM data into WGM
650noCCSnoNuclearWGM	650noCCSnoNuclearWGM	Incorporating GCAM data into WGM
450 CO2wDelay case	450CO2wDelayWGM	Incorporating GCAM data into WGM

CO2 Pricing Scenarios
Comparisons Used in the Study

CO2 pricing scenarios used in the study



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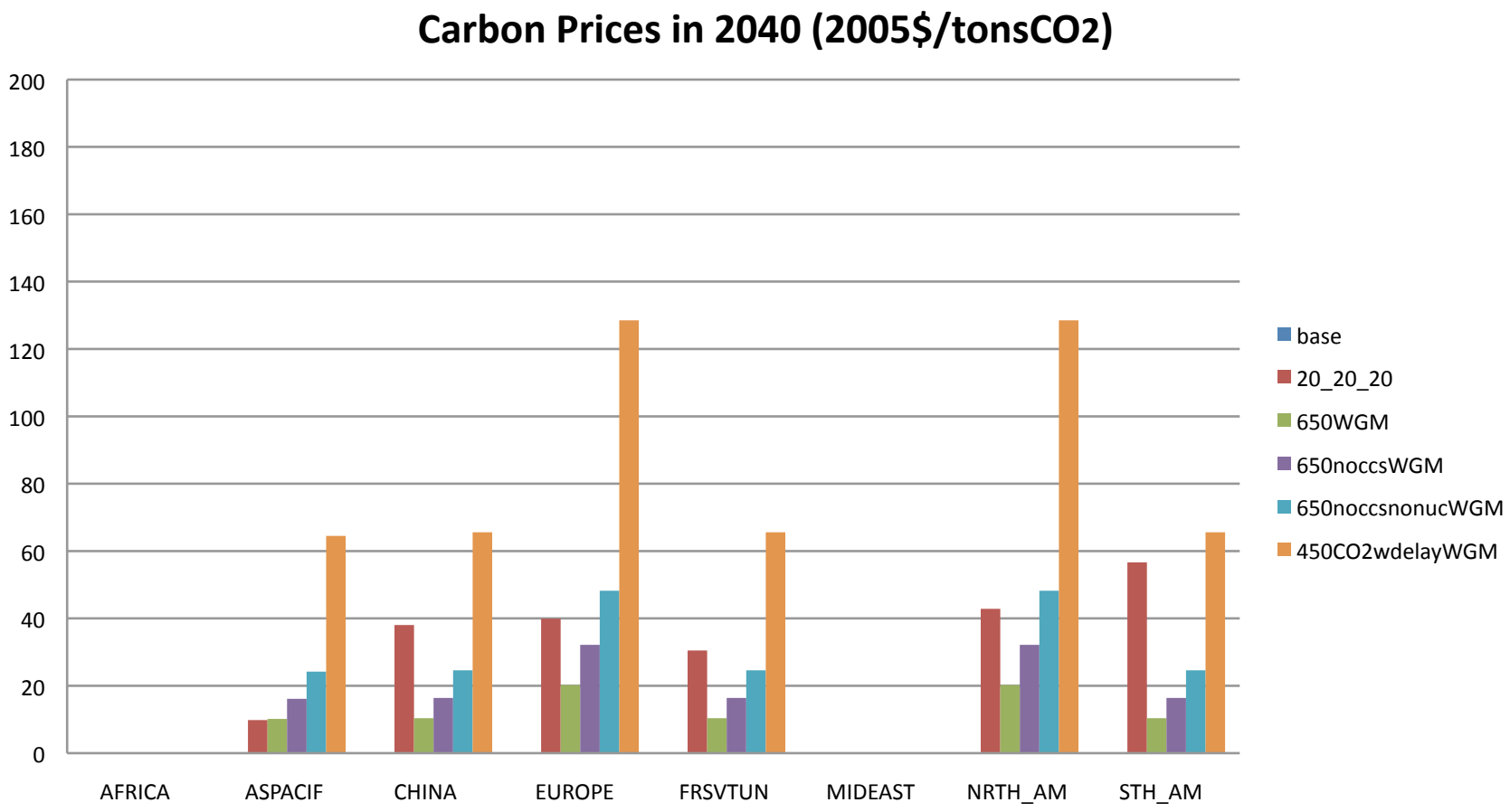

