

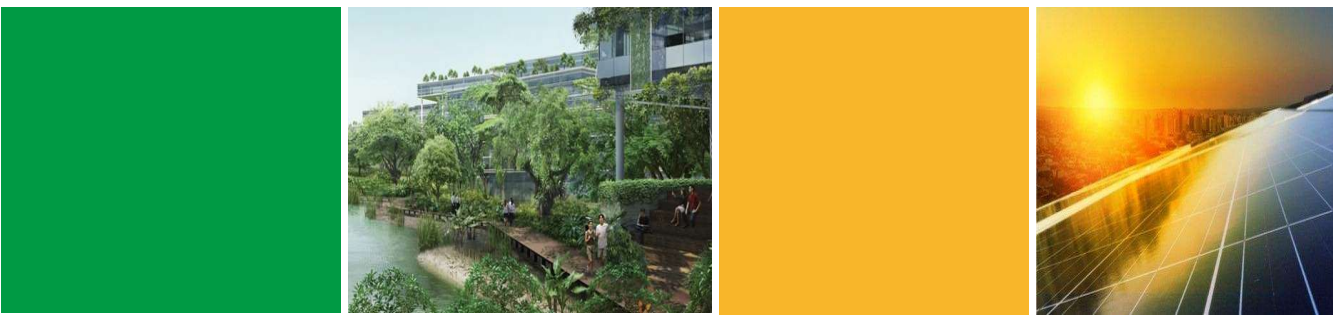


Outlining an Ex-Ante Evaluation Strategy of a Solar-Powered Transit-Oriented Development (TOD) Project in Indonesia

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Studies, Jakarta**



Energy Evaluation Asia Pacific Virtual Conference, 1 October 2026, 10:00 – 14:00, Bangkok

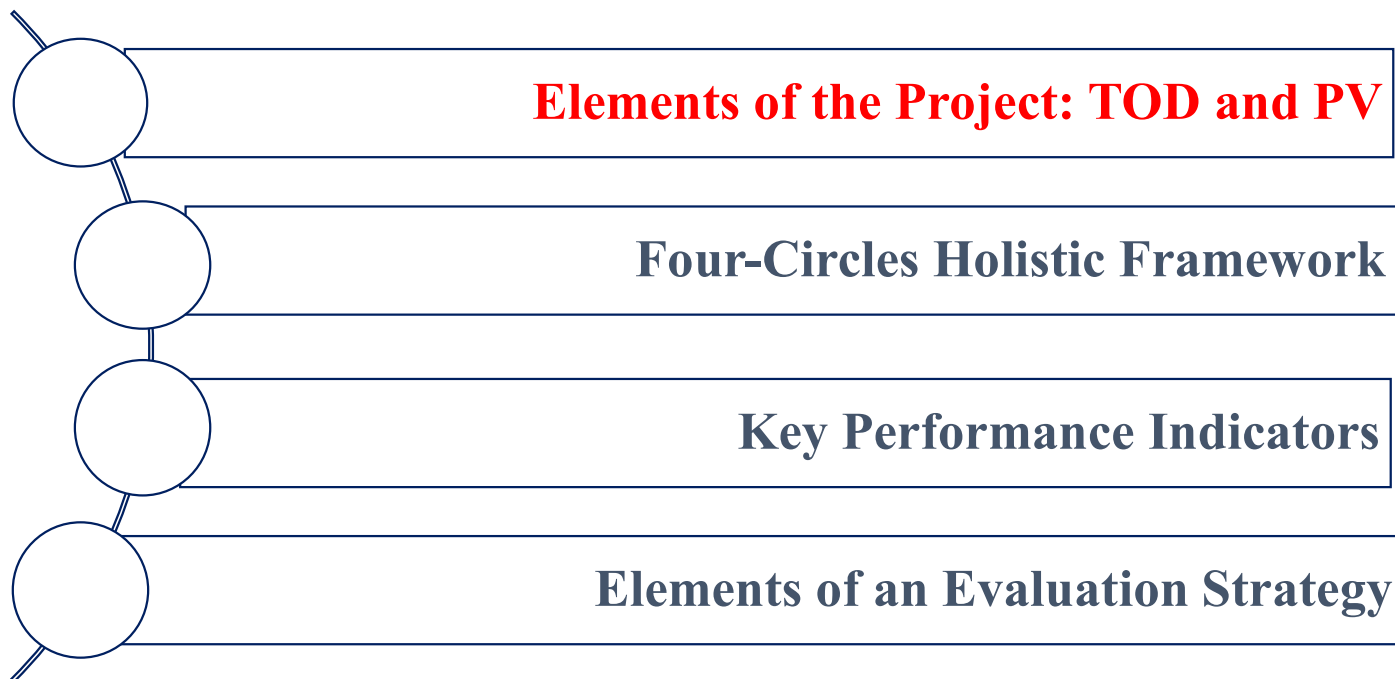
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Summary

Transit-Oriented Development (TOD) projects are among the biggest urban infrastructures and can potentially deliver considerable impacts and benefits towards achieving key policy objectives such as net zero. The combination of TOD with photovoltaic electricity generation is designed to ensure that carbon neutrality is satisfied. However, in today's context, characterized by high oil prices and scarce project finance, project developers are obliged to focus on key financial objectives, possibly neglecting other types of objectives.

This paper applies the main author's holistic four circle sustainable development framework developed in the APEC Integrated Planning Report 2021 and refined in the APEC Urban Energy Report 2023, to align the four strategic objectives that may be set for any TOD: 1) be financially viable despite high investment cost, 2) enhance economic growth and skills of the city and region, 3) diminish urban congestion and improve livability of the city, 4) contribute towards carbon neutrality. The paper identifies three groups of key performance indicators (KPI): contextual variables or border conditions, exogenous or decision variables and endogenous or outcome variables.

The paper sets out first elements of an evaluation strategy as it can be elaborated before the start of the project, when little or only approximate data is available.



Transit-Oriented Development in SDGs (2015)



SDG Goal 11 “Make cities and human settlements inclusive, safe, resilient and sustainable”, calls for “increasing the proportion of population that has convenient access to public transport, by sex, age and persons with disabilities” (indicator 11.2.1).

UNHABITAT (2015) has concretized this target in the global strategy concerning urban settlements in the **Five Principles of Sustainable Neighborhoods Design**,
<https://unhabitat.org/five-principles-of-neighbourhood-design>

	Principle	Measurement Unit	Optimum
1	Street land area / Total Floor Area	%	30% - 45%
2	Population density	kpers/km2	15 - 60
3	Economic Floor Area / Total Floor Area	%	40% - 60%
	Residential Floor Area / Total Floor Area	%	30% - 50%
4	Single Tenure / Residential Floor Area	%	0 - 50%
	Affordable Housing / Residential Floor Area	%	20% - 50%
5	Single Function Block Area / Neighborhood Area	%	0 - 10%

Eight Principles of Transit-Oriented Development (TOD Standard v.3, 2019)

TOD is more about “Development” than about “Transit”

Walk

Develop neighborhoods that promote walking.

Mix

Plan for mixed uses, income, and demographics.

Cycle

Promote nonmotorized transport networks.

Densify

Optimize density and match transit capacity.

Connect

Create dense networks of streets and paths.

Compact

Create regions with short transit commutes.

