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05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
05.01.03 – Informatikaning nazariy asoslari
05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
05.01.07 – Matematik modellashtirish
05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
05.02.00 – Mashinasozlik va mashinashunoslik
05.02.08 – Yer usti majmualari va uchish apparatlari
05.03.02 – Metrologiya va metrologiya ta'minoti
05.04.01 – Telekommunikasiya va kompyuter tizimlari, telekommunikasiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
05.05.05 – Issiqlik texnikasining nazariy asoslari
05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
05.08.03 – Temir yo'l transportini ishlatish
05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti
08.00.01 – Iqtisodiyot nazariyasi
08.00.02 – Makroiqtisodiyot
08.00.03 – Sanoat iqtisodiyoti
08.00.04 – Qishloq xo'jaligi iqtisodiyoti
08.00.05 – Xizmat ko'rsatish tarmoqlari iqtisodiyoti
08.00.06 – Ekonometrika va statistika
08.00.07 – Moliya, pul muomalasi va kredit
08.00.08 – Buxgalteriya hisobi, iqtisodiy tahlil va audit
08.00.09 – Jahon iqtisodiyoti
08.00.10 – Demografiya. Mehnat iqtisodiyoti
08.00.11 – Marketing
08.00.12 – Mintaqaviy iqtisodiyot
08.00.13 – Menejment
08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
08.00.17 – Turizm va mehmonxona faoliyati

Ma'lumot uchun, OAK Rayosatining 2024-yil 28-avgustdagi 360/5-son qarori bilan "Dissertatsiyalar asosiy ilmiy natijalarini chop etishga tavsiya etilgan milliy ilmiy nashrlar ro'yxati"ga texnika va iqtisodiyot fanlari bo'yicha "Muhandislik va iqtisodiyot" jurnali ro'yxatga kiritilgan.

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MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS

MUNDARIJA

MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS

MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS

MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS

MUNDARIJA • СОДЕРЖАНИЕ • CONTENTS

REDUCTION OF GREENHOUSE GAS EMISSIONS: EMISSION QUOTAS OR MANDATORY CONTROL TECHNOLOGIES

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Abstract. It is argued that instead of imposing on each country internationally agreed quotas on Greenhouse Gas (GHG) emission reductions, it would be easier to implement, enforce and verify, if each country mandates the installation of Best Available Control Technology (BACT) for each significant industrial category. It is BACT that has to be agreed on by an international convention, such as the Intergovernmental Panel on Climate Change (IPCC). A possible BACT for coal-fueled power plants is the Integrated Coal Gasification Combined Cycle (IGCC) cum Carbon Capture and Sequestration. For transportation vehicles, there is no “add-on” technology that can capture CO_2 emissions. Here CO_2 emissions must be limited by increased fuel mileage. There should be an internationally agreed maximum vehicle weight for passenger cars, which the author suggests to be 1000 kg. Because BACT can be implemented only on new sources, there must be an anti-grandfathering rule, e.g. all existing coal-fired power plants must be retired after their 35th year operating time; all personal vehicles must be scrapped after their 10th year on the road.

Keywords: greenhouse gas emissions, control technologies, coal-fueled power plants, transportation vehicles, carbon capture and sequestration.