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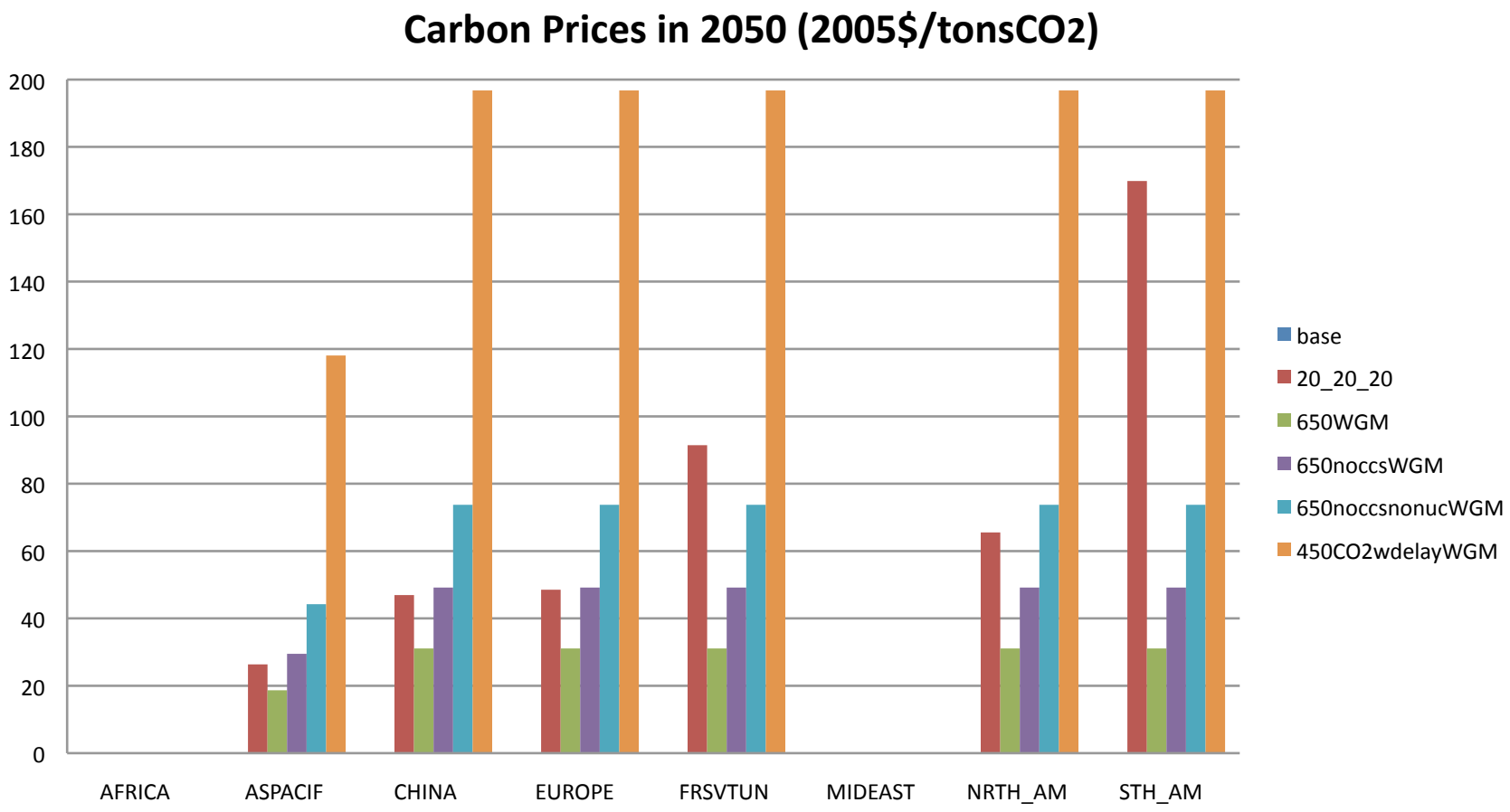
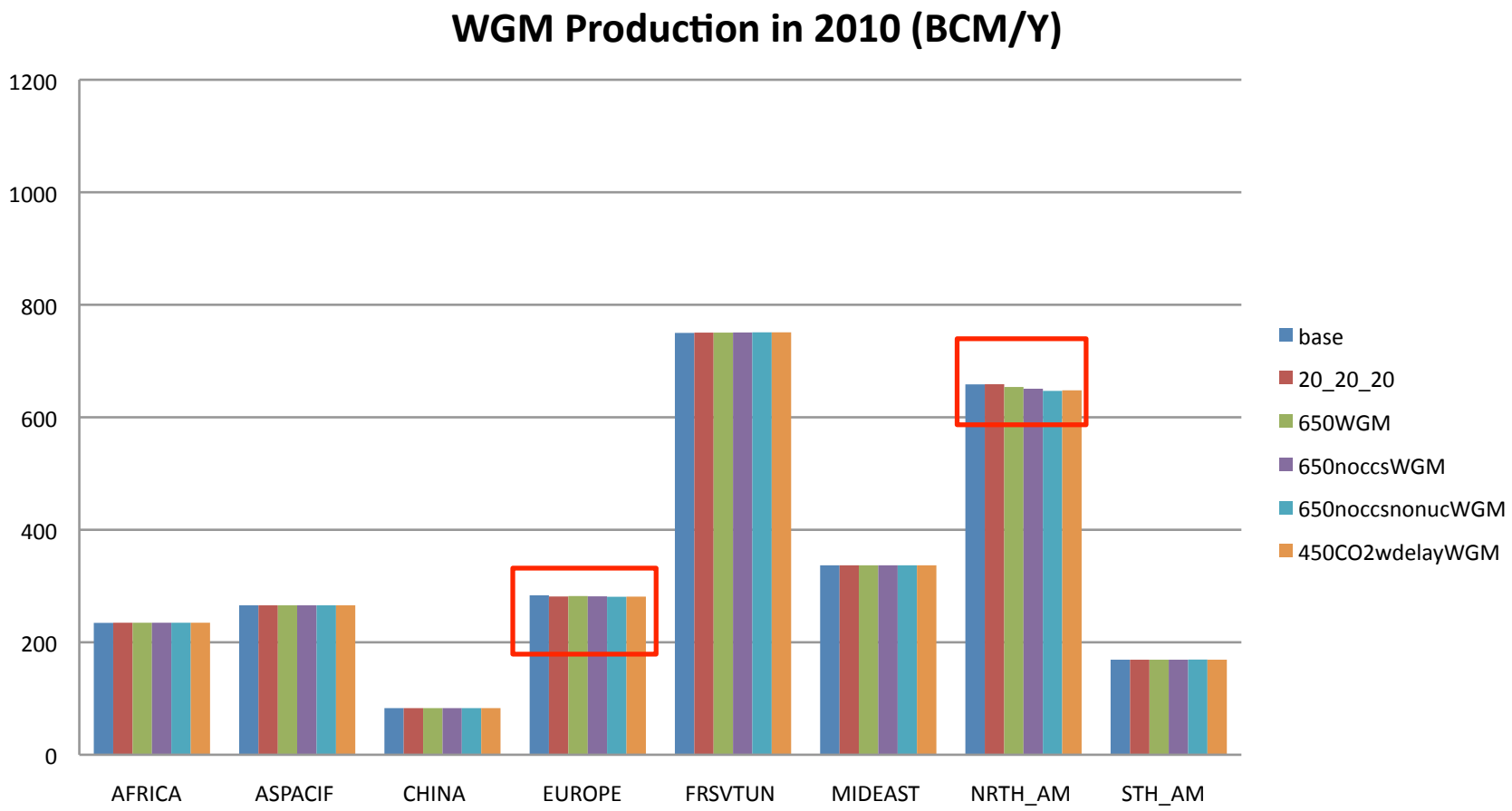


WGM Production Comparison Results

WGM Production in 2010(BCM/Y)



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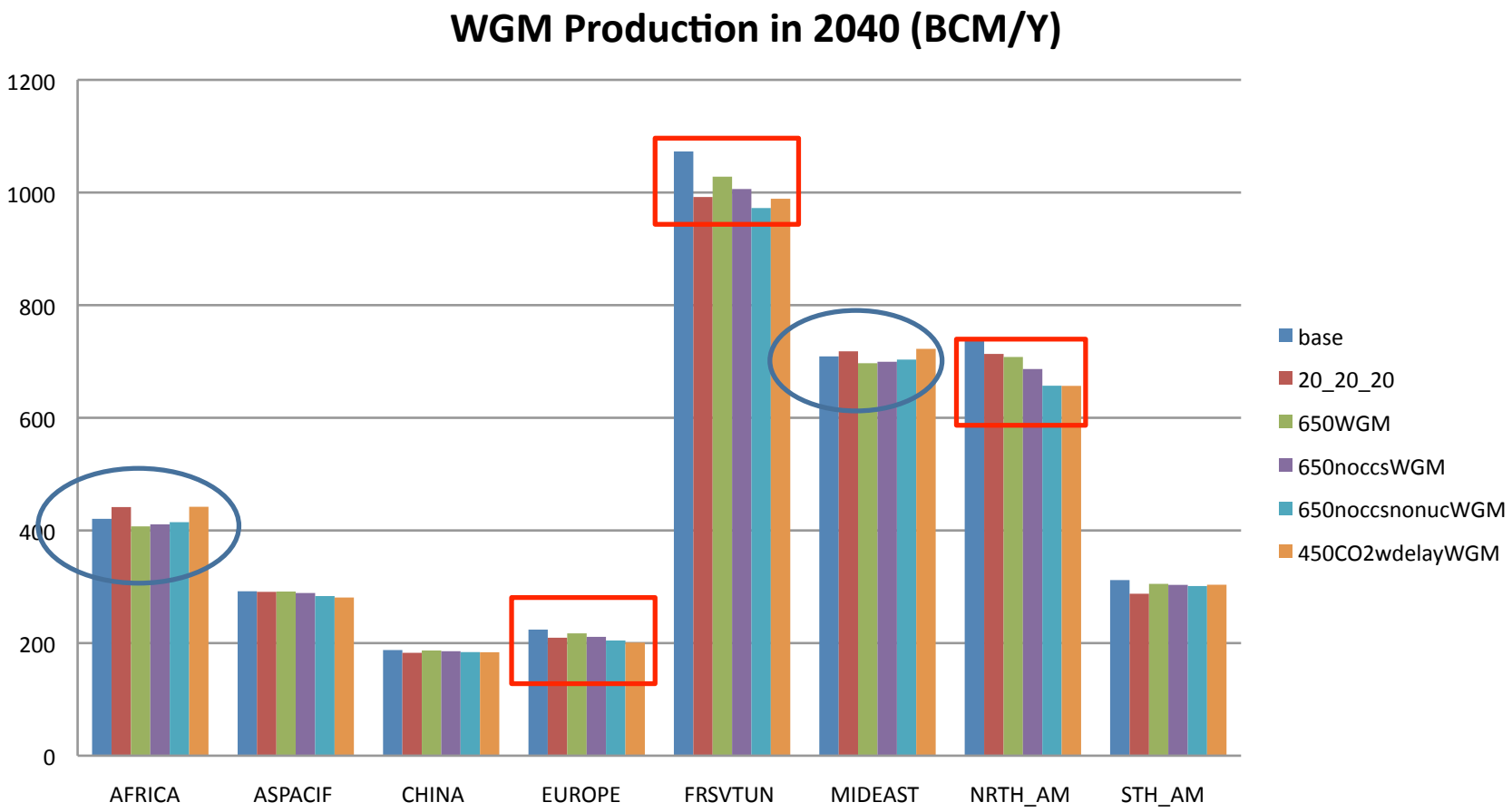
WGM Production in 2040(BCM/Y)



