



Sjálfbær Þróun

Orkukerfi

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Yfirlit

1. Sjálfbær þróun (SD)

- Markmið
- Vísar (indicators) – Commission for SD

2. Sjálfbær orkuþróun (SED)

- Markmið
- Vísar (indicators)
 - IEA/IAEA
 - GSAP

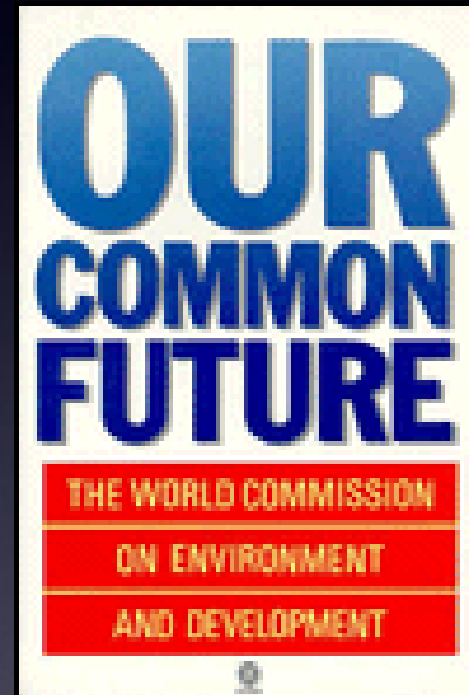
Sjálfbær þróun

“ Þróun er sjálfbær þegar þörfum samtíðarinnar er mætt án þess að skerða möguleika komandi kynslóða til að uppfylla sínar eigin þarfir.”

Brundtland Nefndin

“Our common future” 1987

Tekur til þróunar; leiðir til aukinnar velferðar (wellbeing)



Þrjár víddir sjálfbærrar þróunar

Áskorun: Að ná jafnvægi á milli hagrænnar þróunar og félagslegra og umhverfislegra markmiða.

Æskilegt að ná markmiðum í öllum víddum samtímis



En hvert er markmið sjálfbærrar
þróunnar?

Yfirmarkmið

Að stuðla að aukinni velferð/velsæld
(human well-being) til framtíðar

Undirmarkmið – eða skilyrði tengd
víddunum þremur

Sjálfbær þróun verkfæri til að tryggja
velferð til framtíðar

Hagræna víddin: markmið

Að viðhalda framleiðslu vara og þjónustu
(viðhaldið þjóðarframleiðslu) á hagkvæman
hátt

Að viðhalda atvinnustigi

Að viðhalda viðráðanlegri stærð ríkisvaldsins og
staðið undir skuldum ríksins.

Varast einsleitni (avoid sectoral imbalances).

Viðhalda manngerðum auð (man-made capital)

Umhverfis víddin: markmið

Ekki losa meiri mengun eða úrgang út í umhverfið en náttúran getur ráðið við.

Ekki nýta meira frá endurnýjanlegum auðlindum en þær geta viðhaldið.

Aðeins nota óendurnýjanlegar auðlindir að því marki að fjárfest sé í endurnýjanlegum auðlindum á sama tíma.

Viðhalda náttúruauð (natural capital) og ekki ganga á þjónustu náttúrunnar.

Félagslega víddin: markmið

Jöfnuður

Jafnrétti

Fullnægjandi aðgengi að félagslegri þjónustu
svo sem heilbrigðisþjónustu og menntun.

Lýðræði

Þátttaka almennings

Viðhalda mannauð og félagsauð (human and
social capital)

CSD vísar fyrir SP (2002)

Notaðir til að meta hvort
við erum að fylgja SP
eða ekki

Margvíðir vísar (auðvitað
til einvíðir svo sem
EF, og GPI)

58 vísar valdir

3 víddir

Themu og undirthemu



Vísar CSD

CSD framework

Dimension	Theme	Sub-Theme	Indicators
Social			
Environmental			
Economic			
Institutional			

CSD nýtt safn vísa 2007

50 vísar sem eiga við alla –
öll lönd; styður margvíða
eiginleika hugtaksins. Ss.
ekki nóg að auka
hagvöxt.