Transit

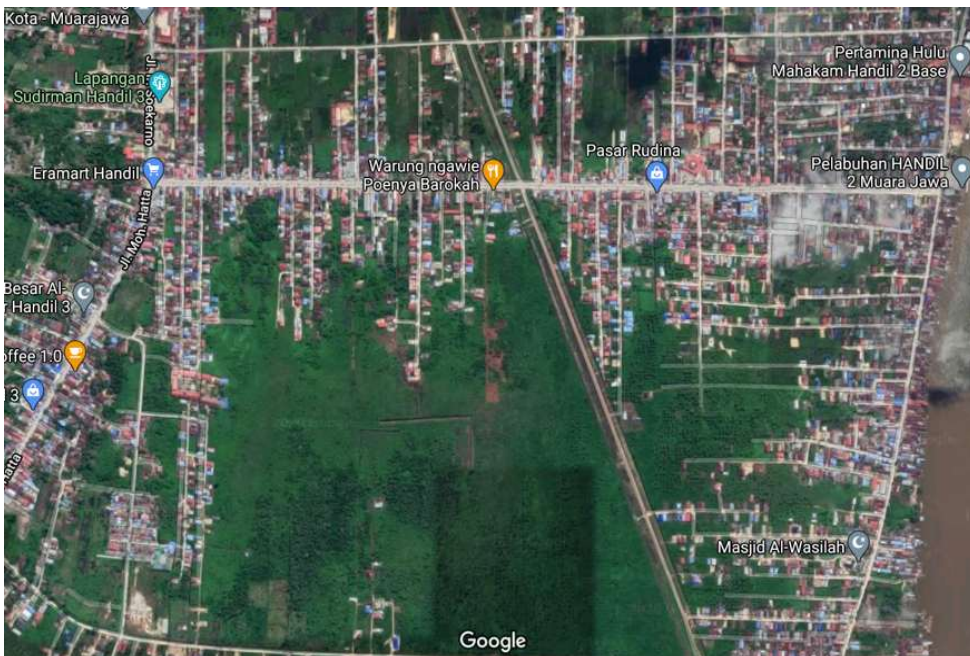
Locate development near high-quality public transport.

Shift

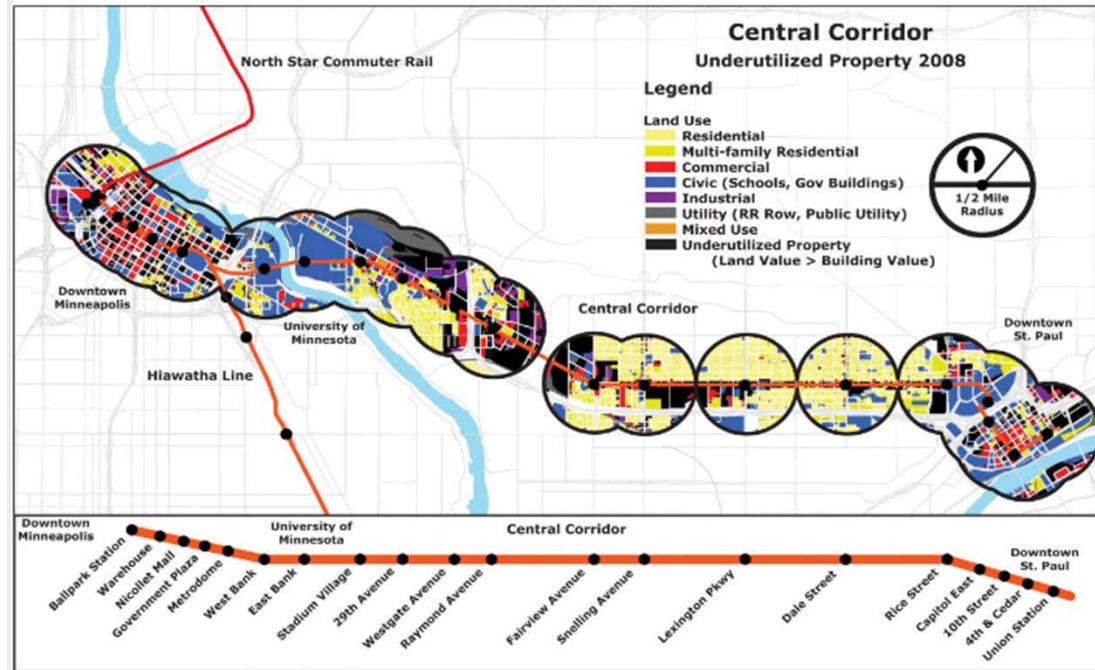
Increase mobility by regulating parking and road use.

Street-Based Development vs Transit-Oriented Development

Two Planning Philosophies in Comparison



Street-Based Planning in Indonesia
(Samarinda, Kalimantan)



Transit Oriented Development (TOD): Planning strategy aiming at developing cities around transport hubs

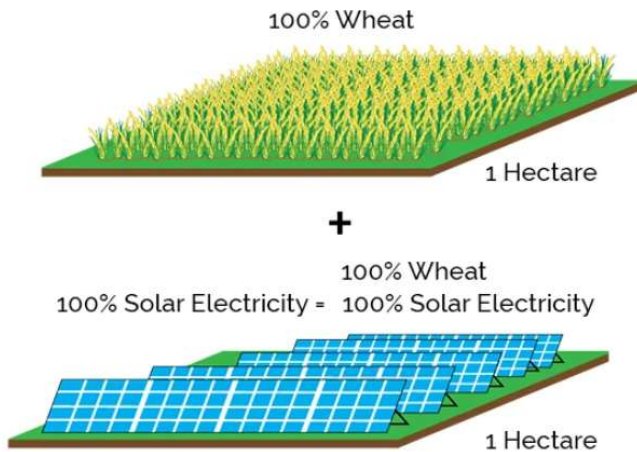
Possible Light Sky Rail Link in Manado

The Light Sky Rail Link from the city center to the airport: The line would link the following points: Zero-Point Manado - Paal Dua Station 1 - Manado-Bitung Railway Station - Manado-North Minahasa Station - Mapanget Station - Sam Ratulangi International Airport Station, with a total of 6 stations and 5 segments and a total length of 22 km. To minimize cost, the rail link has been planned as a sky rail.