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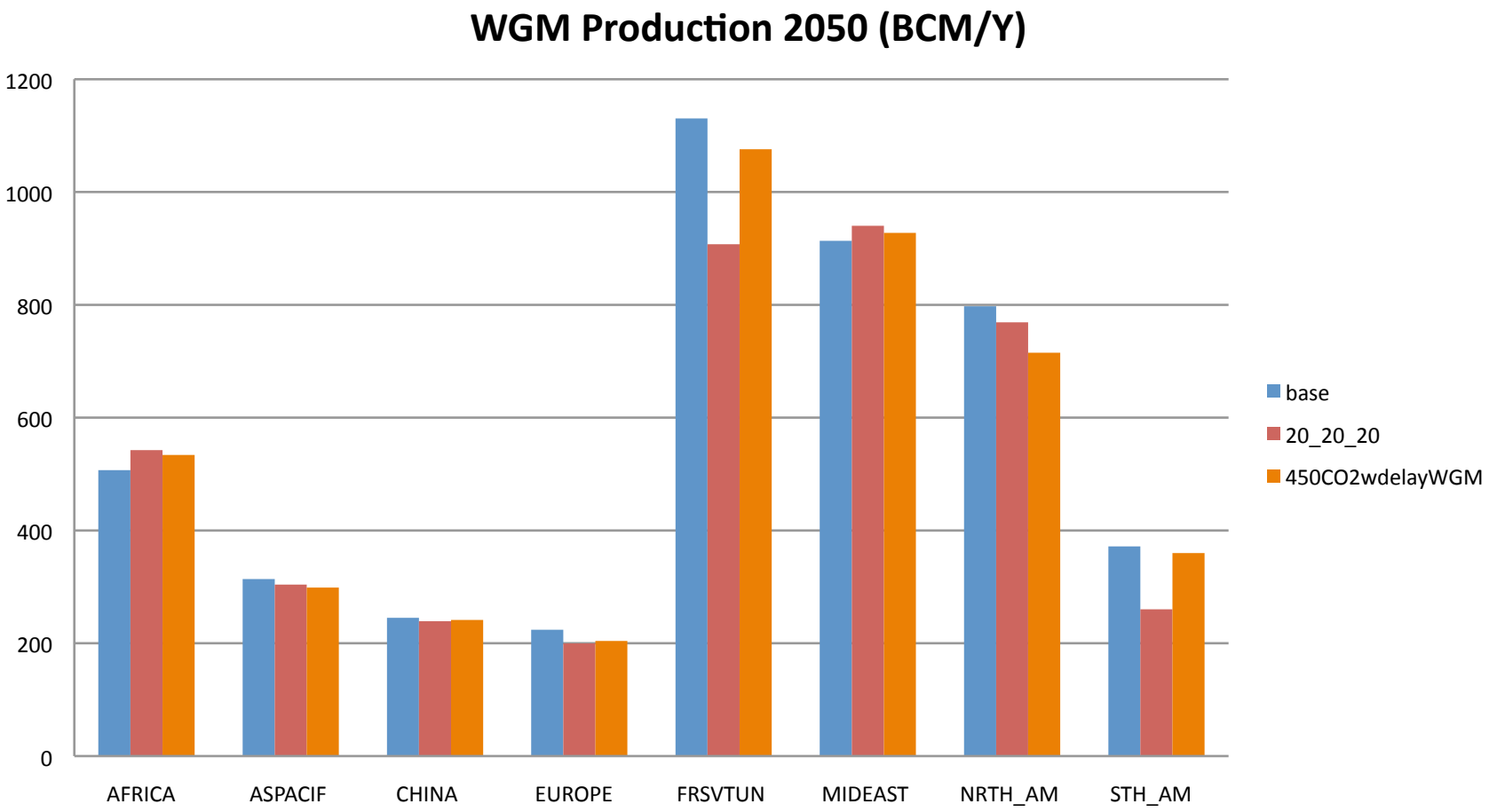
WGM Production in 2050(BCM/Y)