46 vísar sem eru valkvæðir

Themu og subthemu

Tengsl milli vísa skilgreind



2007 framework

Theme	Sub-theme	Core indicator	Other indicator
Poverty (continued)	Access to energy	Share of households without electricity or other modern energy services	Percentage of population using solid fuels for cooking
	Living conditions	Proportion of urban population living in slums	
Governance	Corruption	Percentage of population having paid bribes	
	Crime	Number of intentional homicides per 100,000 population	
Health	Mortality	Under-five mortality rate	
		Life expectancy at birth	Healthy life expectancy at birth
	Health care delivery	Percent of population with access to primary health care facilities	Contraceptive prevalence rate
		Immunization against infectious childhood diseases	
	Nutritional status	Nutritional status of children	
	Health status and risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Prevalence of tobacco use
		Suicide rate	
Education	Education level	Gross intake ratio to last grade of primary education	Life long learning
		Net enrolment rate in primary education	
		Adult secondary (tertiary) schooling attainment level	
	Literacy	Adult literacy rate	
Demographics	Population	Population growth rate	Total fertility rate
		Dependency ratio	
	Tourism		Ratio of local residents to tourists in major tourist regions and destinations

Theme	Sub-theme	Core indicator	Other indicator
Natural hazards	Vulnerability to natural hazards	Percentage of population living in hazard prone areas	
	Disaster preparedness and response		Human and economic loss due to natural disasters
Atmosphere	Climate change	Carbon dioxide emissions	Emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone depleting substances	
	Air quality	Ambient concentration of air pollutants in urban areas	
Land	Land use and status		Land use change
			Land degradation
	Desertification		Land affected by desertification
	Agriculture	Arable and permanent cropland area	Fertilizer use efficiency
			Use of agricultural pesticides
			Area under organic farming
Oceans, seas and coasts	Forests	Proportion of land area covered by forests	Percent of forest trees damaged by defoliation
			Area of forest under sustainable forest management
	Coastal zone	Percentage of total population living in coastal areas	Bathing water quality
	Fisheries	Proportion of fish stocks within safe biological limits	
	Marine environment	Proportion of marine area protected	Marine trophic index
			Area of coral reef ecosystems and percentage live cover

2007 framework

Theme	Sub-theme	Core indicator	Other indicator
Freshwater	Water quantity	Proportion of total water resources used	
		Water use intensity by economic activity	
	Water quality	Presence of faecal coliforms in freshwater	Biochemical oxygen demand in water bodies
			Wastewater treatment
Biodiversity	Ecosystem	Proportion of terrestrial area protected, total and by ecological region	Management effectiveness of protected areas
			Area of selected key ecosystems
			Fragmentation of habitats
	Species	Change in threat status of species	Abundance of selected key species
Economic development	Macroeconomic performance		Abundance of invasive alien species
		Gross domestic product (GDP) per capita	Gross saving
		Investment share in GDP	Adjusted net savings as percentage of gross national income (GNI)
	Sustainable public finance		Inflation rate
		Debt to GNI ratio	
	Employment	Employment-population ratio	Vulnerable employment
		Labor productivity and unit labor costs	
		Share of women in wage employment in the non-agricultural sector	
	Information and communication technologies	Internet users per 100 population	Fixed telephone lines per 100 population
			Mobile cellular telephone subscribers per 100 population