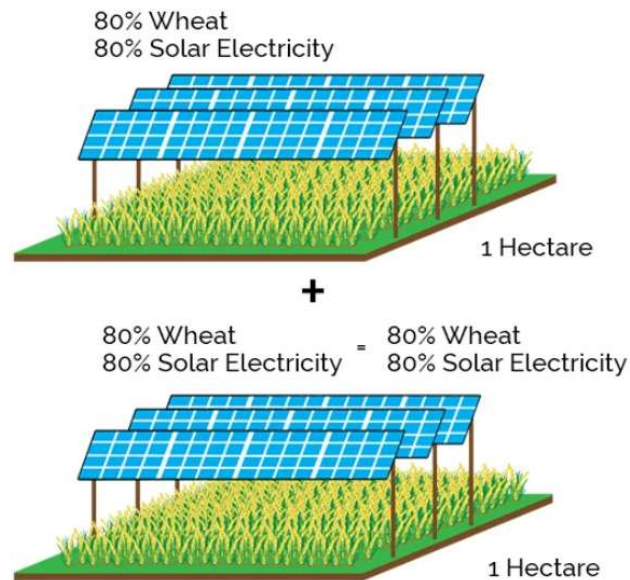


Agrivoltaics, the Agriculture-friendly Photovoltaics

Separate Land Use On 2 Hectare Cropland



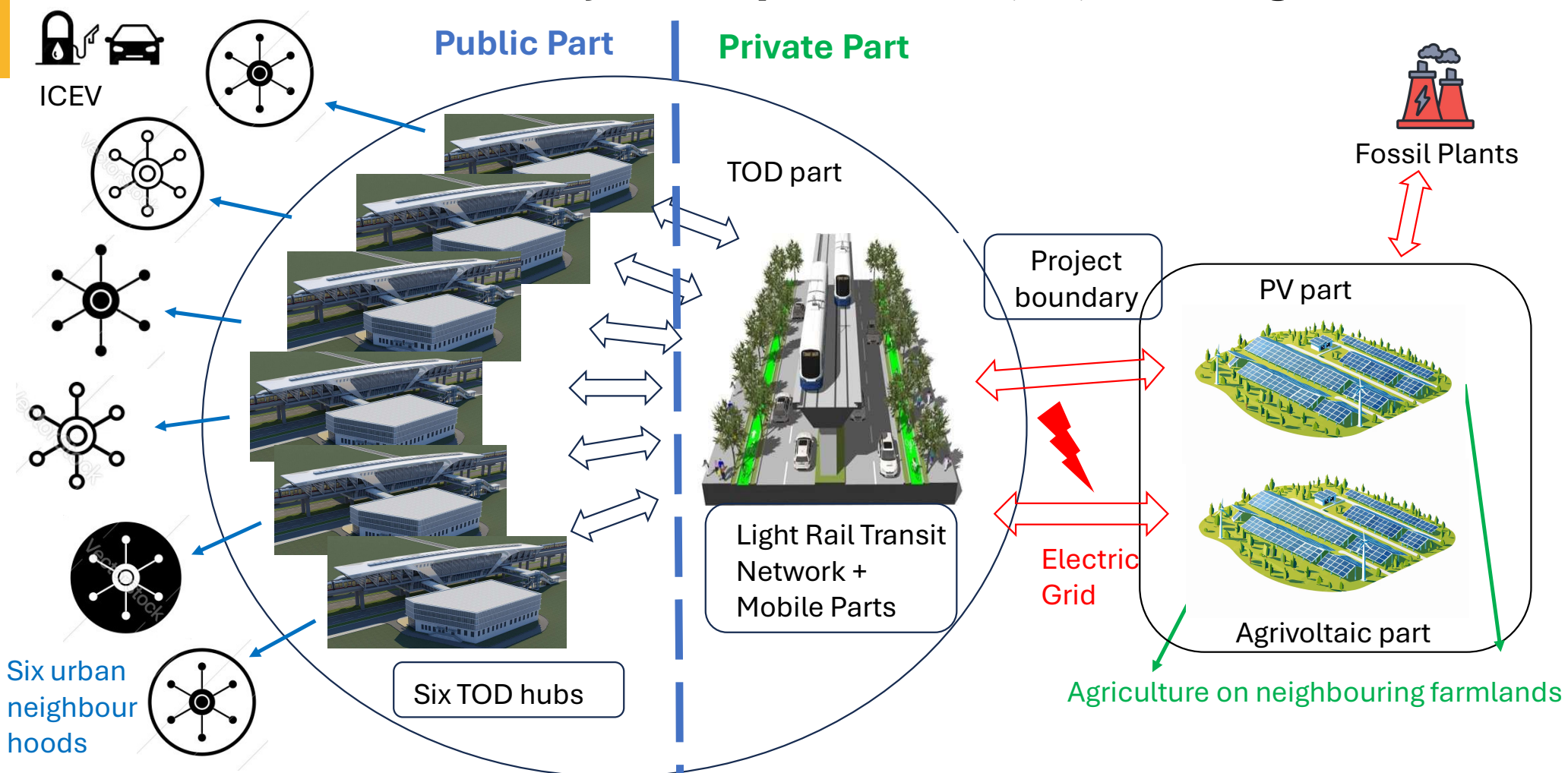
Combined Land Use On 2 Hectare Cropland:
Efficiency Increases Over 60%



Combine solar PV with high value-added crops culture

- From $100\% + 100\% = 200\%$ to $160\% + 160\% = 320\%$, much better combined land use
- Allow for agriculture vehicles to circulate under the PV panels

Overview of Project Components: TOD, PV, PPP Design



Public Private Partnership (PPP)

It is suggested that the project creates a public private partnership (PPP). Either the City or the Province or the Ministry would create a new public enterprise that should be the **public partner** of this PPP, ideally listed on a stock exchange, with a certain share of equity (e.g. 25%) provided by private investors.

The **public partner** is in charge

- (1) of constructing and maintaining the **TOD hubs**,
- (2) of constructing and maintaining **affordable housing, schools and hospitals** (the institutions that contribute to human capital formation) 1-2 km around the TOD hubs,
- (3) advocating a favorable regulatory framework for the private partner.

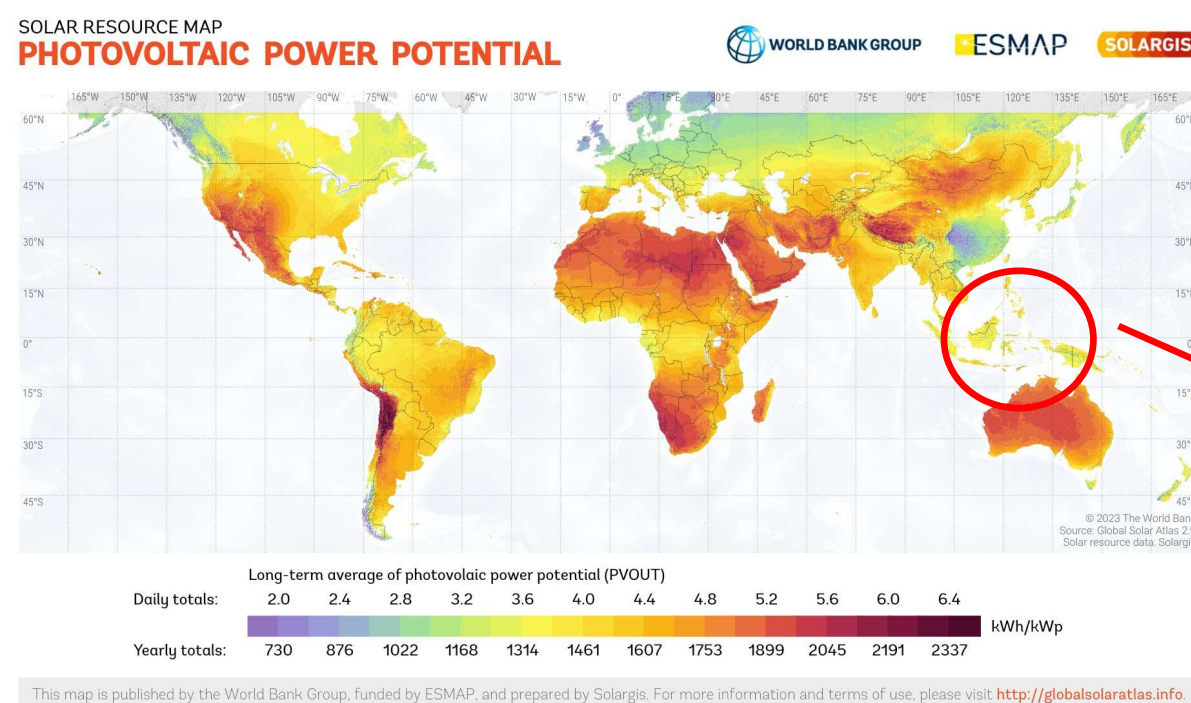
The **private partner** of this PPP could be a national or a foreign investor with experience in local infrastructure and a strong commitment to TOD and would operate e.g. under a **BOT concession** agreement. The private partner may e.g. be chosen by **public tendering** following an awareness-rising investor roundtable. In this option, the PV plant will be integral part of the BOT concession.

The private partner is in charge of

- (1) constructing and maintaining the **railway, bridge support and mobile parts**
- (2) constructing and maintaining the **PV plants**.

