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Thomas E. Griffith, JR.

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TO: Lt Col Thomas E. Griffith

Sir,

I have reviewed your article entitled "Attacking Electrical Power: A Targeting Study for the New World Order" and have approved it for public release.

STEVEN E. PAYNE, Captain, USAF
Program Manager, Grad Sci & Engrg
Civilian Institution Programs

ATTACKING ELECTRICAL POWER:

A TARGETING STUDY FOR THE NEW WORLD ORDER

BY

THOMAS E. GRIFFITH, JR.

This work is condensed from my thesis "Strategic Attack of National Electrical Systems" done at the School of Advanced Airpower Studies, Maxwell AFB, Alabama. For their help in that project I would like to thank Bob Pape, Mark Clodfelter, Peter Faber, Phil Meilinger, Jerry Hust, Scott Westhoff and Liz Griffith. The opinions in this article are mine alone and do not necessarily represent the position of the United States Air Force or the Department of Defense.

ABSTRACT

The increased interest in the idea of using conventional strategic bombing as a means of solving foreign policy crises mandates a thorough examination of which targets should be attacked. Electrical power has been considered a critical target in every war since World War II, and will likely be nominated in the future. Yet, despite the frequency of attacks on this target system planners and decision makers tend to become enamored with the vulnerability of electric power to air strikes, and fail to analyze the relationship between attacking electrical power and the stated political objectives. Historically there have been four basic strategies behind attacks on national electrical systems: to cause a decline in civilian morale; to inflict costs on political leaders; to hamper military operations; and to hinder war production. The evidence shows that the only sound reason for attacking electrical power is to affect the production of war material in a war of attrition against a self-supporting nation with little outside assistance. Because attacks on electrical power offer minimal benefits yet can cause politically counterproductive collateral damage, the implications for future strategic air operations are significant.

ATTACKING ELECTRICAL POWER:

A TARGETING STUDY FOR THE NEW WORLD ORDER

National electrical systems have been a favorite target of air power advocates since the Air Corps Tactical School first considered this target system in the 1930s. It has been designated as a critical target in every war since then, and has even been nominated for attack in a future air campaign against the Serbian government.[1] Despite the persuasiveness of this target system for strategic air attack, there has been little thought given to understanding the conditions that determine when these attacks will be successful in obtaining the desired political objectives. If American policy makers are to continue believing in the utility of attacking electrical power then some effort must be made to define the conditions and the effects of such attacks.

It is not surprising that targeting electrical power has not been closely analyzed, since there has been little scrutiny given to the topic of conventional strategic attack in general, with only minimal debate about what targets should be attacked and why.[2] Providing an intellectual foundation for strategic target planning is important because interest in the idea of conventional strategic bombing as a tool for U. S. policy makers has been revived by a number of recent events, including the increasing number of crisis situations in a multipolar world; the growing sophistication of weapons which makes the blunt instrument of military force more precise; and the belief that a strategic air attack will be able to enforce political demands without committing large numbers of ground forces with the concomitant domestic political problems.[3] As Eliot Cohen has observed, "Air power is an

unusually seductive form of military strength, in part because, like modern courtship, it appears to offer gratification without commitment."[4]

The conventional wisdom about targeting electrical power rests on the assumption that such attacks have wide ranging effects on a variety of institutions. Two political effects are presumed to result from the loss of electricity. The first is that this loss will diminish civilian morale and thus alter a nation's political behavior. The second is that the loss of the electrical system will increase the costs to the political leaders of a country thereby, forcing a change in the government's behavior. Likewise, there are two important military effects usually mentioned: that the loss of power will have a direct impact on the fighting military forces or that it will cause a reduction in war material production. These four arguments, either separately or in combination, have been used for decades to advocate attacking national electric systems.

My analysis shows that none of these arguments is sound. Attacks on electric power to reduce civilian morale have not been effective in changing political behavior. Attempts to influence governments through increasing costs by targeting national electrical systems have also been ineffectual because leaders of most regimes generally embark on actions with high resolve, and thus are unwilling to change their policies simply as a result of losing electrical power. Moreover, political leaders and military forces are prepared for such contingencies, and therefore are well insulated from the loss of the national power grid and able to continue functioning. In contrast, attacking electrical power can be effective in slowing the production of war material, and in a prolonged war against a self-sufficient nation attacking electrical power would be prudent. Given the current limited nature of war against small powers it does not appear that war production will

be a factor in the near future. In addition, there are several drawbacks to attacking electricity, especially in terms of death and disease in the civilian population, and the potential negative international censure that could result from such actions. Because of current political and military conditions, the minimal military benefit gained from attacking electrical power must be compared with the potentially negative political consequences.

To assess the effectiveness of electrical power targeting, this article concentrates on the historical record of the effects produced by destroying electric power. The single target approach allows a detailed examination of the historical precedents over a wide range of conditions to discover if the findings are consistent and likely to occur in future cases, and allows a more detailed discussion of the system than would be possible in a broader study of strategic targeting in general.

Critics may object that focusing on one system does not take into account the possible synergistic benefits that result from a strategic attack on several systems in concert. Although this study concentrates on one system the historical evidence of the attacks has been evaluated synergistically. For example, in assessing the attacks on the North Vietnamese national power system during the Vietnam War, I found no evidence to suggest that these attacks affected other areas such as the air defense system or strained their logistics capability by increasing petroleum demand for generators. Thus, while these problems were predicted before the attacks, there is no evidence to suggest that they actually did occur. Moreover, spotlighting electrical power should exaggerate its impact because the ability of other systems to compensate for the loss of power are not considered. For instance, an attempt to hinder the air defense system of a country through the targeting of electrical power to stop the air defense radars from working would not take

into account the ability of a nation to compensate for the loss by launching more air defense aircraft. In short, the single target approach offers the best perspective for determining the conditions under which certain targets should be attacked.

This article is arranged in three parts. The first reviews historical United States Air Force thinking about the benefits of attacking electrical power systems in total war, which includes the theoretical teachings of the Air Corps Tactical School and the strategic planning for World War II. The second section examines attacks in limited wars, including Korea, Vietnam, and Iraq.[5] Finally, the necessary conditions for attack will be proposed, including the implications of bombing national electrical systems in the current global environment.

ATTACKS IN TOTAL WAR

The first conceptual work in identifying specific strategic bombing targets in general, and electrical power in particular, was done during the 1930s at the Army service school for airmen, the Air Corps Tactical School (ACTS). The bomber advocates at ACTS believed that the will or morale of a country, not the destruction of the field forces, was the true objective in war. This will, they believed, could be destroyed by precision bombardment strikes against the war-making capability of the enemy country; however, there were too many potential targets in an economic structure to allow even a very large air force to hit every target. These strategic bombing advocates hypothesized that because the modern nation was very specialized and interdependent--an "industrial web" in their terms--it would be vulnerable to interruption at certain pivotal points, which could be identified through a scientific analysis of the economic system.[6]

Electrical power was a key target set in the entire industrial web theory, and in some respects, might be termed the "panacea target" because of the presumed success attacking this system would yield. An attack on electric power was attractive for several reasons: it would affect, simultaneously, the social and economic spheres of a nation; the targets were relatively easy to locate and were believed to be vulnerable to air attack; the equipment was difficult to replace; and perhaps most importantly, this type of attack was economical, because a small amount of destruction would, they believe, yield impressive results.[7] According to their calculations, 100 bombs could destroy three-quarters of the electric generating capacity in the Northeastern United States.[8]

These instructors studied the New York City electric system in detail, using it as a model for a hypothetical attack on electrical power to demonstrate the effectiveness of their theory.[9] They knew that the city contained 26 steam generating plants for general use, and 8 additional plants for the sole use of the transportation system. Although the city could be supplied by two outside sources of power, these sources were routed through the normal generating plants for distribution. Therefore, the destruction of the main plants would eliminate the outside sources of power as well. Along with focusing on how to destroy the power system, the instructors also hypothesized about the effects of such an attack.[10]

They showed that eliminating power would halt almost any form of modern transportation, stopping rapid transit and snarling road traffic because of problems with signal lights. Shipping would be disrupted because ships could not be unloaded at the port. Cutting power would also cause water supply distribution problems and fire hazards. Such an attack would destroy the enemy's capacity to wage war, but perhaps more importantly, it would hurt the

morale of the population "by making life under war conditions more intolerable to them than the acceptance of our terms of peace."[11] The presumed result, though left unstated, was the immediate capitulation of the foe.

