



Evolution of Coal

-From a viewpoint of Evolutionary Biology

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Evolution of Coal

- Evolution in Biology, Evolution in Energy Sector
- Games for New Evolutionary Stable Strategies (ESSs) in Energy Sector
- Evolution of Coal ; Past
- Evolution of Coal ; New Games



Evolution in Biology, Evolution in Energy Sector

- Evolution in Biology
 - Evolutionary stable strategies (ESS)
 - Mutation, Change of environment
 - Transitional process for new ESSs
- Evolution in Energy Sector
 - ESS of energies
 - Climate change, Shale revolution, Fukushima crisis, Electricity liberalization
 - Transitional process for new ESSs



Games for New ESSs in energy sector

- ESS's after Oil Crisis and current games for new ESSs
- Nuclear power
 - "Main-character" of oil-substitute energy after Oil Crisis
 - "Fukushima crisis"
 - Electricity liberalization
- Liquefied Natural Gas (LNG)
 - Led by Japan for development of imported energy
 - Gaining more applicability in the world
 - Modification of ESS for further development
- Renewables (VREs)
 - Started as ESS of "niche" in the energy system
 - New ESS required under quantitative expansion led by FIT
 - New ESSs in electricity sector for system integration of VREs



Evolution of Coal ; Past (1 of 2)

- Coal's ESS after Oil Crisis
 - Seaborne transport, Export-oriented coal mines, Imported coal fired power plants
 - Clean coal technologies
 - "Sub-character"
- Inherent DNA of Coal's ESS
 - Distributed reserves across national borders
 - Smaller investment cost and shorter lead time for supply chain capacity development
 - Competitor in the fuel market, Default fuel



Evolution of Coal ; Past (2 of 2)

- Acquired DNA of Coal's ESS
 - Development of CCT: FGD, SCR, USC, etc.
 - Deregulations for international coal market
 - Japan; abolition of import quota, support for domestic coal mine closure, etc.
 - Australia; deregulation of coal export, foreign capital introduction, etc.
 - Development of international coal supply and purchase contract
 - "market indices", "destination free", etc.



Evolution of Coal ; New Games

- DNAs to be acquired
 - De-carbonization; IGCC, CCUS, etc.
 - Flexibility for VRE support and “Teamwork” for system integration
- DNAs to be maintained:
 - Competitor / Counter in electricity sector
 - Secured substitute players for market arbitrage
- Strategies to be Evolutionary Stable
 - Holistic strategy for climate change, access to affordable energy, geo-political risks, etc.
 - Non-existence of universal optimum strategy