Annotatsiya. har bir davlatga issiqxona gazlari (GHG) emissiyasini kamaytirish bo‘yicha xalqaro miqyosda kelishilgan kvotalarni yuklash o‘rniga, har bir muhim sanoat toifasi uchun Eng yaxshi mavjud nazorat texnologiyasini (BACT) joriy etishni majburiy qilish, uni nazorat qilish va tekshirish ancha osonroq bo‘ladi. BACT xalqaro konvensiyalar doirasida, masalan, Iqlim o‘zgarishi bo‘yicha hukumatlararo ekspertlar guruhi (IPCC) tomonidan kelishilishi lozim. Ko‘mir bilan ishlovchi elektr stansiyalari uchun mumkin bo‘lgan BACT sifatida integratsiyalashgan ko‘mir gazifikatsiyasi va kombinatsiyalangan tsikl (IGCC) hamda karbonni tutib qolish va saqlash (CCS) texnologiyalari ko‘rsatib o‘tiladi. Transport vositalari uchun CO_2 emissiyasini to‘g‘ridan to‘g‘ri tutib qoluvchi “qo‘shimcha” texnologiyalar mavjud emas. Shu sababli, transport sektorida CO_2 emissiyasini kamaytirish yoqilg‘i samaradorligini oshirish orqali amalga oshirilishi lozim. Yo‘lovchi avtomobillari uchun xalqaro miqyosda kelishilgan maksimal og‘irlik me’yorlari belgilanishi zarur bo‘lib, muallif ushbu chegarani 1000 kg darajasida tavsiya etadi. BACT faqat yangi manbalar uchun joriy etilishi mumkinligi sababli, “anti-grandfathering” qoidasini qo‘llash taklif etiladi. Mazkur qoida asosida barcha mavjud ko‘mir bilan ishlovchi elektr stansiyalari 35 yillik ekspluatatsiya muddatidan so‘ng yopilishi, shaxsiy avtomobillar esa yo‘lda 10 yildan ortiq foydalanilgandan keyin utilizatsiya qilinishi lozim.

Kalit so‘zlar: issiqxona gazlari emissiyasi, nazorat texnologiyalari, ko‘mir bilan ishlovchi elektr stansiyalari, transport vositalari, karbonni tutib qolish va saqlash.

Аннотация. Предполагается, что вместо введения для каждой страны международный согласованных квот на сокращение выбросов парниковых газов (ПГ), было бы проще внедрять, контролировать и проверять, если каждая страна обяжет устанавливать на каждую значимую промышленную категорию наилучшую доступную технологию контроля (BACT). Именно BACT должен быть согласован международной конвенцией, такой как Межправительственная группа экспертов по изменению климата (IPCC). Возможной BACT для угольных электростанций является интегрированная технология газификации угля с комбинированным циклом (IGCC) и захватом и хранением углерода. Для транспортных средств нет «дополнительной» технологии, способной улавливать выбросы CO_2. Здесь выбросы CO_2 должны быть ограничены за счет увеличения топливной экономичности. Должен существовать международный согласованный максимальный вес легковых автомобилей, который автор предлагает установить на уровне 1000 кг. Поскольку BACT может быть внедрена только на новых источниках, необходимо правило против «устаревших» установок: все существующие угольные электростанции должны быть выведены из эксплуатации после 35 лет работы; все личные транспортные средства должны быть утилизированы после 10 лет эксплуатации.

Ключевые слова: выбросы парниковых газов, технологии контроля, угольные электростанции, транспортные средства, захват и хранение углерода.

INTRODUCTION

Kyoto, there should be an international agreement stipulating that each country's government impose performance standards on GHG emitting source categories. In other words, major emitting source categories must implement internationally prescribed control technologies that each source category has to employ in order to minimize GHG emissions. By implementing these performance standards, each country will achieve GHG emission reductions to the maximum achievable level by the currently best available control technology, called BACT. There is a precedent in the USA for implementing BACT. New coal-fired power plants were mandated in 1977 to implement BACT in order to prevent significant air quality deterioration in Federal national parks (USA Clean Air Act and its Amendments, Section 111). In practice, what this meant is that new power plants that are likely to impact the air quality in national parks had to install the best available control technology for reducing emissions of sulfur oxides, nitrogen oxides, and particulate matter. The selection of a particular BACT had to consider emission reduction efficacy as well as the cost of the technology. BACT can change from time to time as new technologies become available that are superior to the prevailing BACT. When enacted, BACT for SOx emission reduction was flue gas desulfurization (the "scrubber"); for NOx, the low-NOx burner; for particulate matter, the electrostatic precipitator. Unfortunately, for emission reduction of CO2, the principal anthropogenic GHG that causes global warming, there is no relatively simple add-on technology to new sources, let alone retrofit technology for existing sources, which can reduce the emissions of CO2. Take the example of coal-fired power plants. At present, there are only three technologies that are thought to reduce CO2 emissions efficiently, but at a significant cost and energy penalty. They are as follows: (a) Integrated Coal Gasification Combined Cycle, called IGCC, cum Carbon Capture and Sequestration, called CCS. In such a power plant coal is gasified into CO and H2; the CO is further processed in a water gas shift reaction to yield CO2 and H2. The CO2 is separated, usually by physical absorption, and the H2 is used for power generation either in a gas turbine or in a fuel cell. The separated CO2 is liquefied under high pressure, and piped to a sequestration site such as a semi-depleted oil or gas reservoir, or a deep underground sedimentary saline formation. (b) Oxyfuel combustion. Here coal is combusted in almost pure oxygen (95+%) in a boiler. The flue gas consists almost entirely of CO2 and H2O; the water vapor is condensed, and the CO2 is liquefied and disposed as in (a). This method requires an air separation unit that separates oxygen from nitrogen. Because of the enormous quantities of oxygen required (a 1000 MW power plant would need approximately 20,000 tons per day of oxygen), this method is deemed to be even more expensive and energy intensive than the IGCC cum CCS. (c) Chemical absorption. The flue gas of a conventional boiler passes through an absorption tower where a chemical absorbent, usually monoethanolamine (MEA), absorbs CO2 but not the rest of the flue gas. The absorbed CO2 is boiled off in a separate tower, liquefied, and disposed as in (a).