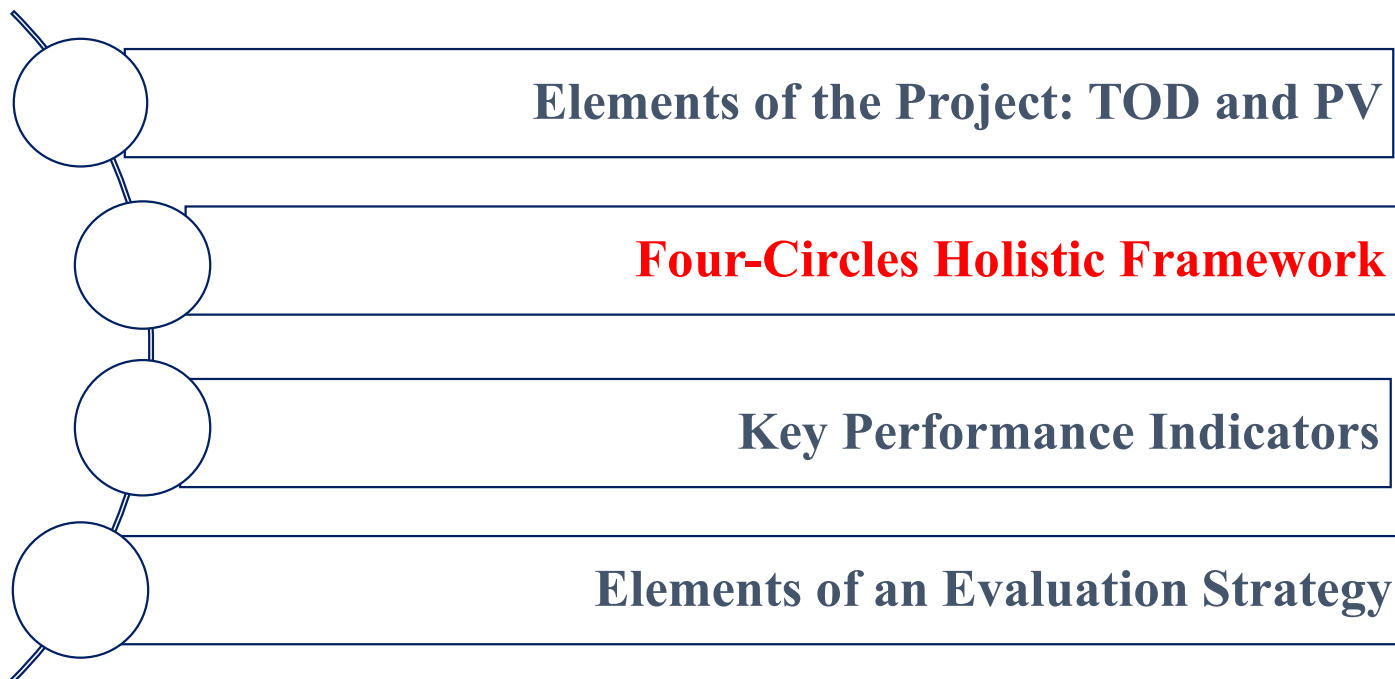
Location of the Agrivoltaic Plant outside Manado

The favored location of new 20 MWac ground-mounted solar PV stations is near Bitung, about 50 km away from Manado.

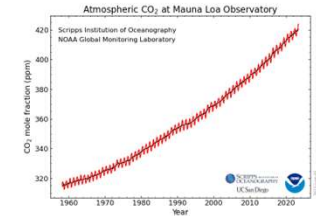


<https://solargis.com/maps-and-gis-data/download/world>

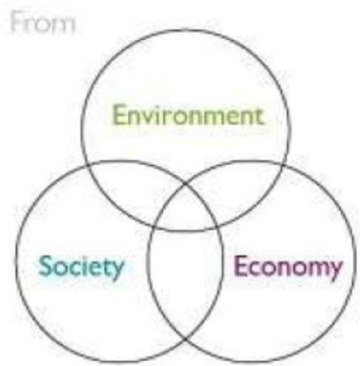




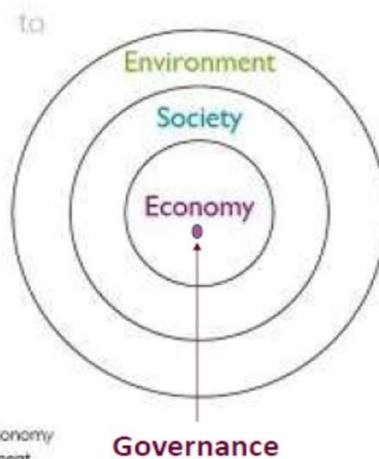
Conceptual Design to Minimize Conflicts Between Objectives



UNCED, Rio 1992



APSEC (2021)



Source: B. Giddings, B. Hopwood, G. O'Brien, Environment, Economy and Society: fitting them together in Sustainable development, Wiley Interscience, 2002

Problem: The 1992 diagram creates conflicts between objectives because it is factually questionable: part of the economy is outside the society, and part of the society is outside the environment

APSEC (2021)



Biggest failure:
CO₂ emissions

Economic goals (5)

Social goals (13)

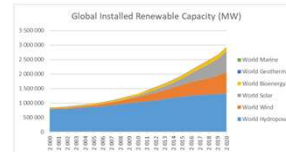
Environmental goals (17)

Climate,
Cities,
Energy

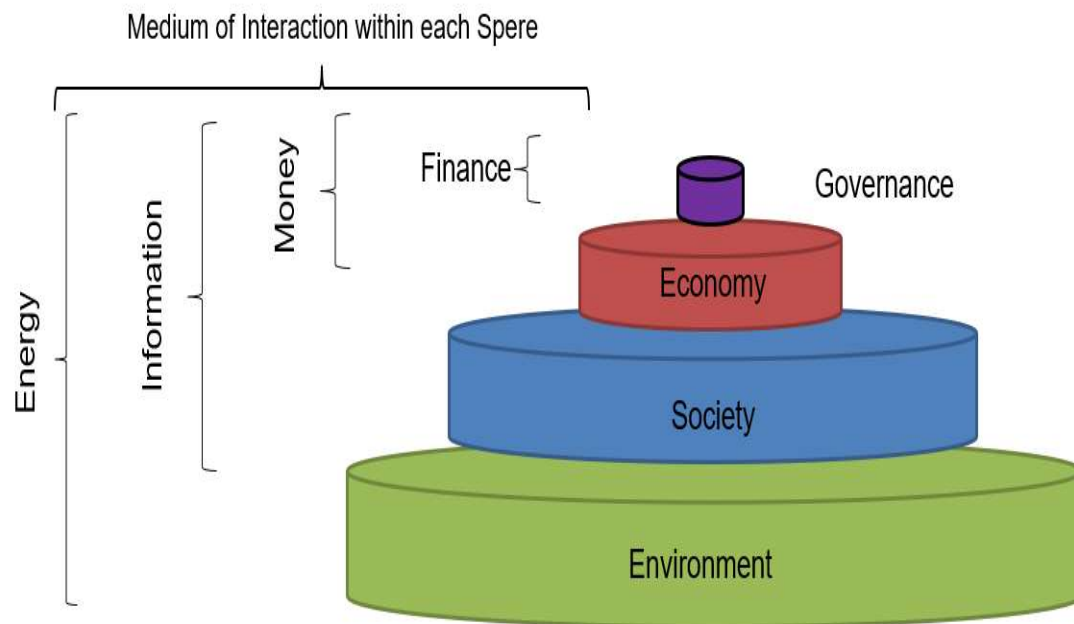
Governance goal (1)

Below vs
above water

Biggest success:
renewable energy



Theoretical Foundation for the Four Concentric Spheres (APSEC 2021, 2023)



Financial Assets: Mc Kinsey Global Balance Sheet (since 2021)

Industrial and Infrastructure Assets: UN System of National Accounts (SNA 1993, 2008, 2025)

Social Assets (skills, culture): UNECE Guide on Measuring Human Capital (2016) (on a test basis)

Environmental Assets: UN System of Environmental-Economic Accounting (2012, 2022)

Energy is the universal accounting and measurement unit of the physical environment ($E=mc^2$, $E= hf$).

Information is a special form of energy (entropy $S=k*\ln(W)$; if $k=1$ and with binary log, $S= \ln(W) = 1$ bit information).

Money is a special form of information (quantitative accounting transaction history for traded goods and services) and accounting unit, but **no scientific measurement unit**. Exergy can estimate the physical purchasing power of money.

Finance is a special form of money (against trust of deferred payment with interest), accounted by money x time.