Theme	Sub-theme	Core indicator	Other indicator
Economic development (continued)	Research and development		Gross domestic expenditure on R&D as a percent of GDP
	Tourism	Tourism contribution to GDP	
Global economic partnership	Trade	Current account deficit as percentage of GDP	Share of imports from developing countries and from LDCs
			Average tariff barriers imposed on exports from developing countries and LDCs
	External financing	Net Official Development Assistance (ODA) given or received as a percentage of GNI	Foreign direct investment (FDI) net inflows and net outflows as percentage of GDP
			Remittances as percentage of GNI
Consumption and production patterns	Material consumption	Material intensity of the economy	Domestic material consumption
	Energy use	Annual energy consumption, total and by main user category	Share of renewable energy sources in total energy use
		Intensity of energy use, total and by economic activity	
	Waste generation and management	Generation of hazardous waste	Generation of waste
		Waste treatment and disposal	Management of radioactive waste
	Transportation	Modal split of passenger transportation	Modal split of freight transport
			Energy intensity of transport

Margvítt hugtak

Áskorun: Að ná jafnvægi á milli hagrænnar þróunar og félagslegra og umhverfislegra markmiða.

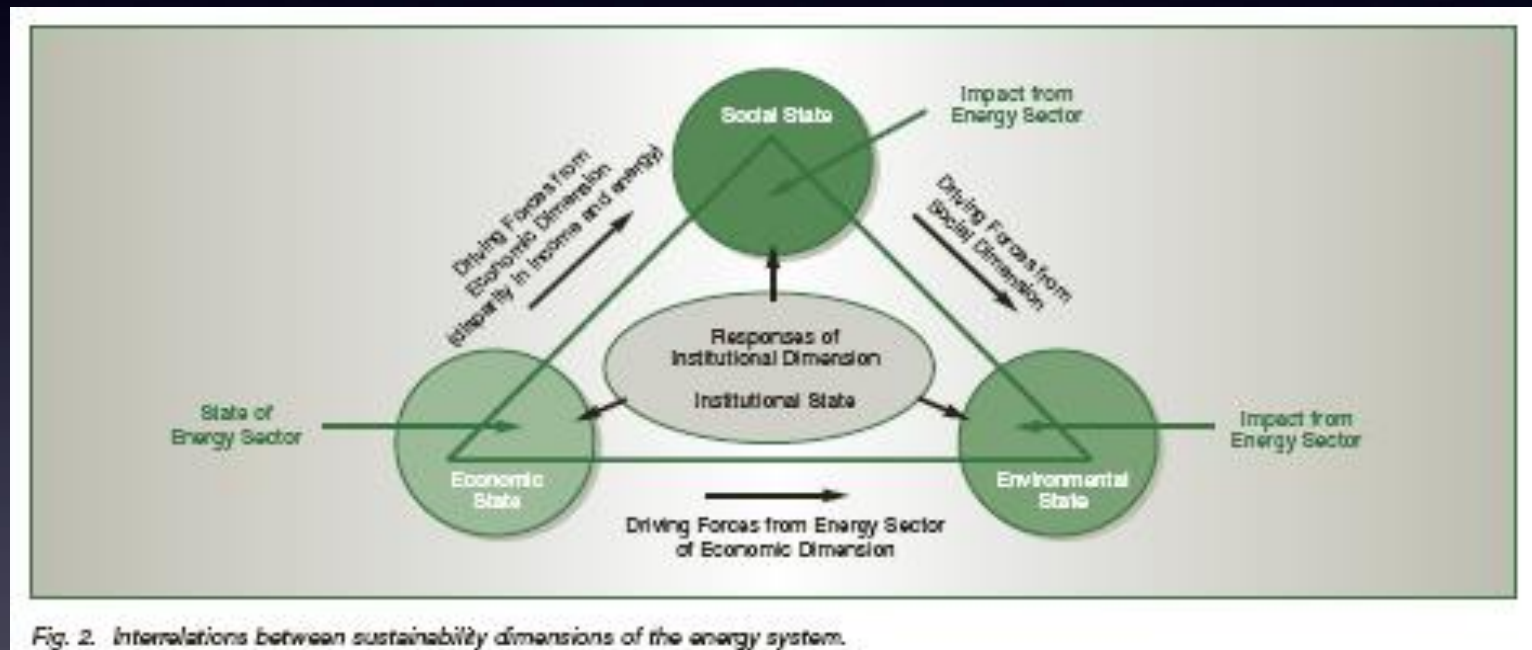
Æskilegt að ná markmiðum í öllum víddum samtímis

Hægt að nota vísa í multi-criteria analysis

NB: margir aðrir vísar til – einvíðir (EF), Vísitölur margskonar (GPI, EPI).