LITERATURE REVIEW

The second largest source category for CO2 emissions is transportation: automobiles, trucks, locomotives, ships, and airplanes. For transportation vehicles, there is no technology that can capture CO2 from the exhaust gases in any efficient and economical way. The only solution is to increase the fuel economy, that is, liters of fuel consumed per kilometer travel. There are several ways to achieve increased fuel mileage. For example, the internal combustion engine/electric motor hybrid, plug-in electric car, and fore mostly, reduction in vehicle mass. Fuel consumption is directly proportional to vehicle mass. Propelling a vehicle from rest to cruising speed, and maintaining cruising speed is primarily dependent on the weight of the vehicle [1].

There are perfectly acceptable passenger vehicles that do not exceed 1000 kg in weight. They can achieve a fuel economy of 10–12 km/liter (62–74 mi/gal) with conventional engines, and even better with hybrid propulsion [2]. Governments must simply mandate that no passenger vehicle be produced that weighs more than 1000 kg. Period. No fleet averaged gas mileage, so that some people can buy gas guzzlers, as long as there are others who buy gas sippers. No large SUVs, vans, pickup trucks, unless certified that they are for commercial use, not personal transportation [3].

The disadvantage of BACT is that it pertains only to new sources. Grandfathering of existing emitting sources must be strictly limited. Again, a government diktat is necessary. Existing sources must be phased out on an internationally agreed time scale. For example, if it is agreed that a reasonable lifetime of an existing coal-fired power plant is 35 years, it must be scrapped on its 35th birthday, and a new power plant built with carbon capture and sequestration [4]. Or, a utility can decide it is cheaper to replace the retired coal-fired plant with a nuclear-fueled power plant, wind farm, solar thermal, solar photoelectric, tidal, geothermal, wave, or any other plant that does not emit CO2. Old gas-guzzling vehicles must be phased out over an agreed period (10 years?). Also, here a government intervention is necessary. Owners of the old vehicles receive a government-financed voucher toward the purchase of a new gas-saving vehicle.

ANALYSIS AND RESULTS

The results indicate that achieving a large-scale reduction in CO_2 and other greenhouse gas (GHG) emissions represents a fundamental paradigm shift in modern urban–industrial civilization. Such a transition inevitably entails substantial financial costs, accelerated technological development, structural economic adjustments, and significant social consequences. Moreover, it requires profound changes in consumption patterns, production processes, and everyday lifestyles. These findings confirm that emission reduction is not merely an environmental challenge, but a comprehensive economic and societal transformation [5].