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Generalized GDP (= Gross Holistic Product = GHP) & Net Holistic Surplus NHS

	Agent Based Input Output Table Period 0														
	FLOWS	INTERINDUSTRY			Σ	FINAL CONS		CITY	EXPO	WORLD	INVESTMENT (FLOWS)				ΣΣΣΣ
	FLOWS	A	B	R	V=Σ	G	C	U=ΣΣ	X	Q=ΣΣΣ	Fin	Ind	Hum	Env	TOT ΣΣΣΣ
PRIMARY	A	21	45	34	100	74	32	206	31	237	1	57	83	6	384
SECOND	B	63	21	61	145	67	56	268	41	309	5	37	64	7	422
TERTIARY	R	26	59	4	89	23	31	143	61	204	103	39	81	4	431
INTERM Σ	V=Σ	110	125	99	334	164	119	617	133	750	109	133	228	17	1237
TAXES	T	43	61	46	150	0	28	178	0	178	2	35	38	5	258
WAGES	W	78	81	16	175	12	0	187	9	196	4	72	365	7	644
CITY ΣΣ	U=ΣΣ	231	267	161	659	176	147	982	142	1124	115	240	631	29	2139
IMPORTS	Z	5	7	9	21	0	8	29	8765	8794	147	67	772	35	9815
WORLD ΣΣΣ	Q=ΣΣΣ	236	274	170	680	176	155	1011	8907	9918	262	307	1403	64	11954
TBALANCE	TSL	1	35	34	70	2	41	113	-113	0	CITY LEVEL (U)				
KBALANCE	KSL	-187	-60	-748	-995	-139	-52	-1186	339	-847	DOMESTIC		HOLISTIC		
DIVEST	Financial	32	12	931	975	161	126	1262	15	1277	GDP1	528	GHP1	882	
DIVEST	Industrial	18	38	7	63	13	23	99	28	127	NDP	465	NHP	-600	
DIVEST	Human	41	36	24	101	14	329	444	424	868	NICF	141	NHCF	-1186	
DIVEST	Environmental	243	87	13	343	31	22	396	215	611			NHS	-1073	
ΣΣΣΣ	TOT ΣΣΣΣ	384	422	431	1237	258	644	2139	9815	11954	GLOBAL LEVEL (Q)				
Black numbers are positive or zero						Net industrial capital forma				NFCF	Net holistic capital formation			NHCF	-847
Brown numbers can in principle be positive or negative						Gross holistic product (1)				GHP1	Net holistic surplus			NHS	-847
Global trade is a zero sum game						Net holistic product				NHP					

The Eight Types of Sustainability of Cities

Category 1:
Net current surplus
Net capital formation
Overall surplus

Expenses	Receipts
Surplus	
DD	II

Category 2:
Net current surplus
Net capital loss
Overall surplus

Expenses	Receipts
Surplus	
DD	II

Category 3:
Net current loss
Net capital formation
Overall surplus

Expenses	Receipts
Surplus	
DD	II

Category 4:
Net current surplus
Net capital loss
Overall break-even

Expenses	Receipts
DD	II

Category 5:
Net current loss
Net capital formation
Overall break-even

Expenses	Receipts
DD	II

Category 6:
Net current surplus
Net capital loss
Overall loss

Expenses	Receipts
DD	Loss
	II

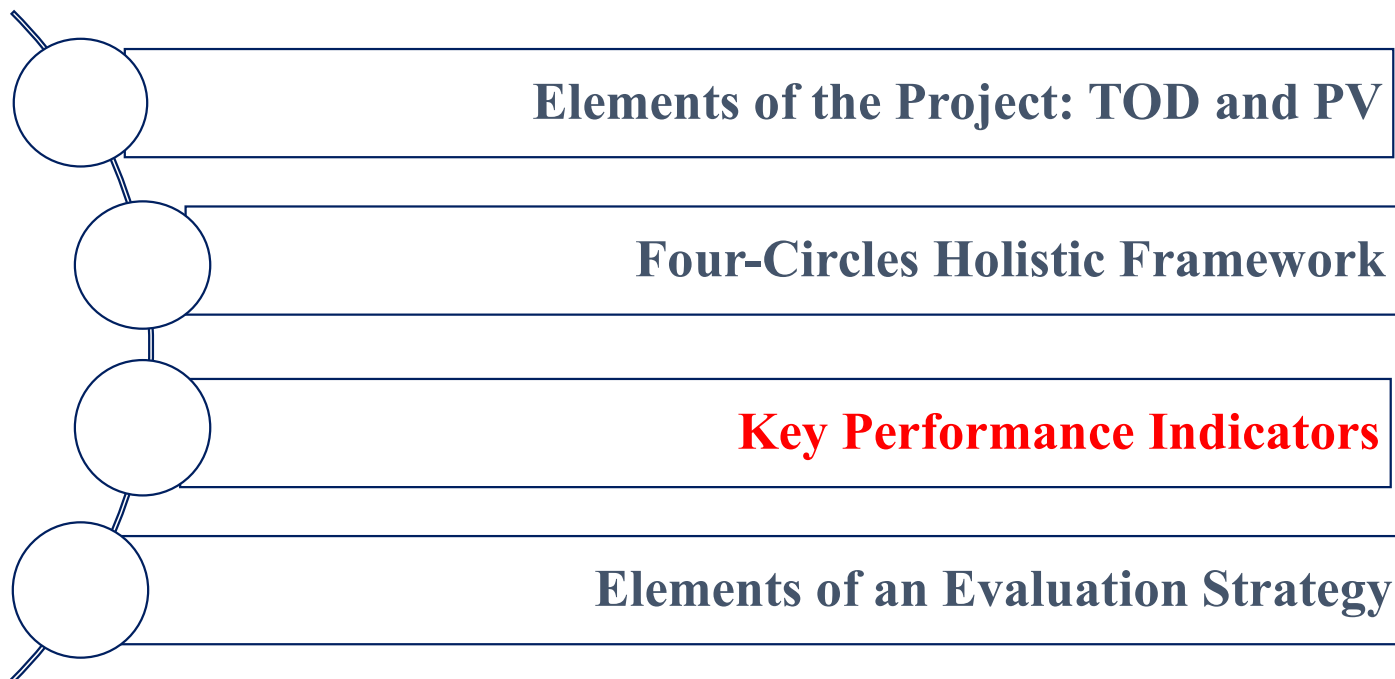
Category 7:
Net current loss
Net capital formation
Overall loss

Expenses	Receipts
	Loss
DD	II

Category 8:
Net current loss
Net capital loss
Overall loss

Expenses	Receipts
	Loss
DD	II

DD: Gross Holistic
 Divestment
 II: Gross Holistic
 Investment



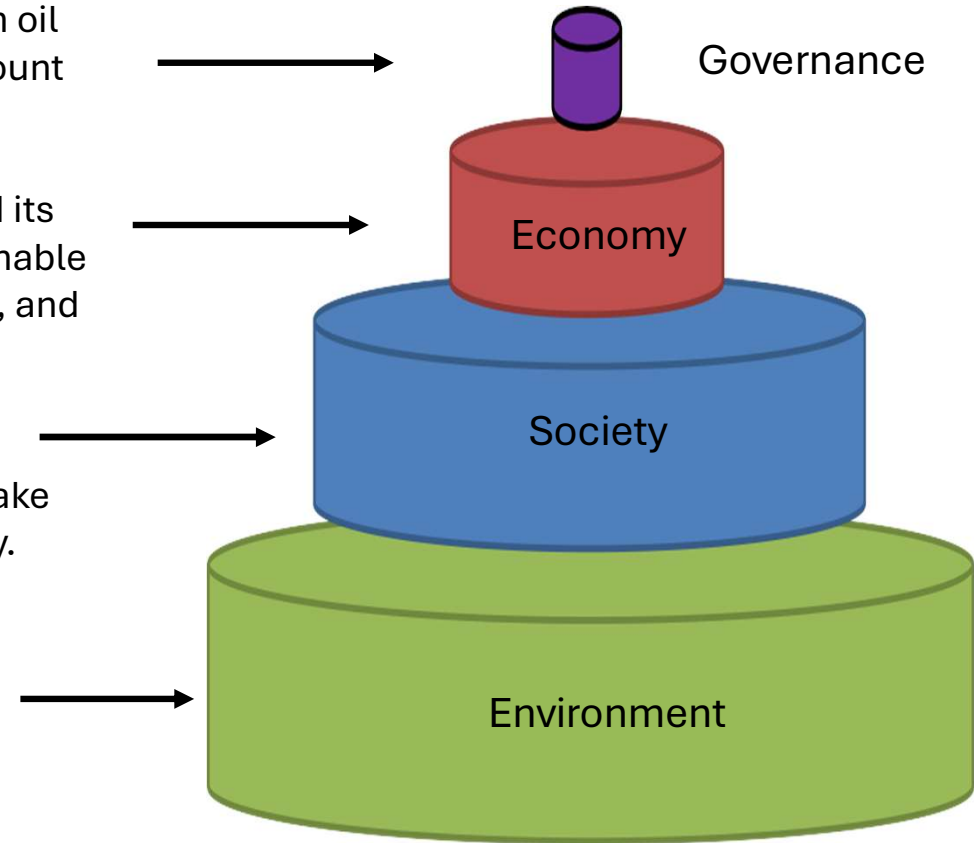
Four Strategic Objectives Mapped into the Four Spheres