These ideas about strategic attack developed at the Air Corps Tactical School became more than academic theories—they strongly influenced the target selection of the first air war plans for World War II.

The first opportunity for air planners to present their ideas on strategic bombing outside of the Air Corps Tactical School came in 1941, when President Franklin D. Roosevelt requested that the Army and Navy submit plans for their production requirements.[12] The aircraft portion of the Army's request was formulated in August 1941, by the newly established Air War Plans Division. While this plan, christened AWPD/1, was technically only a production forecast and not an employment plan, the air planners seized this opportunity to advocate their ideas on how the United States could defeat Nazi Germany through strategic bombardment.[13]

The four primary planners for AWPD/1, Colonel Harold L. George, Lieutenant Colonel Kenneth N. Walker, Major Laurence S. Kuter, and Major Haywood S. Hansell, Jr., had been students and then instructors at the Tactical School. This common intellectual foundation gave them a strong belief in the efficacy of strategic bombardment and the importance of electrical power as a target system.[14] They believed that strategic bombing could produce an Allied victory by causing "the breakdown of the industrial and economic structure of Germany." Therefore, they selected targets that were essential to war production and to the civilian population, such as electric power, transportation, and oil.[15]

The planning team found that there would be problems in attacking the electrical system, such as the difficulty of destroying hydroelectric dams and

of hitting small targets like the generating plants and transformer stations. Nevertheless, the planners were seduced by the system's vulnerability. They believed that destroying 50 electrical power plants would eliminate 40 percent of the German electric generating capacity. Furthermore, they were confident that despite the small size of the targets (calculated as 500 feet by 300 feet for the entire plant) they would be easy to find in daylight and that "about 17 hits in that area will guarantee destruction of the plant."[16] Because of the value of electrical power to both industry and society, they concluded that the number one priority of the air campaign should be the "Disruption of a major portion of the Electric Power System of Germany."[17]

The target priorities and air strategy of this first air plan were reviewed one year later, in August 1942, when the armed services prepared a new plan for the production requirements of aircraft in order to achieve "Air Ascendancy" in 1943.[18] In light of this new objective, the new plan, called AWPD/42, revised the target priority list, displacing electrical power to fourth, preceded by attacks against the German air force, submarine construction, and transportation.[19] Because the new air strategy focused less on affecting civilian morale and war production, and more on the impact of bombing the fielded military forces there was less emphasis on hitting economic targets like electricity and more on traditional military targets. Additionally, the extra year of war also played a role in the change of target priorities. At the time AWPD/42 was drafted German submarines were enjoying great success in sinking large amounts of Allied shipping, creating considerable concern over the ability of the United States to keep Great Britain supplied with war materials. As a result, submarine construction yards were accorded a high priority on the strategic bombing target list.[20]

The targeting assumptions in AWPD/42, however, were soon criticized by members of the Joint Intelligence Committee who objected to the presumptions involved in the target selection process.[21] This questioning led to the creation of an Army Air Force headquarters organization which performed an independent target analysis of Germany.[22] First known as the Bombing Advisory Committee and later as the Committee of Operations Analysts (COA), this group was composed of civilian and military personnel charged with analyzing the potential disruption of the German economy through bombing, to determine the "date when deterioration will have progressed to a point to permit a successful invasion of Western Europe."[23]

The COA assessment did not support an attack on the German electrical system for several reasons. The first was their belief that the German national power grid was highly flexible and could transfer power quickly between regions. Because of this flexibility, the COA concluded that the German electrical system contained between 15 and 20 percent excess power, an "enormous reserve" in their view.[24] They also concluded that the poor results of the Luftwaffe bombing of British power plants had demonstrated that "The vulnerability of electric power plants is debatable."[25] Finally, they argued that targeting other systems such as ball bearings, petroleum, and steel production would have a more immediate impact on the military capability of Germany.[26] The net result was that, relative to other target systems, electrical power did not appear to be an especially important target, and in the formal report to General Henry H. (Hap) Arnold, Commanding General of the Army Air Forces, electric power was ranked thirteenth--eliminating it from any real consideration for attack.[27] Arnold forwarded the recommended targets to the American 8th Air Force headquarters in England and this list constituted the major target priorities for the Combined Bomber Offensive.[28]

At least one other American targeting organization in Europe addressed the possibility of attacking electrical power--the Enemy Objectives Unit (EOU). As part of the Economic Warfare Division in the U.S. Embassy, this group attempted to develop a methodology for target selection based on targets "chosen in light of an explicitly defined military aim, linked to the full context of war strategy."[29] The members of this group opposed attacks designed to weaken the economy or affect morale, and instead studied the impact of bombing on the German military capability.[30] A study of targeting information prepared by the EOU states, "The target systems in this Handbook have been selected on the basis of their direct military effects only."[31] Thus, electrical power was rejected on general principle by the EOU analysts because attacking it would not lead to "an early reduction in military strength disposable in the field."[32]

These analysts also eliminated electric power as a result of three specific assumptions. Contrary to the COA, the EOU felt that the targets were dispersed in "extraordinarily small" units and they postulated that "23 [of the] largest stations produce only 20 per cent of German output."[33] However, they agreed with the COA findings regarding the grid system's flexibility which minimized the effectiveness of any attack. Finally, the EOU felt that "installations in power plants and switching stations are of such a kind as to require bombing of the highest concentration and precision,"[34] a level of precision, they intimated, that was beyond the capability of 8th Air Force.

Thus, there were two main factors that caused these two independent targeting groups to disagree with the air planners about the value of attacking the German electrical power system. The first was the assumption that the interconnections within the German electrical system would allow power to be transferred easily, thus reducing the vulnerability of the system.

The second was the change in air strategy from emphasizing an attack on war production and the will of the civilian population to one of more direct support for a land invasion. As a result, the German power system was never systematically attacked during the war.