Orka og sjálfbær þróun

Energy is central to all three dimensions of SD



Orka og sjálfbær þróun (SÞ)

Orka skiptir gríðarlegu máli í öllum víddum SÞ

Drífur hagvöxt

Energy “causing” GDP (growth of nations) and vice versa

Forsenda lífsgæða

Lífskjaravísitalan (HDI) nátengd aðgengi að hágæðaorku.

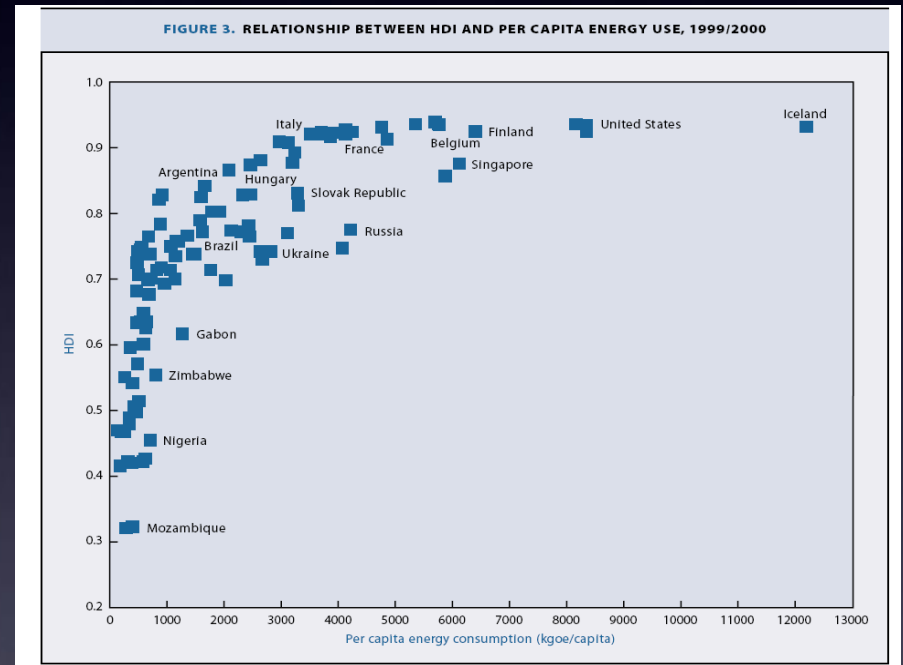
Leiðir til umhverfisáhrifa

Loftslagsbreytingar, súrt regn, vatnsmengun, loftmengun

=> Skiptir máli í öllum víddum SÞ

Orkunotkun og þróunarvísitalan (HDI)

- Langlífi (eða life expectancy)
- Þekking (a. læsi fullorðinna, b. Meðalára fjöldi í skóla)
- Standard of living
- <http://hdr.undp.org>



Sjálfbær orkuþróun (SED)

Þar sem orka hefur áhrif á allar víddir SP, þá hefur þróun orkukerfa eftir lögmálum sjálfbærrar þróunnar forgang ef takast á að færa heiminn í átt að sjálfbærni. (Malkina-Pykh et al. 2002)

Sustainable Energy Development

Defined as “the provision of adequate energy services at affordable cost in a secure and environmentally benign manner, in conformity with social and economic development needs”
(IAEA/IEA 2001)

Sustainable Energy Development

“improving access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services and resources, taking into account national specificities and circumstances through various means such as enhanced rural electrification and decentralized energy systems, increased use of renewable energy, cleaner liquid and gaseous fuels and enhanced energy efficiency.” (Johannesburg declaration 2002)