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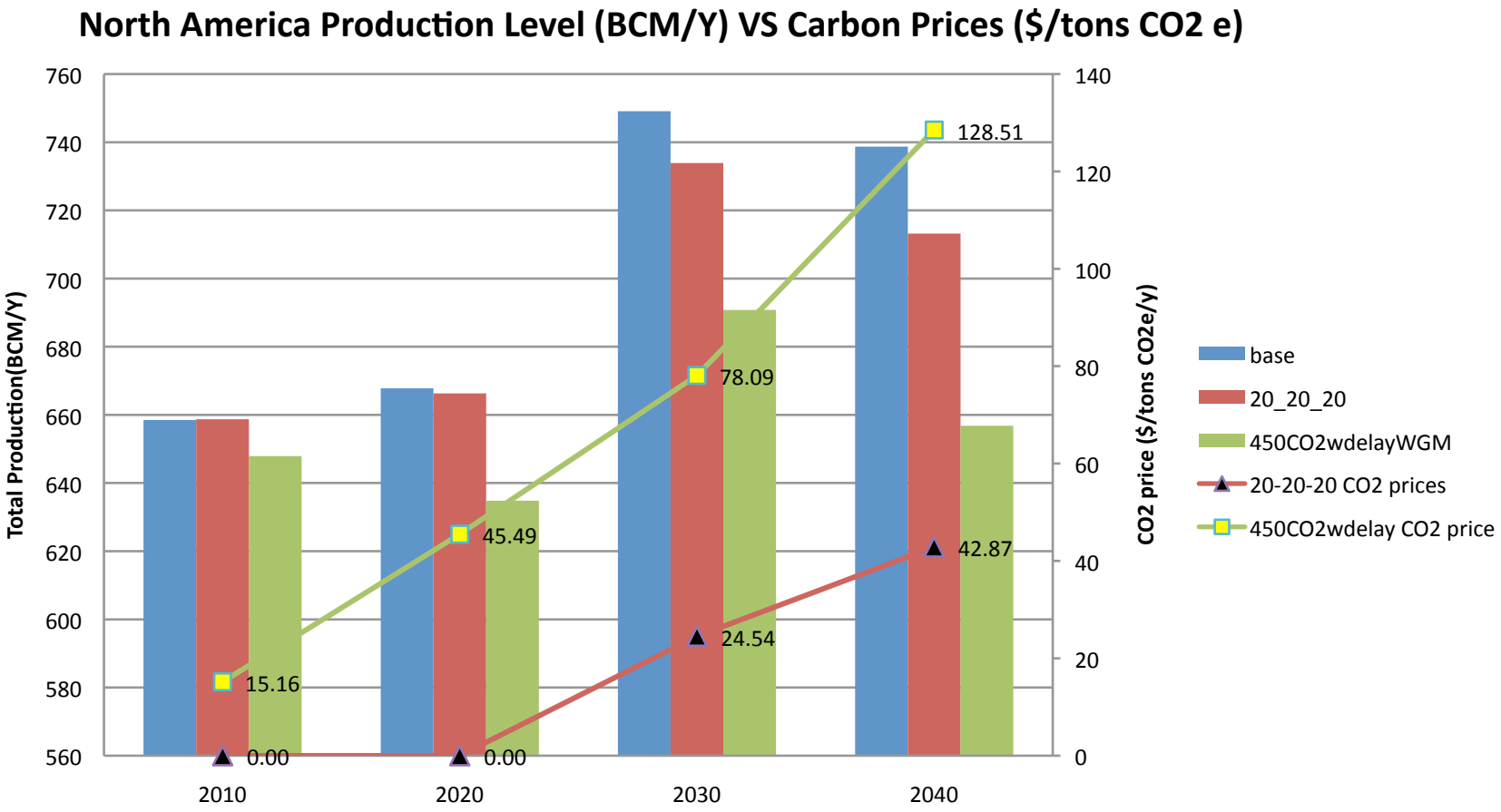
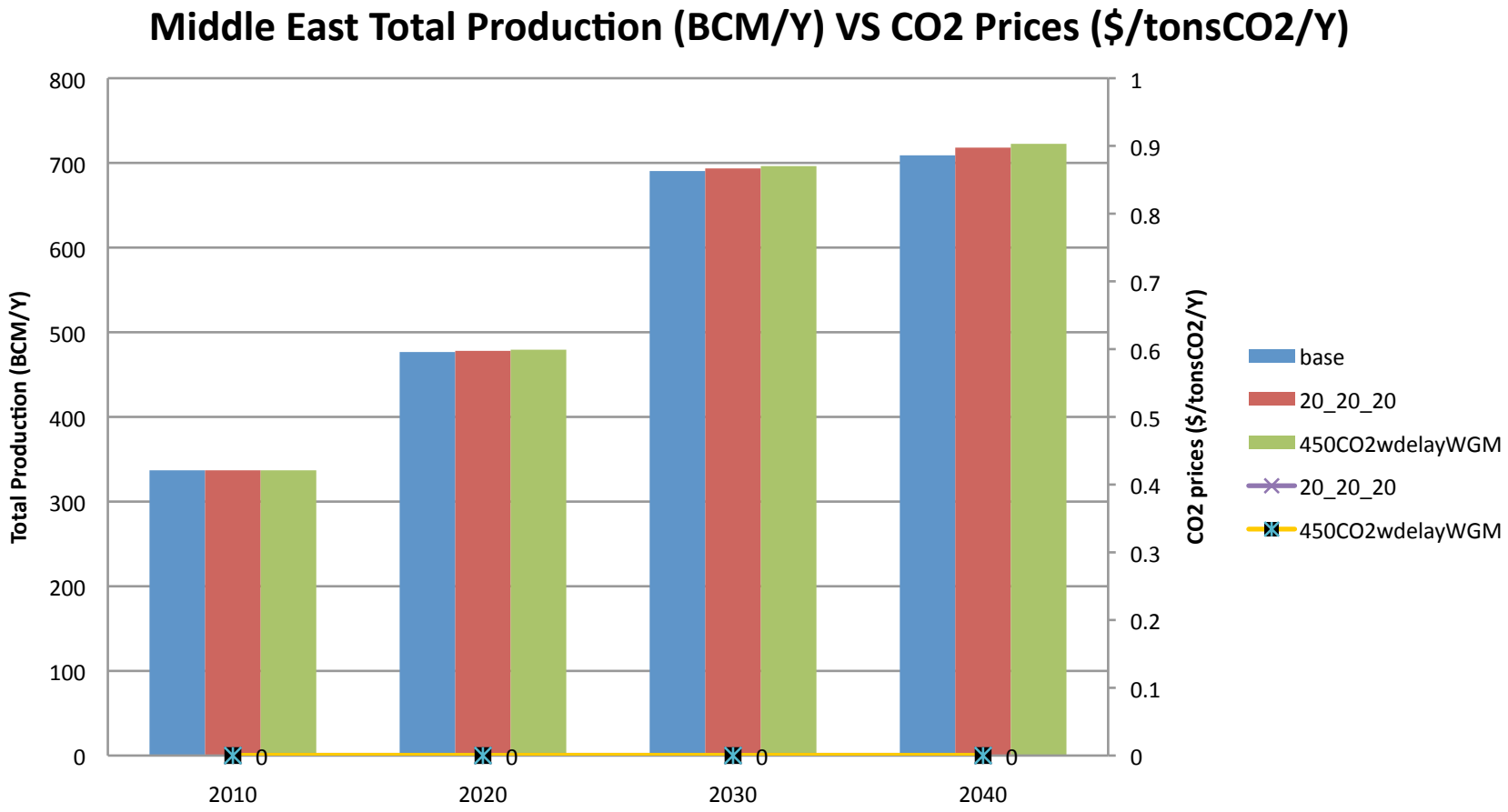
North America Total Production VS CO2 Prices