By contrast with the extensive planning for the strategic bombing of Germany, a serious study of Japan was not begun until early 1943 when General Arnold directed the COA to analyze the Japanese economy to determine appropriate strategy targets.[35] Prior to this time the "Germany first" strategy that the United States and Great Britain had adopted dictated that the COA's targeting attention would initially be focused on Europe. In addition, the Army Air Forces possessed little capability, even by 1943, to attack mainland Japan on a sustained basis.[36] Perhaps most importantly for target selection, though, was the lack of intelligence on Japan.[37]

In October 1943, the COA began consolidating subcommittee reports prior to making targeting recommendations to General Arnold. The electrical power subcommittee noted that isolated attacks on the power system would be of "little more than nuisance value," but that large scale attacks on the system would take too long (estimated at between six months to one year) to be effective in weakening Japan. Furthermore, they were pessimistic about actually hitting the large number of small hydroelectric dams which made up the bulk of the power system. Finally, the dispersion of the power plants, which lowered the vulnerability of the electrical system, made it difficult to totally eliminate the Japanese power supply.[38] As a result of these difficulties and perhaps their ambivalence toward electrical power based on their German targeting experience, the COA did not recommend attacks against the Japanese electrical system.[39]

United States Strategic Bombing Survey

During the war, members of the Army Air Forces recognized that one of the most difficult problems in strategic air warfare was trying to relate the effectiveness of attacking particular targets to the overall objectives of the war. The only way to gauge if the correct targets had been selected against Germany and Japan was through a post-war survey of the results. This desire for feedback resulted in a high-level commission called The United States Strategic Bombing Survey (USSBS) which was formally implemented by executive order of President Roosevelt in November 1944.[40]

The members of the Survey who focused on the German electrical system felt it would have been an excellent target for strategic bombing. Like the earlier air planners, the survey members found that electrical production was concentrated in a few plants, there was very little reserve capacity in the system, and the generation and transmission equipment was easily damaged through bombing.[41] The report also points out two glaring errors in the war time assessment of the system: the lack of appreciation for how tight the supply of power was in Germany, and the limited ability of the Germans to transfer power. As the electric team members wrote, "the German utility system was in a state of continuous tension, straining it almost to the breaking point."[42] In making their assessment of the value of attacks on electrical power the team members concentrated on the vulnerability of the system to bombing and statements from German officials regarding their fear of attacks on the system. These comments ranged from those of the Nazi Minister of Armaments, Albert Speer, to a German electrical engineer who claimed that the war would have ended two years sooner if the Allies had attacked electric power.[43] The economic report of the Strategic Bombing Survey also notes that the supply of power was a problem and that curtailments of electricity, which

began in October of 1941, had, a year later caused some temporary halts in production. By November 1943, there was an eight percent curtailment in power, which resulted in synthetic nitrogen production falling by 12.5 percent and steel production by 20 percent.[44] While these reductions may seem important, there was no evidence to document that this reduction actually led to a drop in the production of war materials, since stockpiled nitrogen and steel could have been used to maintain war materials.

There is little argument over the importance of electricity in the Germany economy, but it does not necessarily follow that attacking the national electrical system would have resulted in an earlier victory for the allies. In fact, the USSBS economic report disagrees with the basic assessment of the electrical report, the economic writers noted, "It seems likely that the Germans overestimated the vulnerability of their power system."[45] In addition, the electrical report concentrates on the output of the national system, which accounted for only 58 percent of the generating capacity in Germany. The remaining 42 percent was made up of small electrical generating units located in industrial factories, such as aluminum plants and the Krupp iron works, which generated their own electricity.[46] Because of this large amount of private capacity, a reduction of half of the public power production would have meant a loss of only one quarter of the entire capacity. Because so much of the power was located within the factories a reduction in the public power supply might not have had much effect on overall war production. Another factor that would have helped Germany substitute for a loss in power was a fuller mobilization of their economy. As the USSBS economic team reported, most German industries remained on a single shift throughout the war.[47] By using two or three shifts, power demand could have been spread out over a longer period of time, allowing the same amount of

electricity to be used with fewer disruptions. If necessary, power could also have been saved by substituting manual labor for machines, allowing electricity to be conserved for more critical tasks. While a concentrated attack on power would have put a strain on German war production, the effect of this attack on the timing of the Allied victory is unclear.

While the European report of the Strategic Bombing Survey offered some vindication for the ACTS theory, its report on bombing in Japan confirmed most of the assessments made of the Japanese electric power. The biggest complaint in the Pacific report was on the lack of adequate intelligence about the Japanese economy. Part of this was related to poor American preparedness, but it was also the result of a concerted effort by the Japanese to withhold information.[48] Despite the lack of intelligence, the USSBS analysis believed that, "Japan's electric power system was properly rejected for specific attack because of the large number of small targets presented."[49]

In many ways the Strategic Bombing Survey brought thinking about air attacks on electrical power full circle. The former instructors at the ACTS and the writers of AWPD/1 felt vindicated by the results of the investigation into electrical power in Germany.[50] While the actual evidence is more ambiguous, for air planners the lesson was clear--hit electrical power. This attitude prevailed despite the changes in the nature of war and in the enemies the United States faced in the post-World War II era, and remains the basis for current attitudes about the value of attacking electrical power.

ATTACKS IN LIMITED WAR

Korea

When North Korean forces launched their invasion on 25 June 1950, the United States Air Force, like much of the rest of the world, was caught by surprise. Prior to the invasion, the Air Force had accomplished little contingency planning for Korea. Not until 3 July did Strategic Air Command, which retained operational control of the bomber force, begin looking for potential strategic targets.[51] Their investigation revealed that the North Korean electrical system consisted of five hydroelectric plants in the east: Fusen, Choshin, Kyosen, Funei, Kongosan; and one plant, Suiho, in the west, which together produced 90 percent of the power used in North Korea.[52]

The rationale for attacking electrical power bore a striking resemblance to the strategy of AWPD/1. The objectives were spelled out in a memorandum to the Far Eastern Air Forces (FEAF) by Air Force headquarters in Washington: "Destruction of the plants was expected to lower North Korean morale by putting out lights, bring some electrically-powered industry to a halt, and eliminate most of the surplus power being exported."[53] Based on this report, and other analyses, the Fusen plant was attacked on 25 September 1950. This mission, however, would be the only attack on electrical power in the opening phase of the war.

The Joint Chiefs of Staff halted bombing north of the 38th parallel when General Douglas MacArthur obtained permission to cross into North Korea.[54] The attacks were stopped for a variety of reasons including the delay between the attacks on electrical power and the impact on the battlefield, the higher reconstruction costs if MacArthur did succeed in reuniting the peninsula, and the fear that attacking the power facilities might provoke China into entering the war.[55] MacArthur's drive to reunite Korea, however, was halted near the

Yalu river, and when the Chinese Communist army intervened in November 1950 the United Nations (UN) command retreated south. Following the Chinese attack the war stalemated near the 38th parallel and in July 1951 peace talks began. With UN ground forces committed to holding ground against any further territorial gains by the communist forces while minimizing UN casualties during the negotiation process, air power became the primary military means available to influence, or pressure, the North Korean government.[56]

Attacks on the Korean electrical system resumed in the summer of 1952 with the initiation of the "Air Pressure Strategy." This new plan for pressuring the North Koreans was based, in part, on a Far Eastern Air Forces study which concluded that the most promising avenue to bring pressure on the North Korean government was to use air power to "destroy or damage enemy supplies, equipment, facilities and personnel."[57] This "Air Pressure Strategy," would include maintaining air superiority and continued bombing of the interdiction targets already being attacked but the aim of the new campaign would focus on destruction that would cause "a permanent loss to the enemy and produce an accumulative drain on his strength."[58] In addition to locomotives, vehicles and supplies, electric power was advocated as a target since it constituted "one of the most lucrative air targets remaining in North Korea."[59] Although the primary impact would be on the North Korean leaders, striking electrical power would also inflict costs on the Chinese, who were providing much of the support for the North Korean forces. Because North Korea exported surplus power from the Suiho plant to Manchuria, attacking Suiho would not only cost the Communists monetarily, in terms of repairs, but also inflict indirect damage on Manchuria, a sanctuary for Communist forces.[60]

While the primary rationale for attacking electrical power was the desire to inflict costs on the North Korean and Chinese leadership, there were

other reasons given for attacking the power generation facilities. The official explanation was based on curtailing war production. According to this rationale, previous bombing had largely eliminated North Korean industry, forcing them to take defensive measures by dispersing war production to small workshops and underground facilities, which made the destruction of manufacturing by conventional bombing difficult at best. Eliminating electric power at its source was deemed the most efficient and effective method of cutting North Korean production.[61] The continued Air Force institutional perception of the value of electrical power as a morale target was probably also a factor, as some officials hoped that the destruction of the electrical system would cause an "adverse psychological effect on [the] civilian and military population."[62] How this would translate into a political settlement was, however, left unexplored. In the end, attacking electrical power looked attractive for a number of reasons, and attacks on the system began in late June 1952.