Financial viability: Given the high investment cost of TOD, high oil prices and scarce project finance, **financial viability** is paramount

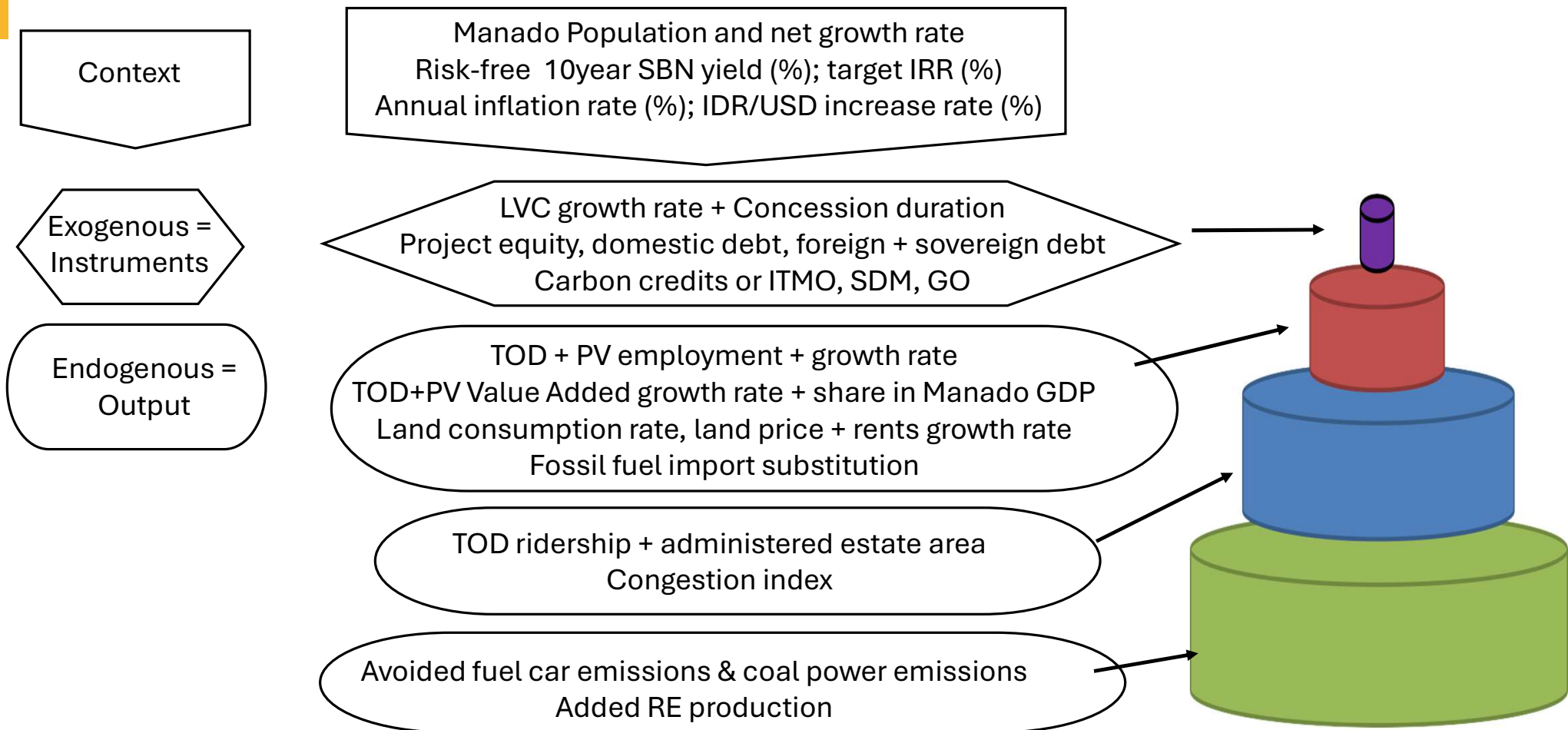
Growth and Employment : Large urban TOD infrastructures contribute to economic growth (measured in terms of **GDP** and its generalization, the Gross Holistic Product **GHP** and Net Sustainable Surplus **NHS**), larger share of formal employment, higher skills, and decrease import dependency (oil)

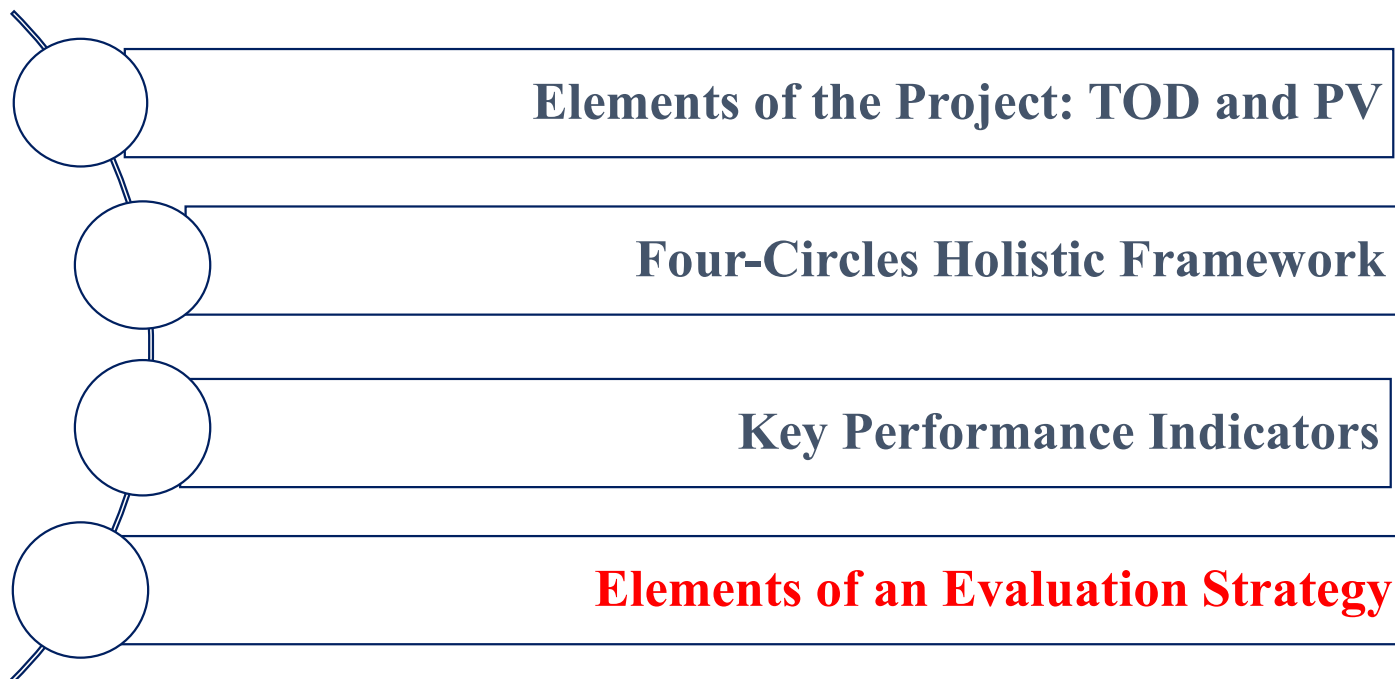
Congestion: Congestion entails average road speed below 20 km/h. Public transport systems and improved land planning make cities more **livable**, depending on the vision + targets of the city.