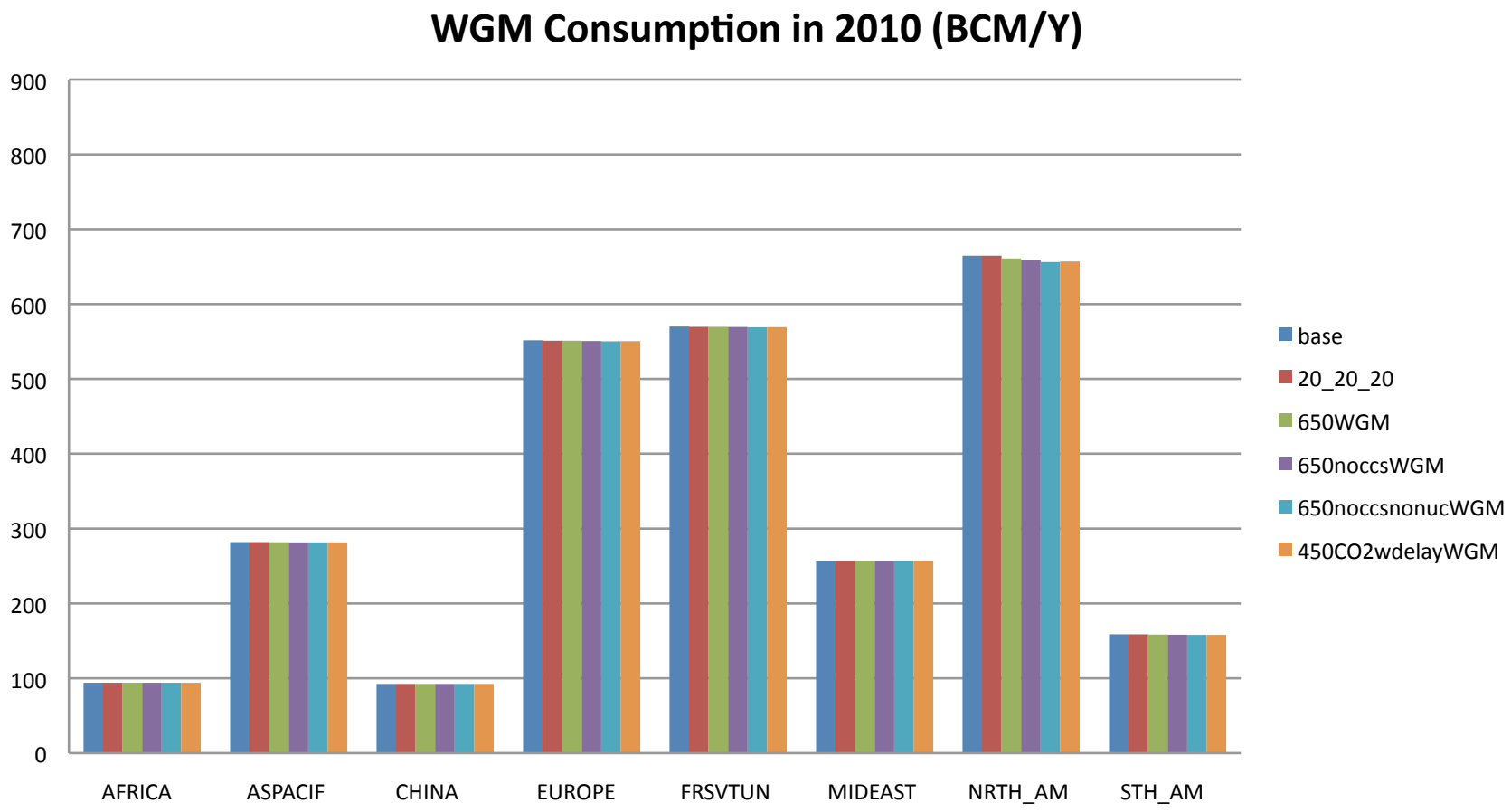


Middle East Total Production VS CO2 Prices



WGM Consumption Comparison Results

WGM Consumption in 2010(BCM/Y)



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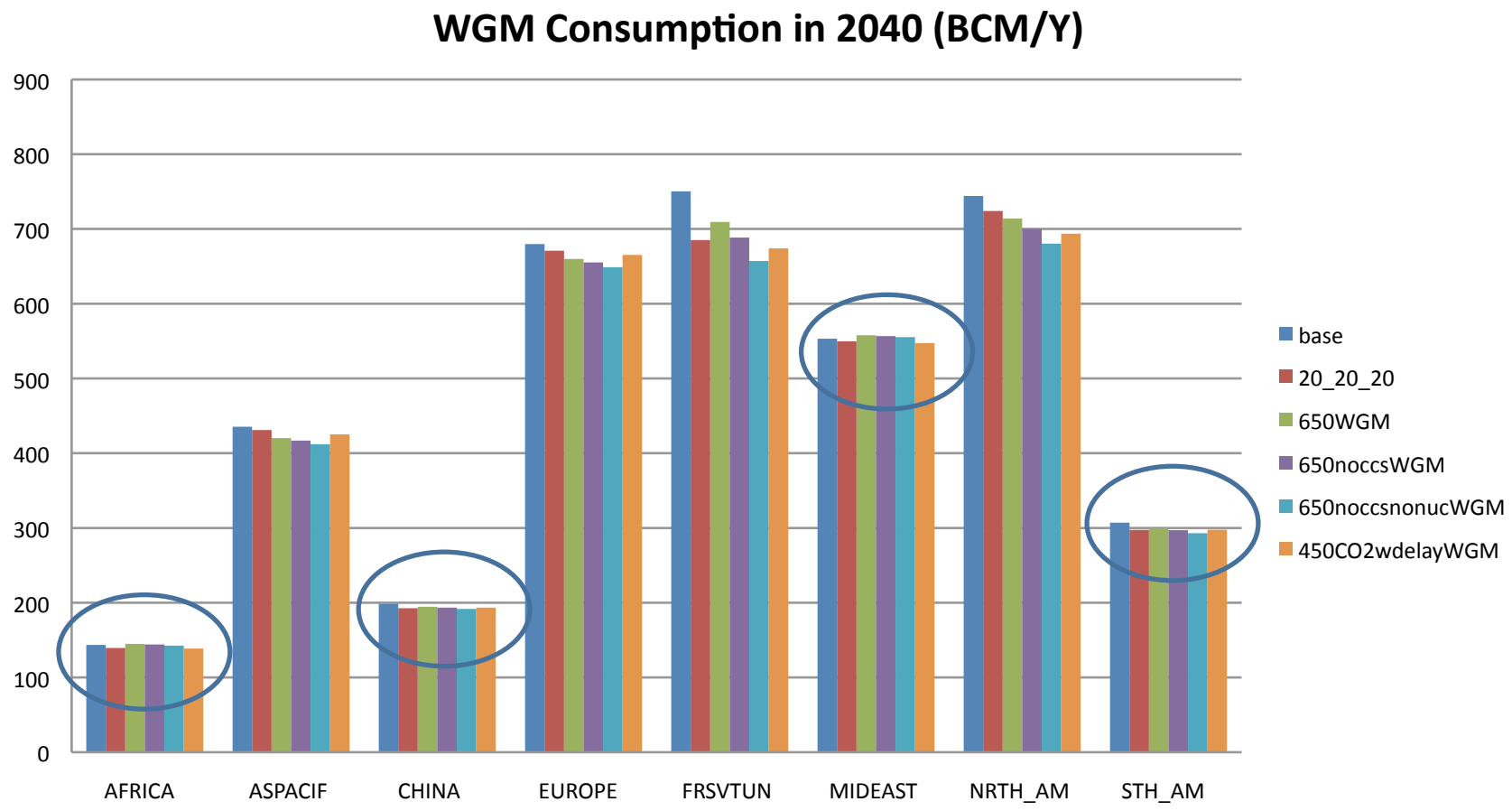
WGM Consumption in 2040(BCM/Y)



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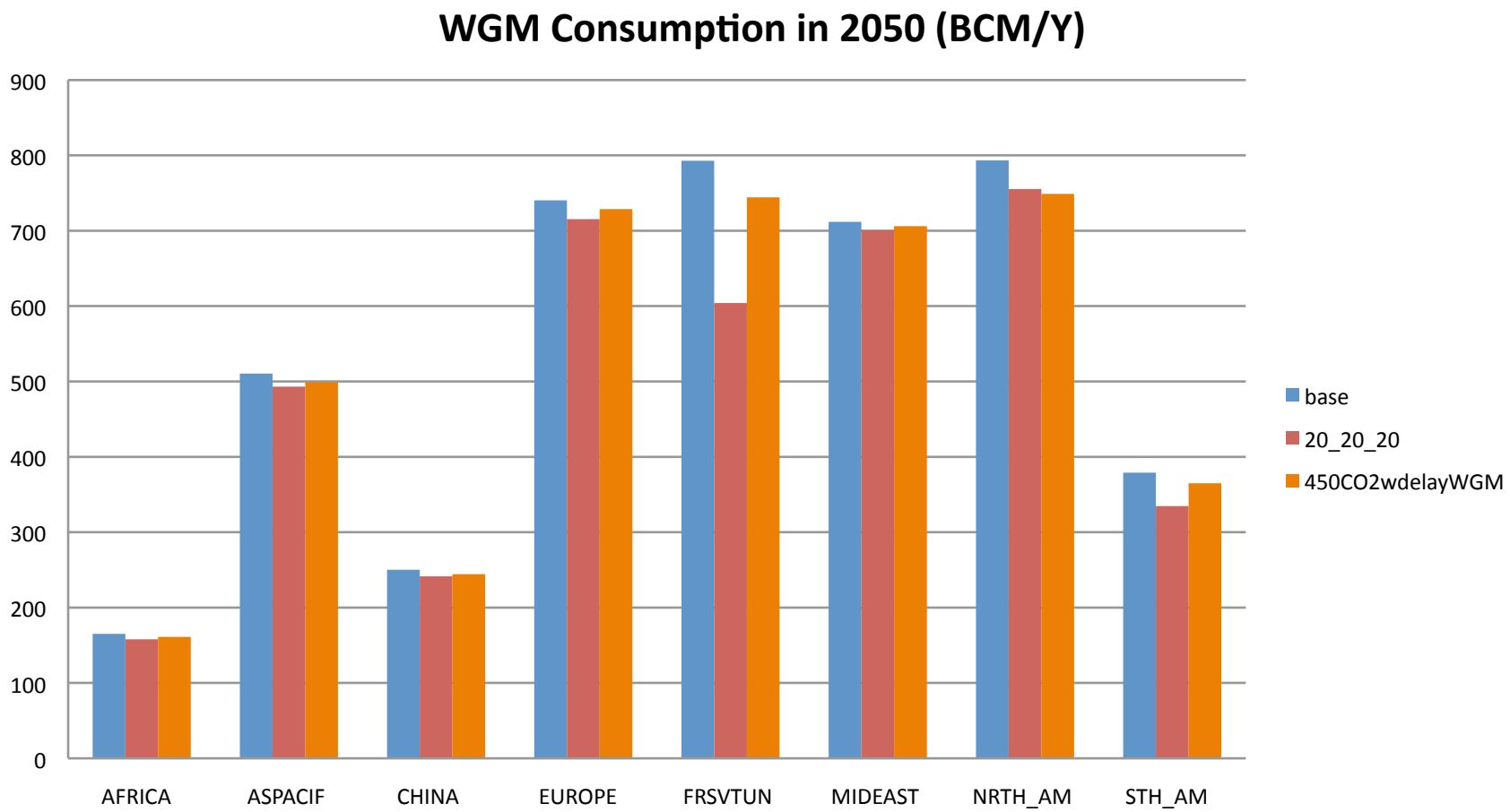
WGM Consumption in 2050(BCM/Y)