The effects of bombing the electrical power system were easy to judge from a military viewpoint. In four days, beginning on 23 June, U.S. Air Force and Navy aircraft destroyed 11 of the 13 generating facilities, eliminating 90 percent of the power in North Korea. The impact of these attacks was widespread. There was a two week blackout in North Korea, which stopped much of the war production going on in small factories and shops. The outage also hampered vehicle and rail car repairs because of problems with electric welders, and impeded agriculture by disabling the rice milling machines and the electric pumps used for irrigation. The damage to the Suiho facility produced a 23 percent loss of the electric power requirements of Manchuria for 1952, and as a result, 30 of 51 important industries in northeast China did not reach their production quotas for the year.[63]

Although the reports on the effectiveness of these attacks indicate that they were successful in crippling the supply of power, their real impact must be judged in light of their aim, which was to increase the costs to the North Korean, Chinese, and presumably Soviet leaders, thereby pressuring them into a peace agreement. The Soviet and Chinese leaders reacted to the bombing by immediately sending technicians to repair the damaged facilities,[64] while the North Koreans bought small generators for mines and manufacturing plants and worked around the power interruptions by staggering shifts at workplaces to take advantage of the power available.[65] Furthermore, because the North Koreans obtained most of their war material from outside the country, the elimination of electricity did little to affect military operations by hampering war production.[66]

Although the effects of the bombing were mitigated by these efforts, the attacks did exacerbate political difficulties for the United States. The British press and Labor Party vehemently protested the bombing out of fear that such attacks would cause the Communists to discontinue the peace talks, and they were also indignant about the lack of consultation prior to the bombing.[67] In retrospect, the attacks were largely responsible for ending peace negotiations between China and India, talks that the United States had secretly endorsed. These discussions had made some progress in resolving issues that had thwarted the U.S. negotiators, but the Chinese walked out of their meetings with the Indian government after the bombing raids, stating that they would not be pressured into a peace agreement.[68]

In the end, the attacks failed in their fundamental objective of pressuring the North Koreans to sign a peace accord. Despite the increased costs caused by the virtual elimination of the national power system and the

concomitant impact on production, the "Air Pressure Strategy" and the war continued for over a year.

Vietnam

Although attacks on electric power did not force an end to the Korean war, this failure did not diminish the high regard air planners placed on electrical power as a target system, and the North Vietnamese power grid was targeted early in the Vietnam War.

The Rolling Thunder air campaign, begun in 1965, was an attempt to fulfill a variety of political objectives through the bombardment of North Vietnam. At various times these objectives included boosting the morale of South Vietnam, demonstrating American resolve, interdicting the supplies used to support the insurgency in South Vietnam, and breaking the will of the Hanoi government to support the Viet Cong insurgency.[69] While attacking the primitive electrical power system of North Vietnam was proposed because it would have some effect on morale and interdiction, the primary purpose was to inflict costs on the North Vietnamese leadership and convince them to stop supporting the unrest in the south.[70]

Although Rolling Thunder began in March 1965, and included intermittent attacks on power plants, the electrical system was not systematically attacked until the spring of 1967. The Joint Chiefs of Staff (JCS) urged a concentrated attack of electrical power, nominating eight major power plants as targets to President Lyndon B. Johnson in the fall of 1966. These strikes were designed to eliminate power in the Red River valley area which would serve two purposes: to reduce production in the railway shops and the shipyard, and disrupt normal life and affect the will of the leaders and people to support the war effort.[71] On 21 February 1967, President Johnson

approved attacks on all of the North Vietnamese thermal power plants except those in Hanoi and Haiphong.[72] The Haiphong plants were later struck on 20 April, and aircraft attacked the Hanoi central power station on 19 May.[73] By the end of May 1967, 14 of the 22 electrical power targets, including generating plants and transformer substations, had been attacked, virtually eliminating electrical power production in North Vietnam. Eighty five percent of the generating capacity was destroyed and the transmission network was heavily damaged.[74]

Despite these impressive results, the overall impact of the attacks was small. The Hanoi government asked residents to voluntarily cut consumption and requested that the foreign embassies turn off their air conditioners.[75] The lack of electricity also forced many factories to use manual tools rather than automatic machinery, and compelled the government to disperse much of the industrial production. Although one of the stated goals of the attacks was to stop or hinder work at the Haiphong shipyard, there were no indications that the lack of power had any impact on the ability to off load cargo.[76] Neither was there any evidence to support the contention that the reliance on generators, along with a concomitant increase in the demand for petroleum, was hurting the Hanoi government.[77] An Air Force intelligence study, completed shortly after the main power plants were struck in 1967, concluded that while the North Vietnamese were concealing many of the effects of the bombing, nevertheless the "results [of the loss of power] will not be as far-reaching as originally expected."[78] In short, the loss of the central power system did degrade the industrial production of North Vietnam, but did not reduce their ability to continue the war.[79]

The North Vietnamese leadership reacted to the loss of power in several ways. The first was to ensure that the priority users still had electricity

by employing 2,000 portable generators and 5 underground diesel generating stations.[80] To compensate for the decline in industrial capacity they relied on support from the Soviet Union and China, which by 1968 amounted to $600 million in economic aid and $1 billion in military assistance.[81] Although the social and economic costs inflicted on North Vietnam were high, they were not enough to coerce the Hanoi government into accepting American demands.

The Rolling Thunder bombing campaign ended in October of 1968, and strikes on the North Vietnamese power system did not take place again until May 1972 with the Linebacker I bombing campaign. Although Linebacker I was primarily aimed at reducing the flow of supplies into North Vietnam, the electrical system was attacked as part of the general effort to attack any target that supported the war effort.[82] When President Richard M. Nixon stopped the bombing of North Vietnam on 23 October 1972, because of progress in the peace negotiations with the North Vietnamese, the bombing raids had eliminated 70 percent of the total power generating capacity in North Vietnam, but what effect this had on stopping the invasion is uncertain.[83]

The bombing of the North Vietnamese power system resumed on 18 December 1972, with the initiation of Linebacker II. The objectives of this campaign were mainly psychological. President Nixon hoped to destroy the North's will to fight, forcing them to sign a peace agreement. At the same time, he hoped to demonstrate American resolve to the South Vietnamese government through the use of air power.[84] In eleven days of bombing in Linebacker II, the USAF attacked 6 electrical power targets in North Vietnam, tallying 166 bombing sorties or 12 percent of the total sorties flown.[85]

Combined, the attacks on electrical power during Linebacker I and II eliminated almost 90 percent of the generating capacity in North Vietnam. Despite the extent of the damage there is little evidence to support the claim

that the loss of electrical power affected North Vietnamese policymakers. Although North Vietnamese citizens lost electricity in their homes and manufacturing stopped, many of the government programs instituted during Rolling Thunder were still in place and could have been implemented if needed to substitute for the loss of electricity. Furthermore, the lack of power had little impact on the functioning of the government or of the military. As the official USAF bombing survey noted, "The limited amount of power available [through the national system and portable generators] was probably supplied only to priority users, such as the more important industrial installations, foreign embassies, and selected government buildings in Hanoi."[86] The best that can be said of the bombing of electrical power in Linebacker II is that, while it had some effect, the level, intensity, and influence as far as the Hanoi government eventually signing a peace agreement are still unclear.