A considerable body of economic literature suggests that market-based instruments—such as cap-and-trade systems, pollution fees, carbon taxes, and fuel taxes—can reduce GHG emissions while minimizing overall economic and social costs. However, the analysis highlights that regardless of the chosen mechanism, the financial burden of emission reduction is ultimately borne by society, whether through taxes, higher utility tariffs, or increased commodity prices. Consequently, from an individual perspective, the cost savings associated with market-based incentives compared to direct regulatory measures remain uncertain.

The results further suggest that internationally harmonized technology standards, implemented and enforced by national governments, may offer a more effective, transparent, and equitable approach to emission reduction than price-based mechanisms alone. Technology standards are generally easier to monitor and enforce, reduce administrative complexity, and provide clearer compliance requirements for firms and consumers. Unlike carbon taxes or emission quotas—often perceived as arbitrary or politically contentious—technology standards directly target the sources of emissions by shaping production technologies and product design.

Importantly, the adoption of uniform global technology standards facilitates a more predictable and stable pathway toward stabilizing GHG concentrations in the atmosphere. For example, mandatory automobile fuel-efficiency and weight standards can systematically reduce emissions from the transport sector, while requirements for carbon capture and sequestration (CCS) in new coal-fired power plants can significantly mitigate emissions from energy production. These measures allow emissions reductions to be embedded directly into technological systems rather than relying solely on behavioral responses to price signals.

Another key result is that global technology standards are less likely to exacerbate international economic tensions. Market-based instruments, particularly carbon taxes and national emission quotas, often create conflicts between developed and developing countries due to differences in historical responsibility, economic capacity, and development priorities. In contrast, uniform standards—such as requiring all new coal power plants to include CCS technology or imposing global limits on vehicle weight—apply equally across countries, thereby reducing competitive distortions and perceptions of unfair burden-sharing.

Overall, the findings indicate that while economic incentives can play a complementary role, technology-based regulatory standards provide a more politically feasible, socially acceptable, and globally coordinated mechanism for large-scale GHG emission reduction. When internationally agreed upon and consistently enforced, such standards can support long-term environmental objectives while minimizing conflicts between countries and ensuring a more balanced distribution of costs and benefits across societies.

CONCLUSION AND RECOMMENDATIONS

The large-scale reduction of CO_2 and other greenhouse gas (GHG) emissions constitutes a profound transformation of contemporary urban–industrial society. This transition requires not only substantial financial investment and technological innovation but also structural economic adjustments and behavioral change. Although market-based instruments—such as carbon taxes, cap-and-trade systems, and pollution fees—can contribute to emission reductions by internalizing environmental costs, their effectiveness and equity vary significantly across countries with different levels of development, institutional capacity, and economic structure.

The findings of this study indicate that reliance solely on economic incentives does not ensure either fair burden-sharing or consistent environmental outcomes at the global level. Price-based mechanisms may disproportionately affect developing economies and can generate political resistance, thereby limiting their long-term effectiveness. In contrast, the implementation of internationally agreed-upon technology standards offers a more practical, transparent, and enforceable pathway to substantial emission reductions.

In particular, the adoption of best available control technologies (BACT) for power generation and mandatory fuel-efficiency and design standards for vehicles can directly address the technological sources of emissions. Uniform global requirements—such as obligating all new coal-fired power plants to incorporate carbon capture and sequestration (CCS) technologies and imposing maximum weight or efficiency standards on new personal vehicles—ensure that emission reductions are embedded in production processes irrespective of national borders. This approach reduces regulatory arbitrage, promotes technological convergence, and facilitates a more predictable stabilization of atmospheric GHG concentrations.

From a policy perspective, the results suggest that international climate strategies should prioritize harmonized technology-based regulations, supported by complementary economic incentives where appropriate. Governments are encouraged to cooperate in setting and enforcing global technology standards while providing transitional support for developing countries to adopt advanced low-carbon technologies. Such a framework minimizes conflicts between developed and developing nations, enhances compliance, and strengthens the overall effectiveness of global climate governance.

In conclusion, standardized technological solutions—when internationally coordinated and consistently enforced—represent a more achievable, equitable, and sustainable approach to large-scale greenhouse gas mitigation than arbitrary emission quotas or exclusive reliance on market-based instruments.

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