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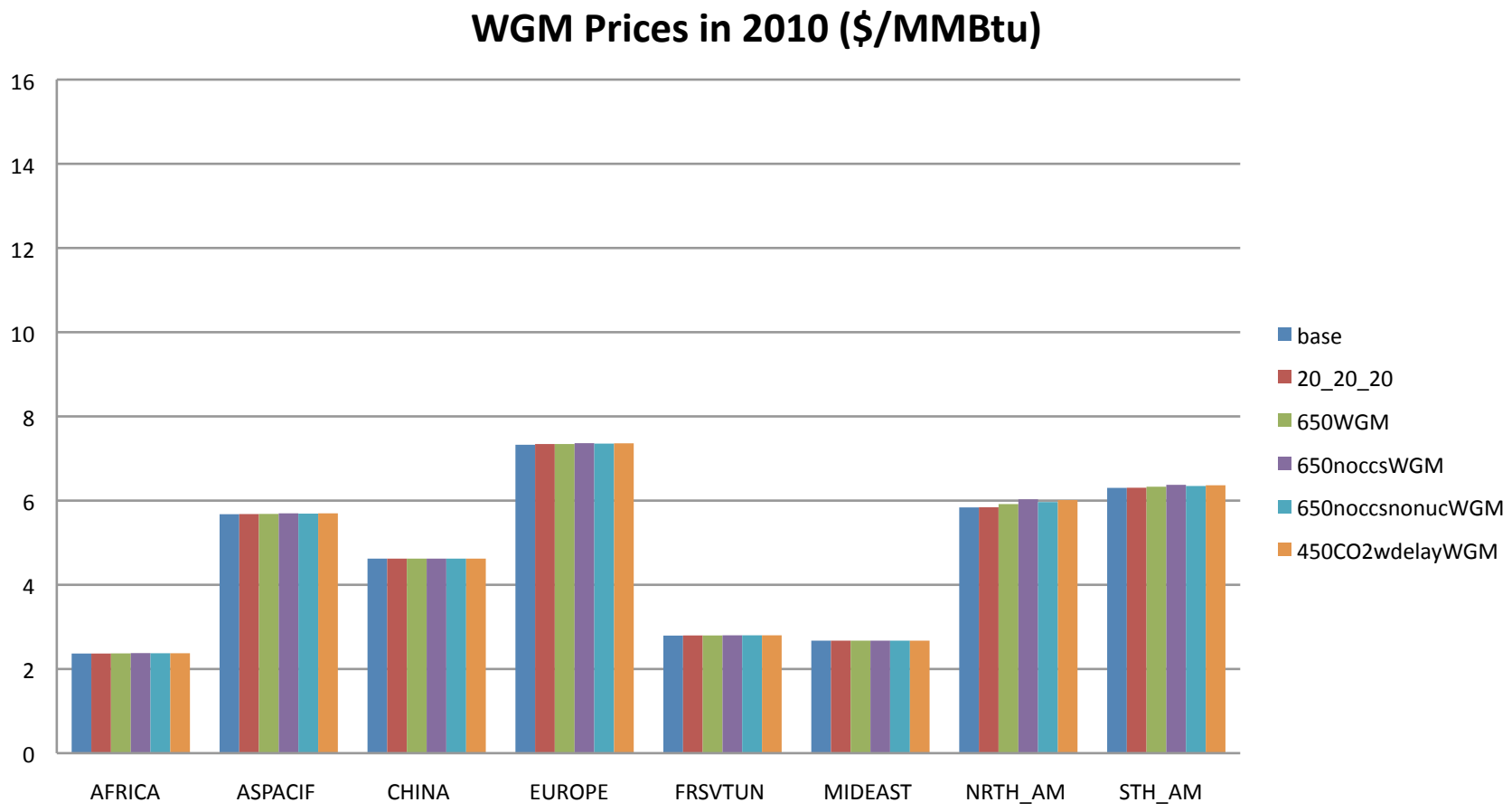
WGM Prices Comparison Results

WGM Prices in 2010($/MMBtu)