Iraq

Because much of the information from Operation Desert Storm is still classified, it is difficult to make definitive judgments about the impact of attacks on electrical power, but once again it was a high priority target. The primary purpose in eliminating electricity was not to stop production, but rather to induce strategic paralysis on the leadership in Baghdad.[87] The focus of these attacks was on the military, with the loss of power intended to affect military facilities such as radar sites and communication facilities.[88] In addition to the military effects, there was also the hope that because electricity touched all aspects of Iraqi society it might have a psychological impact as well.[89]

Prior to the Gulf War, Iraq had a modern electrical power system consisting of 19 main generating stations with a capacity of 9,500 megawatts. One unusual feature of the system was the large amount of reserve capacity available—in 1990 only about 50 percent of the available generating capacity was used.[90] While attacks on electrical power during Desert Storm accounted for 215 sorties, only about 1 percent of the total U.S. sorties flown, these attacks virtually eliminated the Iraqi national power system.[91] By the time the war ended, the Iraqi generating capacity had been reduced to less than 300 megawatts, and the system could only transfer one quarter of the pre-war capacity.[92] Further, a Department of Defense study notes "the synergistic effects of losing primary electrical power sources in the first few days of the war helped reduce Iraq's ability to respond to coalition attacks."[93]

Despite the destruction of Iraq's electrical power system, at least some high priority users had access to electricity, as I personally observed. From 12 January to 4 March 1991, I was as a prisoner-of-war in Baghdad. I was held in four different prisons and was taken to a number of other locations for interrogations. While most places had no electricity, two locations did have electrical power. The first was a building in Baghdad the prisoners referred to as the "Bunker," an underground facility known officially as the Directorate of Military Intelligence.[94] In this building there was power for ventilation, lighting, heating, and a kitchen. I was taken there several times over the course of my first two weeks in captivity for interrogations and there was never a lapse in electrical power. The Iraqi Intelligence Service Regional Headquarters, known to the prisoners as the "Baghdad Biltmore," also had a constant source of power. I was moved to this prison late at night on 31 January 1991. There were lights on inside the prison and I was taken down several floors to my cell in an electric elevator. This

prison had a generator located outside the building which was turned on by the guards as needed. While this information is not definitive, it does offer some evidence that, as in Vietnam, the military and political leaders in Iraq were well insulated from the loss of the national power grid.

There is little doubt, on the other hand, of the impact of the loss of power in Iraq on the civilian population. The civilian effects from the loss of power were reportedly quite severe, including the loss of power to hospitals, the breakdown of water purification systems, and damage to sewage systems, which then contaminated the water supply. A report by William K. Arkin of Greenpeace International attributed 70,000 deaths to this indirect collateral damage caused by a lack of electricity, and other reports have speculated that as many as 170,000 people died.[95] The negative political backlash of such reports is unquantifiable but nevertheless real, and must be considered in future air campaign planning.

The attacks on electrical power in limited wars have echoed some familiar themes. They have been advocated to affect production, as in Korea and Vietnam, and to directly impact the military forces, as in Iraq. Additionally, there has been the continuing hope that somehow the loss of electrical power will have a psychological impact on the target population. The evidence from attacks in North Korea, Vietnam, and Iraq, plus the experiences of World War II, provide the basis for determining when attacks against this system should be performed and for drawing conclusions about the recurring failures in understanding attacks on electrical power.

TARGETING ELECTRICAL POWER SYSTEMS

Despite claims that electrical power should always be attacked, the historical evidence suggests that there are specific conditions that must be evaluated before nominating this system as a strategic target. While electrical power systems are inherently vulnerable to attack, the application of air power against these systems, especially in a limited war, is usually ineffective in achieving strategic objectives, despite accomplishing the intermediate goals of diminishing electrical generating capacity, hindering war production, and causing civilian discomfort.

Deciding to attack the national electrical power system requires an analysis of the vulnerability of a nation's system, and an evaluation of the strategy involved. Unfortunately, in most cases planners and decision makers have focused on the former at the expense of the latter.

In assessing a nation's vulnerability to attacks on electrical power, the dispersion of the generating facilities and the interconnections within the country must be analyzed. Simply put, the more dispersed the generating facilities, the harder it is to attack the electrical power system. The greater the number of plants, the less power each one contributes to the system, which means that eliminating a few plants does little to effect the total output. The high level of dispersion in the Japanese power system in World War II was a key reason why it was not attacked. Similarly, the Enemy Objectives Unit (EOU) analysts rejected the German power system in part because they believed it to be highly dispersed. Determining the dispersion of a nation's electric power grid is relatively simple but extremely important. While many nations have highly concentrated electrical systems, where eliminating 25 plants might destroy three-quarters of the national power system, other systems are more widely dispersed. For example, in China's

national power grid an attack on 100 of the biggest plants would only affect a quarter of the power capacity.[96]

If only a portion of a country's generating capacity is eliminated, it is still be possible to get power from undamaged facilities further afield as long as the transmission system is working. The transmission system consists of the transformers which increase or decrease voltage for transfer over long distance and the wires which carry the power.[97] While the primary function of the transmission system is to deliver power from generating plants to customers, it also interconnects generating facilities. Hence, the transmission system improves the reliability of a nation's entire power system by providing a means to transfer power from one area to another in an emergency.[98] In effect, these interconnections allow each generating plant to serve as an emergency power center for other areas.

Eliminating power through an attack on the transmission system normally means bombing the transformers. Attacking these vulnerable items reduces the capability of a nation to transfer power between areas, causing widespread power interruptions.[99] Attacking the transmission system alone, however, may allow a quicker restoration of power than direct attacks on the generators because power can still be produced, and in some cases it is possible to bypass the destroyed transformers allowing power to be restored.[100]

Analyzing the dispersion of a national power system and the ability to transfer power provides a general indication of the vulnerability of a nation to an attack on electrical power. Such an analysis can be helpful in highlighting if attacking the national power system is possible and the most important targets to hit. Unfortunately, this targeting analysis has remained the sole focus in prior air campaigns. Planners and decision makers have generally overlooked how these attacks will translate into political

objectives. In short, no one has questioned the fundamental reasons behind these attacks. There have been four basic strategies, used either separately or in combination, to justify attacks on electric power: to influence the will of the people; to raise the costs to the leaders; to produce direct military effects; and to impact war production. Highlighting each strategy provides insight into the conditions for attacking electrical power systems.

Attacks on morale

One of the most persistent assumptions among planners has been the belief that depriving civilians of electricity will lead to a change in a nation's political policy. This was key to the strategic targeting theory prior to the Second World War and has remained an enduring thought in the justification for bombing electricity in every war since. The belief in electric power as the panacea target for affecting civilian morale may stem from the ubiquitous nature of electricity in American society. The United States not only accounts for 35 percent of the electrical generating capacity in the world, but also has one of the highest per capita consumption rates in the world--double the rate of other industrialized countries, such as Germany, Japan, and the United Kingdom.[101] Although daily life without electricity is almost unthinkable to Americans, in other areas of the world its loss would not be so catastrophic. Oliver Todd, a journalist who visited Hanoi during the Vietnam war, observed that "To a Western, so-called developed society, cutting our electricity means something. It doesn't mean very much in Vietnam. The Vietnamese for years and years have been used to living by candlelight or oil lamps."[102] In short, there is no guarantee that cutting electricity will have the same disastrous effect on morale in other countries as in the United States.