Einkenni orkukerfa sem stuðla að

SÞ

Endurnýjanleg eða
varanlegar orkulindir

Framleidd og notuð á
skilvirkan hátt

Hagkvæm og hefur
jákvæð hagræn áhrif

Tryggja orkuöryggi
(secure and resilient)

Jafnræði í
aðgengi(accessible,
available and
affordable)

Jákvæð félagsleg áhrif
og félagsleg sátt

Lágmörkun
umhverfisáhrifa

Energy indicators for SD

(IAEA, IEA 2001 og 2005)

Social				
Theme	Sub-theme	Energy Indicator		Components
Equity	Accessibility	SOC1	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	- Households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy - Total number of households or population
	Affordability	SOC2	Share of household income spent on fuel and electricity	- Household income spent on fuel and electricity - Household income (total and poorest 20% of population)
	Disparities	SOC3	Household energy use for each income group and corresponding fuel mix	- Energy use per household for each income group (quintiles) - Household income for each income group (quintiles) - Corresponding fuel mix for each income group (quintiles)
Health	Safety	SOC4	Accident fatalities per energy produced by fuel chain	- Annual fatalities by fuel chain - Annual energy produced

Economic

Theme	Sub-theme	Energy Indicator		Components
Use and Production Patterns	Overall Use	ECO1	Energy use per capita	- Energy use (total primary energy supply, total final consumption and electricity use) - Total population
	Overall Productivity	ECO2	Energy use per unit of GDP	- Energy use (total primary energy supply, total final consumption and electricity use) - GDP
	Supply Efficiency	ECO3	Efficiency of energy conversion and distribution	Losses in transformation systems including losses in electricity generation, transmission and distribution
	Production	ECO4	Reserves-to-production ratio	- Proven recoverable reserves - Total energy production
		ECO5	Resources-to-production ratio	- Total estimated resources - Total energy production
	End Use	ECO6	Industrial energy intensities	- Energy use in industrial sector and by manufacturing branch - Corresponding value added
		ECO7	Agricultural energy intensities	- Energy use in agricultural sector - Corresponding value added
		ECO8	Service/commercial energy intensities	- Energy use in service/commercial sector - Corresponding value added
		ECO9	Household energy intensities	- Energy use in households and by key end use - Number of households, floor area, persons per household, appliance ownership
		ECO10	Transport energy intensities	- Energy use in passenger travel and freight sectors and by mode - Passenger-km travel and tonne-km freight and by mode

Economic

Theme	Sub-theme	Energy Indicator		Components
	Diversification (Fuel Mix)	ECO11	Fuel shares in energy and electricity	– Primary energy supply and final consumption, electricity generation and generating capacity by fuel type – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
		ECO12	Non-carbon energy share in energy and electricity	– Primary supply, electricity generation and generating capacity by non-carbon energy – Total primary energy supply, total electricity generation and total generating capacity
		ECO13	Renewable energy share in energy and electricity	– Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
	Prices	ECO14	End-use energy prices by fuel and by sector	– Energy prices (with and without tax/subsidy)
Security	Imports	ECO15	Net energy import dependency	– Energy imports – Total primary energy supply
	Strategic Fuel Stocks	ECO16	Stocks of critical fuels per corresponding fuel consumption	– Stocks of critical fuel (e.g. oil, gas, etc.) – Critical fuel consumption

Environmental

Theme	Sub-theme	Energy Indicator		Components
Atmosphere	Climate Change	ENV1	GHG emissions from energy production and use per capita and per unit of GDP	– GHG emissions from energy production and use – Population and GDP
	Air Quality	ENV2	Ambient concentrations of air pollutants in urban areas	– Concentrations of pollutants in air
		ENV3	Air pollutant emissions from energy systems	– Air pollutant emissions
Water	Water Quality	ENV4	Contaminant discharges in liquid effluents from energy systems including oil discharges	– Contaminant discharges in liquid effluents
Land	Soil Quality	ENV5	Soil area where acidification exceeds critical load	– Affected soil area – Critical load
	Forest	ENV6	Rate of deforestation attributed to energy use	– Forest area at two different times – Biomass utilization
	Solid Waste Generation and Management	ENV7	Ratio of solid waste generation to units of energy produced	– Amount of solid waste – Energy produced
		ENV8	Ratio of solid waste properly disposed of to total generated solid waste	– Amount of solid waste properly disposed of – Total amount of solid waste
		ENV9	Ratio of solid radioactive waste to units of energy produced	– Amount of radioactive waste (cumulative for a selected period of time) – Energy produced