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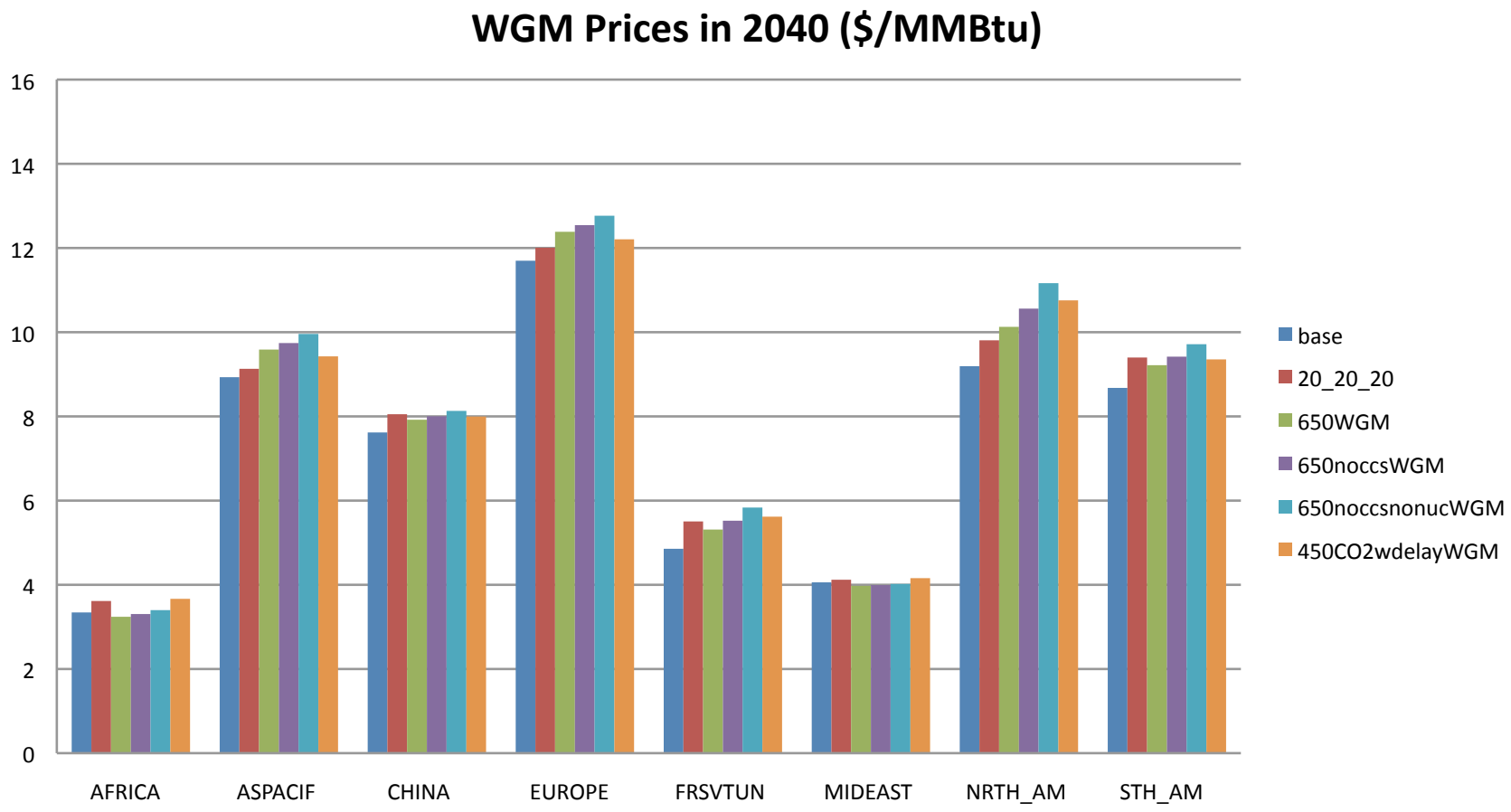
WGM Prices in 2040($/MMBtu)



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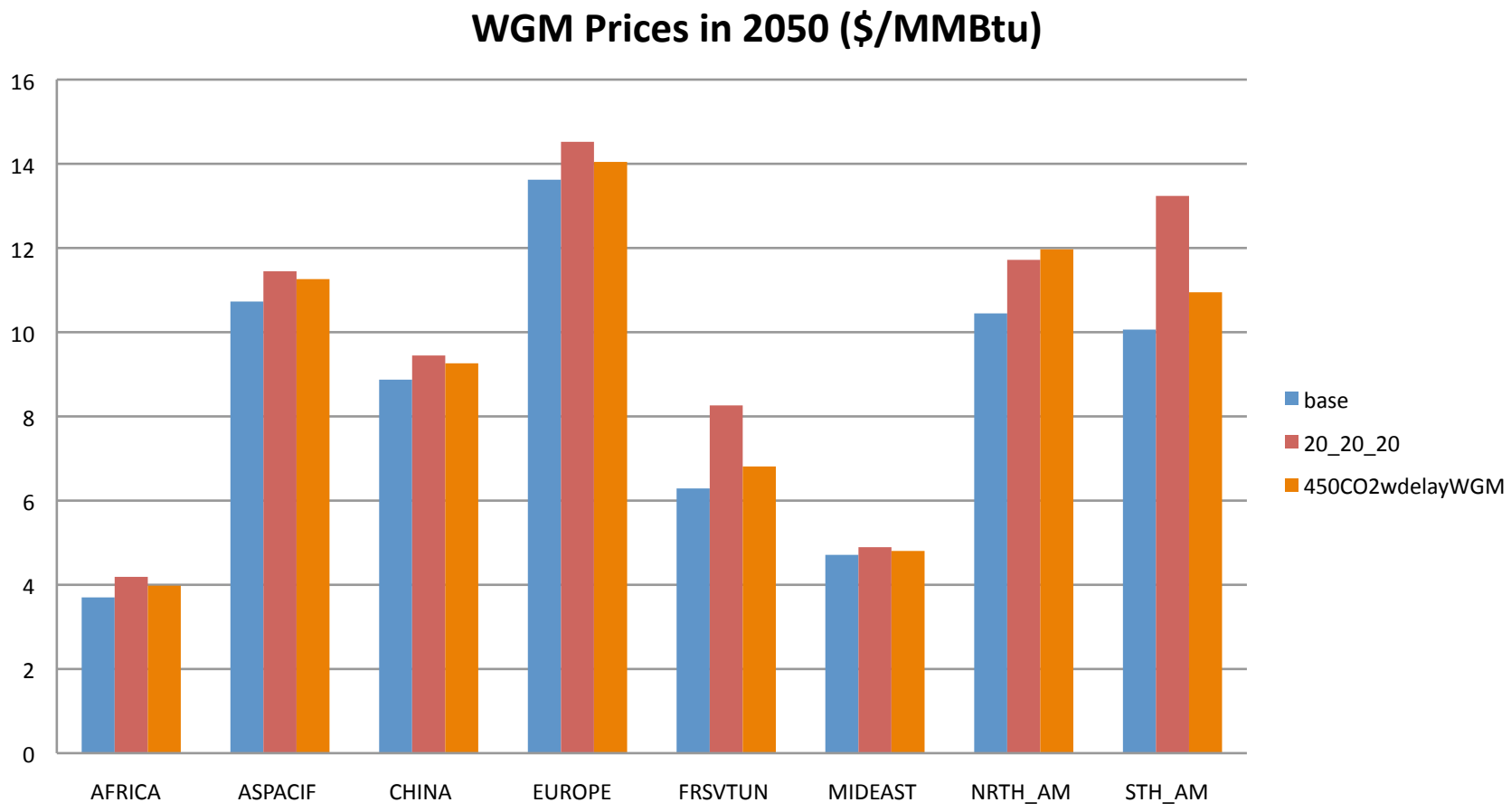
WGM Prices in 2050($/MMBtu)



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Conclusion

- Level of natural gas productions in most regions reduce due to carbon prices. Except, in Middle East and Africa (no carbon tax policy applied).
- The price of natural gas is influenced by carbon prices.

  -Natural Gas prices increase 10-20% in region that carbon prices policy applied.
- Climate policy have effects in term of production, consumption, and prices over all global natural gas markets.

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Extra Slides

WGM Nodes	Country	Sub region	Region
ALG	Algeria	AfrNorth	Africa
NIG	Angola	AfrWest	Africa
ALG	Egypt	AfrNorth	Africa
NIG	Equatorial Guinea	AfrWest	Africa
ALG	Libya	AfrNorth	Africa
ALG	Morocco	AfrNorth	Africa
NIG	Mozambique	AfrWest	Africa
NIG	Nigeria	AfrWest	Africa
NIG	South Africa	AfrWest	Africa
ALG	Tunisia	AfrNorth	Africa
AUS	Australia	Australia	AsiaPacific
CHN	Birma	AsPacOther	AsiaPacific
IDO	Brunei	AsPacGECF	AsiaPacific
CHN	China	AsPacOther	AsiaPacific
IDA	India	AsPacOther	AsiaPacific
IDO	Indonesia	AsPacGECF	AsiaPacific
JAP	Japan	JPKor	AsiaPacific
IDO	Malaysia	AsPacGECF	AsiaPacific
AUS	New Zealand	Australia	AsiaPacific
IDA	Pakistan	AsPacOther	AsiaPacific
CHN	Singapore	AsPacOther	AsiaPacific
JAP	SouthKorea	JPKor	AsiaPacific
CHN	Taiwan	AsPacOther	AsiaPacific
CHN	Thailand	AsPacOther	AsiaPacific
KZK	Armenia	Caspian	Caspian
KZK	Azerbaijan	Caspian	Caspian
KZK	Georgia	Caspian	Caspian
KZK	Kazakhstan	Caspian	Caspian
KZK	Turkmenistan	Caspian	Caspian
KZK	Uzbekistan	Caspian	Caspian
UKR	Belarus	UkrBelarus	Eurasia
UKR	Ukraine	UkrBelarus	Eurasia
GER	Austria	EurOther	Europe
POL	BalticRegion	EurOther	Europe
FRA	Belgium & Luxembourg	EurOther	Europe
ROM	Bulgaria	EurOther	Europe
GER	CzechRepublic	EurOther	Europe
GER	Denmark	EurOther	Europe