There is, however, a more basic problem with attacking civilian morale whether through electricity or any target set--it rarely succeeds in achieving the overall objective. While bombing does lower morale in terms of attitude, these changes do not necessarily influence behavior, especially in countries ruled by totalitarian governments. For example, during World War II, bombing did lower morale. Moreover, this decline was in direct proportion to the amount of civilian depravation, caused in large part by the loss of electricity.[103] Despite the decrease in civilian morale, however, studies after the war showed that active opposition to governmental policy was infrequent, and that bombing electrical power to produce a change in civilian morale did not cause a concomitant change in government policy.[104] Ultimately then, air planners and policy makers must decide not only whether eliminating electricity will impact civilian morale, but also whether a decline in morale will actually influence the political leadership toward the desired objectives. The historical record suggests that it will not.

Attacks to influence leaders

Attempts to influence the political leaders of a country by depriving civilians of electricity or by destroying the costly equipment in a power plant is usually associated with a strategy of increasing costs on the leadership to force a change in policy. This was the primary justification for attacking electric power in Vietnam and Korea, and in neither case was it successful.

There are several reasons why this strategy fails. The first is the high resolve most leaders have in any conflict, which tends to undermine the usual calculus of cost versus benefit that may seem applicable to nations outside of the conflict. If the area or issue in question is of high national

interest then the damage inflicted on electrical power will not likely exceed the costs that the leaders of a country are willing to pay.[105] In addition, once national leaders become committed to a course of action, they are reluctant to change. Such a change could mean the loss of prestige and political power which they may fear more than "losing" the war. Rather than admit certain defeat in domestic politics, they would rather continue the present course of action despite the bombing.[106] A more practical consideration is that political leaders are generally well insulated from the loss of the national power system. As the official U.S. Air Force bombing survey from Linebacker II noted, "An air campaign against the electric power system of a country should not have as an objective the total cutoff of power. All critical elements of military and government agencies have alternate means of generating electric power."[107]

In short, the loss of electrical power is not likely to exceed the cost the political leadership is willing to pay. Coupled with government and military insulation from the loss, it seems unlikely that national political leaders will be convinced to change their policy because of an attack on electrical power.

Attacks for military effects

An attack on electricity to directly affect the military forces of a country is a new phenomena, having been used for the first time in the war against Iraq. In part this may reflect the modern military's dependence on electricity. By contrast, attacks on electrical power for military effects during World War II were specifically rejected because of the length of time between an attack and the impact on military operations.

While striking electrical power plants might be useful as a tactical measure to create temporary confusion (as demonstrated in Iraq) such attacks will have only a minimal long term impact, because the military, as a priority user, will have access to whatever power is available in the national grid, and will also likely have emergency power systems. The military is relatively unaffected by a loss of power for three reasons. The first is that, relatively speaking, the military consumes very little of a nation's electricity. In the United States, for example, the entire Department of Defense consumes only about 1 percent of the electricity generated, and much of that is for peripheral functions such as heating and air conditioning.[108] The amount that is consumed for essential functions such as communications or computing is a fraction of the total. Although the military consumes only a small amount of power, generally they are a high priority user, meaning that if any power is available in the national grid, the military will be able to acquire it.[109]

Even if it were possible to eliminate a country's power system, only a portion of the military would be disrupted. Because most ground tactical units rely on their own organic sources of power the areas of the military most affected would be fixed installations, such as air bases, naval ports, or theater headquarters.[110] precisely because these sites are vulnerable to power interruptions, they will have emergency power equipment. In both the Korean and Vietnam wars, American forces relied almost entirely on generators because the host nation's electrical system could not supply the power necessary. The South Korean system was limited and the supply of power was undependable, so all air bases had emergency power systems, and one base generated all of its own electricity.[111] In South Vietnam, U.S. forces found two problems with the national system. The first was that the South's commercial power used 50

cycles, whereas most American equipment was designed to use power at 60 hertz. Second, when American forces started arriving in large numbers in late 1965 and early 1966, the demand for power quickly outstripped the supply and most American fixed facilities used their own generating facilities for power production.[112] Even during Desert Storm, staged mostly from a country with a sophisticated national power system, there was, nevertheless, a need to supply auxiliary power for U.S. forces.[113]

The combination of the small consumption of the national production of electricity by the military, the high priority for any power that is available, and the extensive use of auxiliary power systems, means that there is little overall effect on military operations due to the loss of the national power grid. If a nation chooses to rely on a national power system for daily military operations, there may be some initial confusion as the change to emergency power is made, but the long term effects are more likely to be the result of a loss of war production, rather than a direct impact on operations. No doubt the attacks against the Iraqi power system did cause some tactical confusion in the Iraqi military, but exactly how well that advanced the goal of strategic paralysis on the Iraqi leadership is still not clearly known.[114]

Attacks to slow production

The strongest argument for attacking electrical power is to stop or slow war production. The industries that make war goods are usually very dependent on electrical power, and many processes are simply not possible without this resource. Furthermore, in most countries the majority of the electricity generated is used in the manufacturing process.

The Strategic Bombing Survey analysis after World War II recommended attacks on electrical power, but only in the context of affecting war production, especially over the long term against a country that cannot import.[115] Hence, bombing electrical power to affect war production would be most effective in a total war of attrition against a major power. In a war of short duration, where the enemy has stockpiled war material, stopping war production will have minimal impact on winning the war. Similarly, against a small nation with outside support attacking electrical power to halt war production will not have much impact because of the ability of the nation to substitute for the loss of power by increasing imports and dispersing manufacturing, as demonstrated by North Korea and North Vietnam .

CONCLUSIONS

Strategic attacks on national electric power systems can be useful in fulfilling national security aims, but only under specific conditions. First, the target country's power system should be vulnerable to destruction by being highly concentrated with few interconnections. Second, and most importantly, the strategy behind the attacks should be focused on stopping war production over the long term. To strike electrical power to affect civilian morale, increase costs to the leadership, or directly affect the military wastes missions that could be used to greater effect elsewhere. In addition, these attacks could prove counterproductive to the political aims of the war.

The problem with attacks on electrical power is the negative political impact caused by the effects of such attacks on the civilian population. There are some actions in attacking electrical power, such as breaching a hydroelectric dam or bombing a nuclear generator, that would be successful at interrupting power, yet are inconceivable because of the extent of civilian

casualties that would occur. Although dams have been attacked in the past, in the current political climate and considering the limited nature of modern warfare, it seems unlikely that these attacks would be considered as a means of eliminating electrical power.[116] In a similar way, the effects on Iraqi civilians as a result of the bombing of electric power, such as the damage to sewage and water purification systems, has raised questions at home and abroad. The official response is that although the attacks were more thorough than planned, they were nonetheless necessary and the post-war suffering of the Iraqi people is the fault of Saddam Hussein.[117] Certainly this is true from the legal aspect, for under international law both the defender and the attacker bear equal responsibility for the protection of civilians, but in practical terms the negative impact of these attacks on world opinion far outweighed the military benefits accrued by bombing electrical power in Iraq.[118] As Lawrence Freedman and Efraim Karsh have noted, "the aspects of its [USAF] campaign most directed against Iraq's economic and political structure [i.e. electrical power] seems to have been the least relevant to the ultimate victory."[119]

The implication is clear--national electrical systems are not a viable target. If the wars of the near future will be limited wars and not total wars of attrition, then attacks on electrical power should not be considered. Although national power systems are vulnerable to air attack, the military is largely insulated from a loss of power, and civilian discomfort in wartime has not been shown to influence government policy. Political leaders are able to mitigate the loss of electrical power by dispersing manufacturing and restricting access to power. Further, their resolve in a conflict is usually greater than the costs inflicted by the loss of electrical power.