CO2 emissions: CO2 emissions create climate change. Low carbon systems (**renewables**) gradually **decarbonize energy supply** and **reduce climate change**



Hierarchy between categories of variables





Evaluation Priority: Avoid TOD Failure

Greatest Risk: Insufficient TOD ridership (empty trains)

Risks originating within the TOD Company

Suboptimal location of TOD hubs => plan TOD locations at present and future hotspots

Insufficient planned service quality: => plan high intermodal connectivity

Insufficient planned amenities at TOD hubs
=> plan for sufficient amenities space

Inadequate business model: over-reliance on ticket sales (farebox recovery ratio) => plan business model with diversified estate services revenue for TOD company.

Risks originating outside TOD Company

Gentrification of TOD neighbourhoods: Self-defeating vicious circle of TOD; causality chain: increased land price in TOD neighbourhoods => poor households unable to live near TOD stations => only two-car households live near TOD stations => TOD ridership declines => financial difficulties of TOD company => reduce TOD services => TOD further loses attractiveness

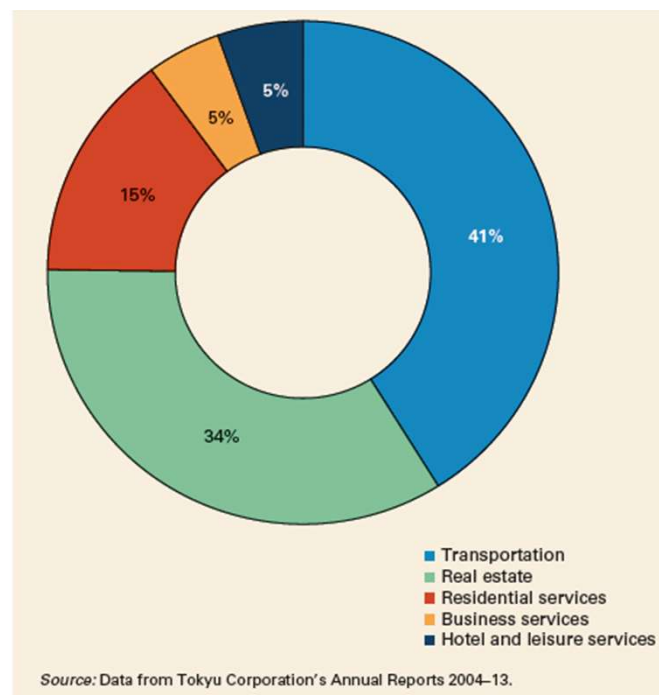
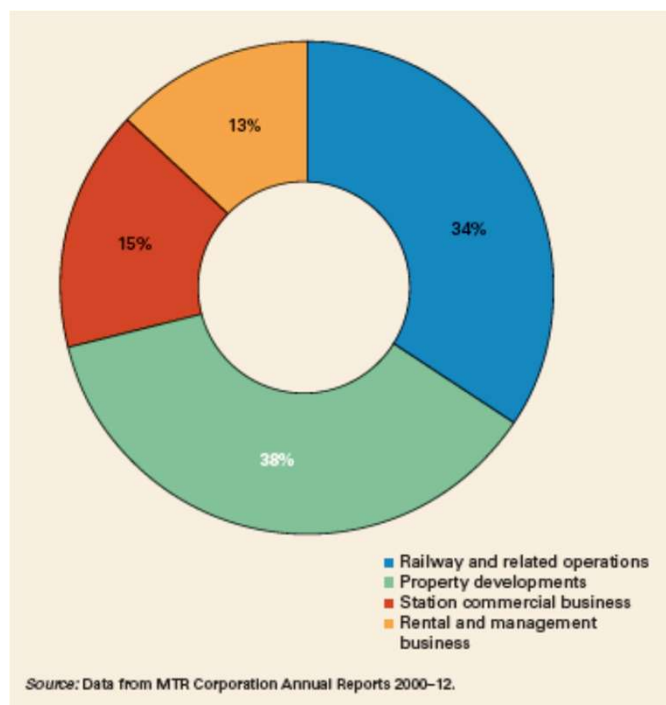
=> Need to diminish gentrification by urban planning and Land Value Capture

Business Model focusing on “D” in TOD

The transit company to be a stock exchange listed publicly owned company opened to private ownership (e.g. 25%). The presence of private investors increases pressure on the management to be market-oriented, price-responsive and open to public concerns.

Diversify revenue: **Hong Kong** (34% from transport)

Tokyo (41% from transport)



Implementing LVC in practice

One of the biggest challenge to implement LVC in practice is the only recently (2022) **harmonized terminology** (OECD) and the very rapid progress on **key ideas** and **key practices** worldwide; OECD identified one more instrument.

World Bank (2018)

Leveraging public real assets

Development charges

Sale of development rights

Land pooling /readjustment

Special assessments/betterment levies

Tax increment financing

OECD (2022)

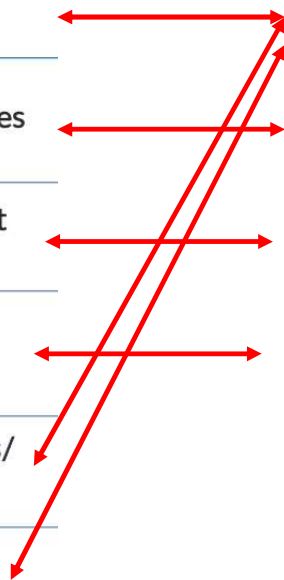
Infrastructure levy: taxes or fees levied on landowners possessing land that has gained value due to government-initiated infrastructure development

Developer obligations: cash or in-kind contributions that defray costs for additional infrastructure or services that need to be provided due to private development

Charges for development rights: cash or in-kind contributions payable in exchange for development rights or development potential above a set density baseline

Land readjustment: the practice of pooling fragmented land parcels for joint development, with owners transferring a portion of their land for public use

Strategic land management: the practice of governments actively buying, developing, selling and leasing land to advance public needs and recoup value increments borne through public action



Land Value Capture (LVC)

The city introduces a Land Value Capture scheme (**infrastructure levy**) along the following lines: A very low **general land tax of 0.5% to 1%** of the square meter value for the whole city area. To this, add a **land value growth tax** calculated from the estimated average annual land price growth rate (%) in 1-2 km around transit hubs (e.g. 5%). Possibly refine the growth zones by identifying core growth zones with higher average growth (e.g. 6%) vs peripheral growth zones with lower average growth (e.g. 3%). Decide on the **part of this growth to be captured by LVC (e.g. 40%)**. Collect an annual land value growth tax of e.g. $0.4 \times 0.06 \times \text{square meter price}$ (from the core growth zone) and $0.4 \times 0.03 \times \text{square meter price}$ (from the peripheral growth zone). The estimation of annual land price growth should be repeated every 5 years and should entail adjustments of the tax, where growth rates changed.

Exempt the **public TOD partner** from paying the LVC tax against the obligation to construct and operate affordable housing, schools and hospitals in the 1-2 km periphery from the TOD hubs.

Exempt the **private TOD partner** from paying the LVC tax against the obligation to offer affordable transit tariffs.

Urban land planning ensures that the neighborhoods around TOD hubs are mixed (economic-residential) neighborhoods, and that the proportion of affordable housing is always between 20% and 40% around each TOD hub to avoid gentrification and to guarantee sufficient ridership of the TOD system.

Carbon Credits and ITMO

Objective: Benefit either from Carbon Credits in general, or from ITMOs or SDM (Article 6 of the Paris Agreement)

Carbon Credits in general: third-party validated and verified credits received for reduction or removal of GHG from atmosphere, either by Technology-based Solutions (TbS, e.g. renewable energy) or by Nature-based Solutions (NbS, e.g. reforestation), carried out under different international programs: Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), Gold Standard (GS), either in regulated or in voluntary carbon markets.

Internationally Transferred Mitigation Outcome (ITMO): mitigation outcome between countries under **Article 6.2** of the Paris Agreement: **country-led cooperation**, “Real, verified and additional GHG reductions or removals”. Possibility for a host country to count ITMOs towards (more ambitious) NDCs or use ITMOs to complement NDCs against receiving investment from a partner country. Must be authorized by both countries.