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POL	Finland	EurOther	Europe
FRA	France	EurSouthWest	Europe
GER	Germany	EurOther	Europe
ROM	Greece	EurOther	Europe
ROM	Hungary	EurOther	Europe
UKD	Ireland	UK Eire	Europe
ITA	Italy	EurSouthWest	Europe
NED	Netherlands	NoNL	Europe
NOR	Norway	NoNL	Europe
POL	Poland	EurOther	Europe
SPA	Portugal	EurSouthWest	Europe
ROM	Romania	EurOther	Europe
POL	SlovakRepublic	EurOther	Europe
ITA	Slovenia	EurOther	Europe
SPA	Spain	EurSouthWest	Europe
POL	Sweden	EurOther	Europe
GER	Switzerland	EurOther	Europe
TRK	Turkey	Turkey	Europe
UKD	UnitedKingdom	UK Eire	Europe
QAT	Iran	MidEastGECF	MiddleEast
YMN	Kuwait	MidEastOther	MiddleEast
YMN	Oman	MidEastOther	MiddleEast
QAT	Qatar	MidEastGECF	MiddleEast
YMN	SaudiArabia	MidEastOther	MiddleEast
YMN	UAE	MidEastOther	MiddleEast
YMN	Yemen	MidEastOther	MiddleEast
CAE	Canada-East	CAN	NorthAmerica
CAW	Canada-West	CAN	NorthAmerica
MEX	Mexico	USAMex	NorthAmerica

ULS	USA Alaska	USAMex	NorthAmerica
ULN	USA Alaska NorthSlope	USAMex	NorthAmerica
US3	USA East North Central	USAMex	NorthAmerica
US6	USA East South Central	USAMex	NorthAmerica
US2	USA Middle Atlantic	USAMex	NorthAmerica
US8	USA Mountain	USAMex	NorthAmerica
US1	USA New England	USAMex	NorthAmerica
US9	USA Pacific	USAMex	NorthAmerica
US5	USA South Atlantic	USAMex	NorthAmerica
US4	USA West North Central	USAMex	NorthAmerica
US7	USA West South Central	USAMex	NorthAmerica
RUE	Russia-East	RusEast	Russia
RUL	Russia-Sakhalin	RusEast	Russia
RUW	Russia-Volga-Uralsk	RusWest	Russia
RUW	Russia-West	RusWest	Russia
BRA	Argentina	LatinEast	SouthAmerica
TRI	Bolivia	LatinGECF	SouthAmerica
BRA	Brazil	LatinEast	SouthAmerica
CHL	Chile	LatinWest	SouthAmerica
CHL	Ecuador	LatinWest	SouthAmerica
CHL	Peru	LatinWest	SouthAmerica
TRI	Trinidad & Tobago	LatinNonGECF	SouthAmerica
TRI	Venezuela	LatinGECF	SouthAmerica

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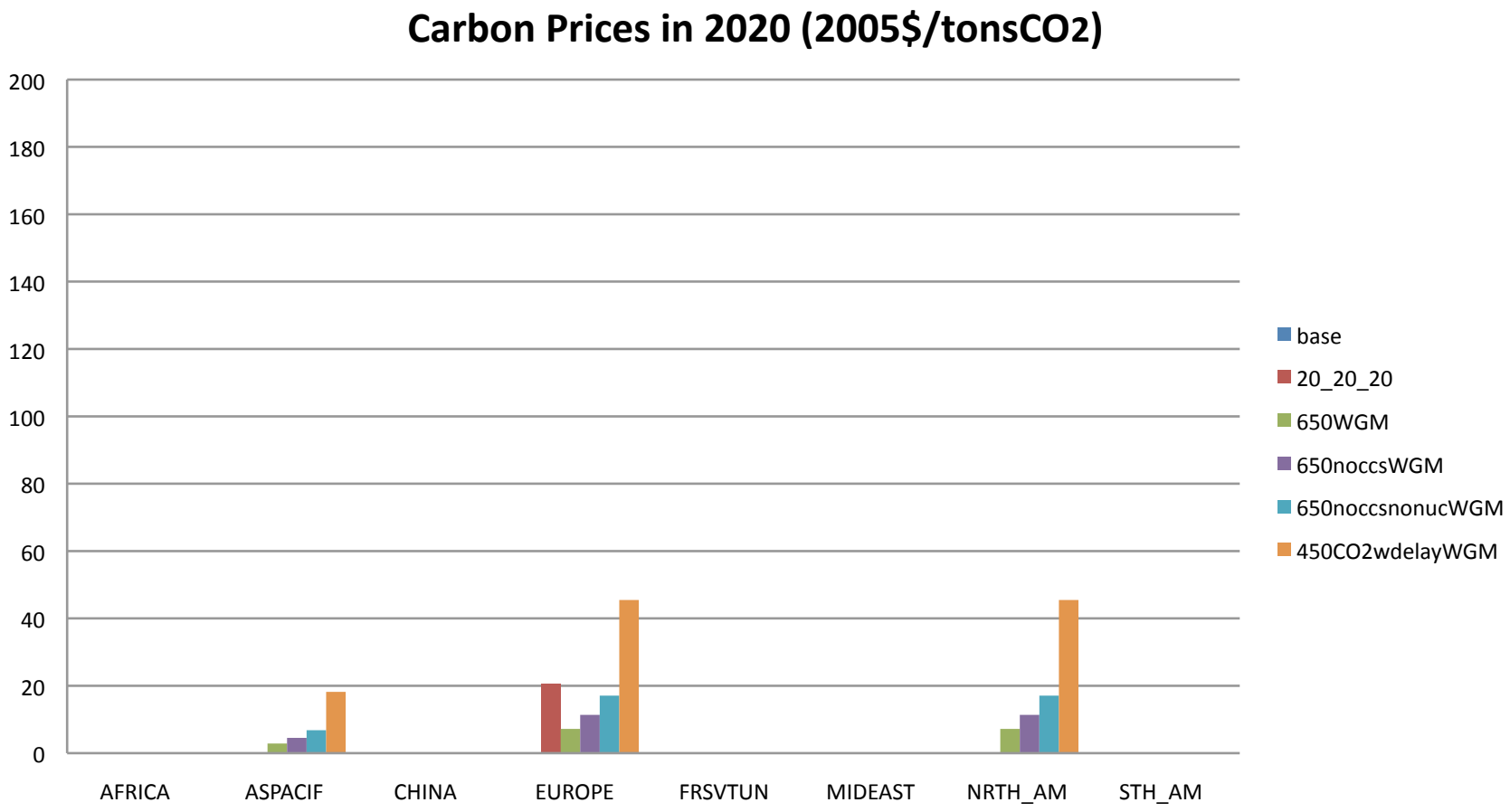
CO2 pricing scenarios used in the study



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