If the true aim of eliminating electricity is to effect other systems, such as communications or computers, then the time and effort would be better spent concentrating on the intelligence and methods for attacking these systems directly. In future strategic air operations, the targeting of national power systems has little utility.

NOTES

[1] For one example of bombing the Serbian national electrical power system see George Kenney and Michael J. Dugan, "Operation Balkan Storm: Here's a Plan," New York Times, November 29, 1992, Section 4, page 11.

[2] In many circles, including the U.S. Air Force, part of the reason is that since 1945 the terms "nuclear" and "strategic" have become, regrettably, synonymous, see Phillip S. Meilinger, "The Problem with Our Air Power Doctrine," Airpower Journal, Vol. 6, No. 1 (Spring 1992), pp. 27-29.

[3] For some examples see, Joseph F. Pilat and Paul C. White, "Technology and Strategy in a Changing World," and Thomas J. Welch, "Technology Change and Security," The Washington Quarterly, Vol. 13, No. 2 (Spring 1990), pp. 79-91 and 111-120; T. Ross Milton, "Strategic Airpower: Retrospect and Prospect," and Dennis M. Drew, "The Airpower Imperative: Hard Truths for an Uncertain World," in Strategic Review, Vol. 19, No. 2 (Spring 1991), pp. 7-15 and 24-31; Jacquelyn K. Davis, "Technology and Strategy: Lessons and Issues for the 1990s," The Annals of the American Academy of Political and Social Science, Vol. 517, (September 1991), pp. 203-216; Leon Sloss, "U.S. Strategic Forces After the Cold War: Policies and Strategies," and Barry D. Watts, "The Conventional Utility of Strategic-Nuclear Forces," in The Washington Quarterly, Vol. 14, No. 4 (Autumn 1991), pp. 145-156 and 173-210; Frank Kendall, "Exploiting the Military Technical Revolution: A Concept for Joint Warfare," Strategic Review, Vol. 20, No. 2 (Spring 1992), pp. 23-30; Patrick J. Garrity and Sharon K. Weiner, "U.S. Defense Strategy After the Cold War," The Washington Quarterly, Vol. 15, No. 2 (Spring 1992), pp. 59-76; Richard H. Shultz, Jr., "Compellence and the Role of Airpower as a Political Instrument," Comparative Strategy, Vol. 11, No. 1 (January-March 1992), pp. 15-27.

[4] Eliot A. Cohen, ``The Mystique of U.S. Air Power,'' Foreign Affairs, Vol. 73, No. 1 (January/February 1994), p. 109.

[5] Although this paper concentrates on American targeting of electrical power, this system has been studied by other air forces. Early in World War II the Royal Air Force advocated attacks on the German power system, especially the hydroelectric dams in the Rhur area. See Sir Charles Webster and Noble Frankland, The Strategic Air Offensive Against Germany 1939-1945, (London: Her Majesty's Stationery Office, 1961), pp. 98-99, 141-142, 461-462. The German Luftwaffe also considered attacks on electric power. According to one source, during the invasion of Poland in 1939 they bombed electric power stations in Warsaw to help speed the surrender of that city, see Paul Deichmann, The System of Target Selection Applied by the German Air Force in World War II, (Karlsruhe, Germany: 1956), pp. 247-251, United States Air Force Historical Research Agency (hereafter abbreviated HRA) file K113.107-186. In June 1943 the Luftwaffe General Staff began planning an operation designed to attack the concentrated Soviet power plants used to supply electricity to factories in the Ural mountains. Their efforts were stymied by a lack of long-range bombers, inadequate munitions, and infighting within the Luftwaffe. In any event, before the attack could be undertaken the Red Army overran the bomber bases, putting the electrical power plants out of range for any attack. See Richard Muller, The German Air War in Russia (Baltimore,

Maryland: The Nautical & Aviation Publishing Company of America, 1992), pp. 162-200, 217-218. During the Iran-Iraq war both sides attempted strategic bombing, and although there were attacks on power plants, there does not appear to have been any systematic attempt to eliminate power production. See Efraim Karsh, The Iran-Iraq War: A Military Analysis, (London: The International Institute for Strategic Studies, 1987), and Ronald E. Bergquist, The Role of Airpower in the Iran-Iraq War, (Maxwell AFB, Al.: Air University Press, 1988).

[6] "Air Force Objectives," ACTS lecture, Maxwell Field, Alabama, 1934-1935, pp. 1, 2, United States Air Force Historical Research Agency, (hereafter abbreviated HRA) file 248.2015A-12. A summary of the theory can also be found in Wesley F. Craven and James Lea Cate, The Army Air Forces in World War II, 7 vols., (Chicago: The University of Chicago Press, 1948-1958), 1:50-52.

[7] Ibid., p. 2.

[8] "The National Economic Structure," ACTS lecture, Maxwell Field, Al., 1939-1940, p. 15, HRA file 248.2021A-7. Their precision was a direct reflection of the amount of information they had on electrical power in the United States. They could pinpoint the number of electric targets because they had obtained a listing of the major power plants in the United States through the McGraw Central Station Directory.

[9] For example, the file containing the 1939-1940 lecture on the National Economic Structure has a 59 page pamphlet, complete with overhead photography and floor diagrams, on the Hudson Avenue Generating Station in New York City.

[10] Major Muir S. Fairchild, "New York Industrial Area," ACTS lecture, Maxwell AFB, Al., 6 April 1939, passim, HRA file 248.2019A-12.

[11] Fairchild lecture, p. 2.

[12] H. H. Arnold, Global Mission, (New York: Harper & Brothers, 1949), p. 245.

[13] For an in-depth look at the planning process and the men involved see Mark Clodfelter, ``Pinpointing Devastation: American Air Campaign Planning before Pearl Harbor,'' The Journal of Military History, Vol. 58, No. 1 (January 1994), pp. 75-101; Craven and Cate, 1: 130-132, 146-150; James C. Gaston, Planning the American Air War: Four Men and Nine Days in 1941, (Washington, D.C.: National Defense University Press, 1982), pp. 14, 90; Haywood S. Hansell, Jr., The Air Plan That Defeated Hitler, (Atlanta, Ga.: Higgins-McArthur/Longino & Porter, Inc., 1972), p. 60.

[14] Hansell, Air Plan, p. 70.

[15] AWPD/1, Munitions Requirements of the Army Air Forces, 26 August 1941, p. 2, HRA file 145.82-1.

[16] Ibid., pp. 3-4.

[17] Hansell, Air Plan, p. 81; AWPD/1, p. 2.

[18] Robert Frank Futrell, Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1960, (Maxwell AFB, AL: Air University Press, 1989; originally pub. 1971), p. 130.

[19] Hansell, Air Plan, p. 163.

[20] Futrell, 1907-1960, p. 157;. For the dramatic successes of the German submarine campaign see John Keegan, The Price of Admiralty: The Evolution of Naval Warfare, (London: Century Hutchinson Ltd., 1988; reprint ed. New York: Penguin Books, 1990), pp. 267-273. Keegan notes that because of their victories the U-boat captains called the period from December 1941 until June 1942 the "happy time."

[21] History of the Committee of Operations Analysts, p. 1, (hereafter cited as COA History), HRA file 118.01; Futrell, 1907-1960, p. 142; David MacIssac, Strategic Bombing in World War Two, (New York: Garland Publishing, Inc., 1976), pp. 24-25.