Environmental

Theme	Sub-theme	Energy Indicator		Components
		ENV10	Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	– Amount of radioactive waste awaiting disposal – Total volume of radioactive waste

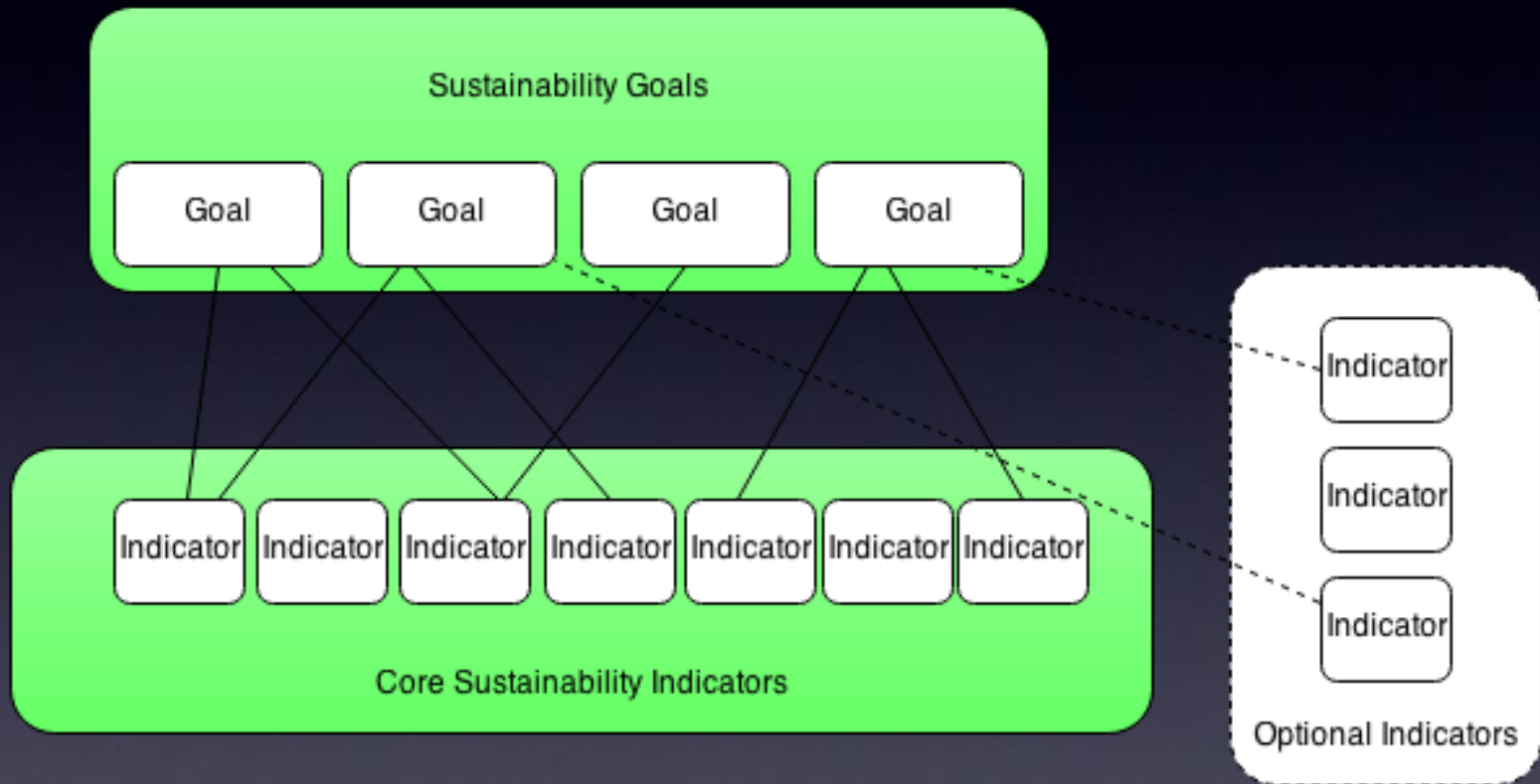
GSAP vísarnir

Meta hvort orkukostir tengdir
jarðvarmavirkjunum stuðla að sjálfbærri
þróun

Verið próaðir með þátttöku almennings á
Íslandi, Nýja Sjálandi, Kenya sem og
nemendum UNU skólans

Ruth Shortall doktorsnemi við HÍ

Strúktúr



GOAL 1 - Renewability
In order to ensure that a geothermal resource remains replenishable, sustainable production should be the goal in all geothermal projects.
GOAL 2 - Water Resource Usage
Water usage of a power plant must not reduce supply of cold fresh water to communities nearby.
GOAL 3- Environmental Management
A geothermal resource should be managed in such a way as to avoid, remedy or mitigate adverse environmental effects.
GOAL 4 – Efficiency
Geothermal utilization shall be managed in such a way as to maximize the utilization of exergy available where practical at sustainable production levels. The desired maximum efficiency for electricity generation should be based on the theoretical maximum efficiency for converting heat to electrical energy (Carnot efficiency).
GOAL 5 - Economic Management & Profitability
Energy use from geothermal power and heat plants must be competitive, cost effective and financially viable. The financial risk of the project shall be minimized. The project should carry positive net national and community economic benefits.
GOAL 6 - Energy Equity
The energy supplied by the geothermal resource is readily available, accessible and affordable to the public.
GOAL 7 - Energy Security & Reliability
The operation of geothermal power and heat plants shall be reliable and prioritize the security of supply.
GOAL 8 - Community Responsibility
The power companies should be responsible toward the community and the effect of the utilization of the geothermal resource shall be as positive for the community as possible and yield net positive social impact.