Sustainable Development Mechanism (SDM), central **multilateral** mechanism supervised through the UNFCCC under **Article 6.4.** of the Paris Agreement: Common registration process, approved methodologies, accredited validation and verification bodies and a mechanism registry. Avoids double counting. Replaces former CDM. Particularly relevant: **Renewable Electricity Methodology**, connecting to Electricity Attribute Certificates (Guarantees of Origin GO, Green Electricity Certificates)

Preliminary Choice of Basic and Derived Key Performance Indicators (KPIs)

The project should formulate Basic Key Performance Indicators (BKPIs) and closely monitor these to ensure the project satisfies its expectations. BKPIs can be used to compute growth rates (%) and also combined among each other to give derived KPIs (DKPIs), e.g. emissions intensity per GDP, value-added per employee

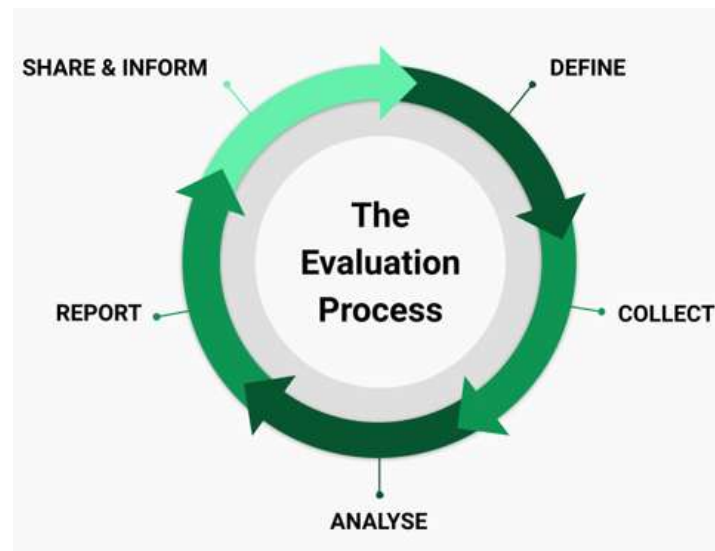
Indicator Type	Basic Key Indicator	Cat	Expected Impact of Project
General background indicators	Population of Manado (persons) and net growth rate (natural + migratory)	Exog	undetermined (context)
	Risk-free 10yr SBN yield (%), target IRR (%)	Exog	undetermined (benchmark)
	Annual inflation rate (%), IDR/USD increase rate (%)	Exog	undetermined (benchmark)
CO2 emissions - grid scope 2	Newly installed fossil power capacity of North Sulawesi (MW)	Env	diminish
	Annual fossil energy production of North Sulawesi (MWh)	Env	diminish
CO2 emissions - ICEV scope 1 (Internal Combustion Energy Vehicles)	Manado fleet of new ICEVs (nb) and Growth rate	Env	diminish
	Annual and daily ICEV trajectories in Manado (vehicle*km) and growth rate	Env	diminish
Renewable energy	Installed renewable energy capacity of North Sulawesi (MW)	Soc	increase
	Annual renewable energy production of North Sulawesi (MWh)	Soc	increase
Sky train ridership evolution	Annual and daily passenger*km of the TOD company (private partner)	Soc	increase
Non-ridership revenue from TOD company	Area administered by TOD companies, public and private partners (sqm)	Soc	increase
Congestion	Congestion index of Manado (see e.g. Tomtom congestion ranking)	Soc	improve
Land	Local land (ha) and consumption rate (%) of Manado (numerator of SDG 11.3.1)	Soc	∝ population growth
Land value	Land price (MIDR/sqm) and annual growth rate 1-2 km around TOD hubs (%)	Soc	increase
	Rents (MIDR/year) and annual growth rate 1-2 km around TOD hubs (%)	Soc	increase
	Local GDP of Manado (or Value-Added, MIDR/year) and growth rate	Econ	increase
GDP	Value-Added of the TOD companies (public and private partners) (MIDR/year)	Econ	increase
Value-Added	Work force of the TOD companies (employee*years, by skills) and growth rate	Econ	increase
Employment and skills	Fossil fuel imports of Indonesia (MUSD/year)	Econ	diminish
Import substitution	Import of TOD and PV materials during construction (MUSD/year)	Econ	increase
Concession duration	Concession duration of TOD private partner (years)	Fin	to be negotiated
LVC	Land value capture (LVC) of Manado (MIDR/year) and annual growth rate	Fin	increase
Financial indicators	Domestic debt of the TOD companies (public and private partners) (MIDR*days)	Fin	variable
	International debt of the TOD companies (public and private partners) (MUSD*days)	Fin	variable

Evaluation Strategy between TOD-Management and Local Urban Policy

Management Cycle of Public + Private TOD Partners



Evaluation



Policy Cycle of Manado City (e.g. LVC, affordable housing)



References: Selected APEC Reports on Sustainable Urban Development

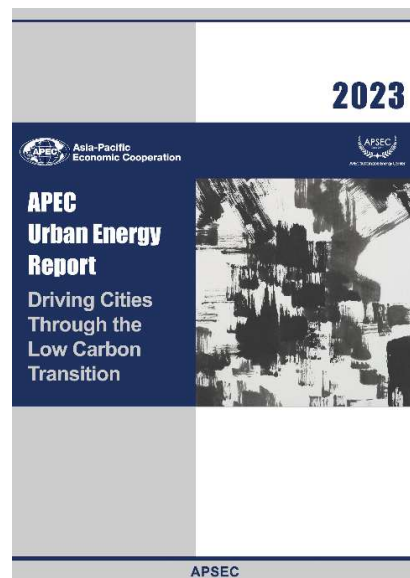
2021



APEC Integrated Urban Planning Report – Combining Disaster Resilience with Sustainability

<https://www.apec.org/Publications/2021/03/APEC-Integrated-Urban-Planning-Report>

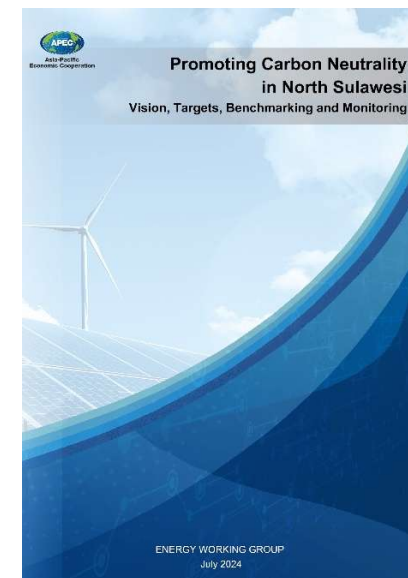
2023



APEC Urban Energy Report 2023 - Driving Cities Through the Low Carbon Transition

<https://www.apec.org/publications/2024/06/apec-urban-energy-report-2023---driving-cities-through-the-low-carbon-transition>

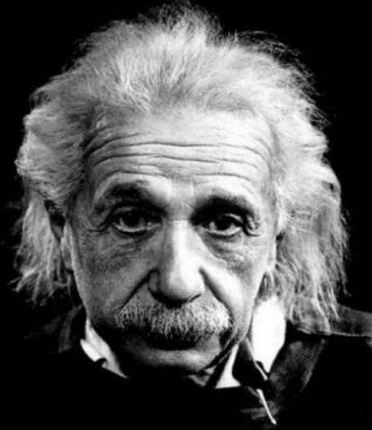
2024



Promoting Carbon Neutrality in North Sulawesi – Vision, Targets, Benchmarking, Monitoring

<https://www.apec.org/publications/2024/10/promoting-carbon-neutrality-in-north-sulawesi---vision-targets--benchmarking-and-monitoring>

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“

If you want to live a
happy life, tie it to
goals, not to people.

”

ALBERT EINSTEIN

THANK YOU
FOR YOUR
ATTENTION!

..., tie it to the Sustainable
Development Goals, ...