GOAL 9 - Research and Innovation
Power companies shall encourage research that improves the knowledge of the geothermal resource as well as technical developments that improve efficiency, increase profitability and reduce environmental effects.
GOAL 10 - Dissemination of Knowledge
Information and experience gained through geothermal utilization shall be accessible and transparent to the public and the academic community alike while respecting confidential intellectual property rights.

Dæmi

Félagslega víddin

Average Income Levels in Project-Affected Communities
(metric: Dollars per annum)

Percentage of community residents that must be relocated due
to energy project (metric %)

Income Equity in Project-Affected Communities (metric: gini
coefficient)

Life expectancy at birth in project-affected area (metric: year)

Social acceptance

Dæmi

Umhverfis víddin

Air quality in the surrounds of the geothermal power plant

Water Quality of water bodies impacted by geothermal power plant operations

Noise levels in working, recreation and residential areas in the surrounds of the geothermal power plant (metric: dB)

Impact on important or vulnerable geothermal features (metric: Value of predefined impact parameters)

Estimated productive lifetime of geothermal resource (metric: Years)

Dæmi

Hagræna viddin

Cost per MW of power produced compared to price per MW from other sources (metric: ratio) Project internal rate of return (IRR) (metric: rate)

Utilization efficiency for the geothermal power plant (metric: %)

Direct and indirect local job creation over lifetime of project (metric: Mo. full-time employees per year)

Economic diversity of project-impacted areas (metric: Adjusted Shannon-Wiener Index (%))

Duration of Plant Power Outages per year (metric: Use hours of unplanned interrupted service)

Lokaorð

Verulega mikilvægt að við tökum
skynsamlegar ákvarðanir þegar kemur
að vali orkukosta

Mikil fjöldi vísa til sem geta hjálpað við
slíkt mat

Verða að vera metnir í fjölvíðu mati, þar
sem áhrif á umhverfi, samfélag sem og
hagræn áhrif

Hver er staða Íslands?

- Fjallað var um umhverfislega sjálfbærni Íslands í greininni *Measuring countries' environmental sustainability performance – A review and case study of Iceland*, sem birt er í *Renewable and Sustainable Energy Reviews* (Olafsson, Cook, Davidsdottir, & Johannsdottir, 2014).
- Í greininni var mat lagt á umhverfislega sjálfbærni Íslands með því að styðjast við 4 umhverfisvísitölur (e. indices) sem hafa verið notaðar til að bera saman umhverfislega sjálfbærni landa.
- Vísitölurnar voru; Ecological footprint; Environmental performance index; Environmental vulnerability index og Happy planet index.
- Niðurstöðurnar leiddu í ljós:
 - afar misvísandi niðurstöður þegar kom að stöðu Íslands hvað varðar umhverfislega sjálfbærni.
 - að enginn þeirra vísa sem skoðaður var virtist ná nægilega vel utanum stöðu umhverfislegrar sjálfbærni á Íslandi.

Yfirlit yfir vísana sem metnir voru

- **Environmental vulnerability index**

- Metur hversu berskjaldað “vulnerable” umhverfi hvers lands er gagnvart ýmsum ógnum og er mælikvarðinn byggður á 50 umhverfisvísnum;
 - Líkur á óveðrum, líkur á eldgosum, stærð lands undir eða nálægt sjávarmáli, % lands sem er illa farið, fjöldi bifreiða etc.
- Metur mögulegar umhverfistengdar ógnir og áhrif á hagsæld
- Hugtakið “vulnerability” ekki næglega vel skilgreint, sem og hvaða tap á umhverfisgæðum sé óviðunandi.

- **Environmental performance index**

- Byggir á 25 umhverfistengdum vísnum sem meta bera saman stöðu umhverfismála milli landa innan 8 vídda
 - % fiskistofna ofveiddir, aðgengi að hreinu vatni, losun GHG per kwh
- Vísar metnir með tilliti til nálægðar við almenn viðmið “proximity to target”
- Tekur til margra þátta umhverfislegrar sjálfbærni, en niðurstaðan byggir algerlega á því hvort viðmið séu viðeigandi

Yfirlit yfir vísana sem metnir voru

- **Ecological footprint - vistsporið**

- Tölulegt mat á álagi vegna neyslu þjóðar á vistkerfi heimsins;
- Það er, hversu mikinn hluta af framleiðni jarðarinnar nýtum við til neyslu.
- Ágæt vísbending um álag vegna neyslu, en tekur ekki til alls álags á umhverfi t.d. vegna uppblásturs.

- **Happy planet index**

- Er byggt á hlutfalli á milli vistsporsins og velferðar, þar sem velferð er mæld á því hversu lengi fólk lifir og hversu fólk er ánægt með lífið.
- Hér er skoðað hvort stærra vistspor leiðir til þess að fólk sé ánægðara með lífið - og þá hversu mikið vistsporið má lækka án þess að skerða lífsánægju.

Niðurstöður vísa

Umhverfislegur veikleiki (e. Environmental vulnerability index)	Umhverfisleg frammistaða (e. Environmental performance index)	Vistfræðilegt fótspor (e. Ecological footprint)	Hamingjusöm jörð (e. Happy planet index)
112/234	12/132	1/154*	88/151
Veik staða	Góður árangur, lækkun frá 2010	Mjög sæm niðurstaða	Slök niðurstaða
*Sigurður Eyberg Jóhannesson (2010) Vistspor Íslands, meistaraprófsritgerð frá Verkfræði- og náttúruvísindasviði. Heimild: (Olafsson o.fl., 2014)			

- Þessi misvísandi niðurstaða sýndi hversu gríðarlega ólíkir vísarnir eru
- Taka sumir hverjir ekki á helstu umhverfisvandamálum Íslands