[22] Hansell, Air Plan, p. 148; Craven and Cate, 2:349-350.

[23] Lt. Gen. H.H. Arnold, Commanding General Army Air Forces, to Assistant Chief of Air Staff, Management Control, 9 December 1942, HRA file 118.01; Craven and Cate, 2:353-354.

[24] Memorandum Committee of Operations Analysis, to Lt. General Arnold, subject: Economic Targets within the Western Axis, 8 March 1943, HRA file 118.04A-1; Craven and Cate, 2:362.

[25] Ibid.

[26] COA history, pp. 16-19; Hansell, Air Plan, p. 161.

[27] COA History, p. 44; Craven and Cate, 2:363; Hansell, Air Plan, p. 159. The target systems listed ahead of electrical power included: the German aircraft industry, especially fighter assembly plants and engine factories; ball bearings; petroleum; grinding wheels; nonferrous materials; synthetic rubber and tires; submarine construction yards and bases; military motor transportation; general transportation systems; coking plants; steel production; and, machine tools.

[28] COA History, p. 44; Craven and Cate, 2: 364-365.

[29] Enemy Objectives Unit, Economic Warfare Division, U.S. Embassy, London, Handbook of Target Information, May 24, 1943, HRA file 512.323, p. 1.

[30] W. W. Rostow, Pre-Invasion Bombing Strategy, (Austin, Texas: University of Texas Press, 1981), pp. 15, 23.

[31] EOU Handbook, p. 18. For a postwar analysis on this approach for target selection see Carl Kaysen, Note on Some Historical Principles of Target Selection, Rand Research Memorandum RM-189 (Santa Monica, California: The Rand Corporation, 15 July 1949).

[32] EOU Handbook, pp. 107-108.

[33] EOU Handbook, p. 108. By way of contrast, the COA believed an attack on 29 targets in the Rhine-Rhur area would disrupt 57 percent of the power in that region.

[34] Ibid.

[35] Craven and Cate, 5:17; Futrell, 1907-1960, p. 159.

[36] United States Strategic Bombing Survey, Summary Report (Pacific War), (Washington: GPO, 1 July 1946), pp. 6, 8-9. Bombing of mainland Japan did begin in the fall of 1943 with B-29 attacks from China however, due to logistical problems these raids were sporadic and ineffective. Sustained attacks began in November 1944 when B-29s began flying to Japan from bases on the Marianas islands.

[37] COA History, p. 82.; Craven and Cate, 5:17; The COA history notes that an intelligence study in March 1943 of Japanese targets did not include electric power, p. 59.

[38] Report to the Committee of Operations Analysts by subcommittee on Far Eastern Electrical Power, 30 October 1943, HRA file 118.04F-1; COA History, p. 82.

[39] Memorandum, Committee of Operations Analysts, to General Arnold, Chief Army Air Forces, subject: Report of Committee of Operations Analysts on Economic Objectives in the Far East, 11 November 1943, pp. 4, 53., HRA file 118.04D; Craven and Cate, 5:93; Futrell, 1907-1960, p. 159. The six target systems they endorsed were: anti-friction bearings, the electronics industry, the aircraft industry, merchant shipping in harbors, urban areas, and coke and steel production.

[40] MacIssac, pp. 21-23; 154-156.

[41] United States Strategic Bombing Survey, German Electric Utilities Industry Report, (Washington: GPO, January 1947), p. 2.

[42] Ibid., p. 18.

[43] Ibid., pp. 46-51.

[44] United States Strategic Bombing Survey, The Effects of Strategic Bombing on the Germany War Economy, (Washington: GPO, October 31, 1945), pp. 72, 121; German Electric Utilities Report, pp. 40-45.

[45] German War Economy, p. 126.

[46] German War Economy, 72, 114; Alfred C. Mierzejewski, The Collapse of the German War Economy, 1944-1945: Allied Air Power and the German National Railway, (Chapel Hill, N.C.: The University of North Carolina Press, 1988), pp. 32-33.

[47] German War Economy, pp. 8-9, 43.

[48] United States Strategic Bombing Survey, Summary Report, (Pacific War), (Washington: GPO, 1 July 1946), p. 31; United States Strategic Bombing Survey, The Effects of Strategic Bombing of Japan's War Economy, (Washington: GPO, December 1946), pp. 69-73.

[49] Electric Power Industry of Japan, pp. 5-6, 17.

[50] United States Strategic Bombing Survey, Summary Report (European War), (Washington: GPO, September 30, 1945), p. 14. See Hansell, Air Plan, for his comments on vindication, especially pp. 286-297 and Haywood S. Hansell, Jr. The Strategic Air War Against Germany and Japan, (Washington, D.C.: Office of Air Force History, 1986), pp. 131-133.

[51] Robert F. Futrell, The United States Air Force in Korea, 1950-1953, New York:(Duell, Sloan and Pearce, 1961; revised ed. Washington, D.C.: Office of Air Force History, 1983), pp. 183, 186.

[52] Air University Quarterly Review Staff, "The Attack on Electric Power in North Korea," Air University Quarterly Review, Vol. 6, No. 2 (Summer 1953), pp. 14; Futrell, Korea, p. 184.

[53] Memorandum, Mr. C. H. Pruefer, to General Banfill, 21 September 1950, cited in USAF Historical Division, United States Air Force Operations in the Korean Conflict, 25 June--1 November 1950, USAF Historical Study 71, (Washington, D.C.: Department of the Air Force, 1952), p. 86, HRA file 101-71; FEAF Report on the Korean War (draft), 15 February 1954, Book 3, p. 35, HRA file K720.04D.

[54] Futrell, Korea, p. 194.

[55] USAF Historical Division, United States Air Force Operations in the Korean Conflict, 1 July 1952-27 July 1953, USAF Historical Study No. 127, (Washington, D. C.: Department of the Air Force, 1956), pp. 29-30, HRA file 101-127.

[56] Otto P. Weyland, "The Air Campaign in Korea," Air University Quarterly Review, Vol. 6, No. 3 (Fall 1953), p. 18.

[57] Col. R. L. Randolph and Lt. Col. B. I. Mayo, Staff Study for Deputy for Operations, FEAF, The Application of FEAF Effort in Korea, 1952, p. 8, HRA file K720.01; Futrell, Korea, pp. 475-504.

[58] Ibid., p. 9.

[59] Ibid., p. 15.

[60] Secretary of State Dean Acheson claimed that the reason behind these attacks was to reduce the amount of electricity being exported to Manchuria and thereby affect the air defense radar system in northwestern Korea and in China. Dean Acheson, The Korean War, (New York: W. W. Norton & Company, Inc., 1971), pp. 135-136. His is the only reference to this rationale, and I could not substantiate it through any other sources.

[61] "The Attack on Electric Power in North Korea," p. 13.

[62] History of the Far East Air Forces, 1 January 1952-30 June 1952, vol. 1, p. 41, HRA file K720.01.

[63] USAF Operations, July 1952-July 1953, p. 33; FEAF Report on Korea, section 13, pp. 7-8; Futrell, Korea, pp. 483-488.

[64] FEAF Intelligence Roundup and Operational Summary, 24-30 January, No. 126, p. 22.

[65] USAF Operations July 1952-July 1953, p. 33.

[66] Futrell, Korea, p. 195; United States Air Force, An Evaluation of the Effectiveness of the United States Air Force in the Korean Campaign, 25 June-31 December 1950, Vol. III, p. 60, HRA file K168.041-1.

[67] Acheson, pp. 135-136; Mark W. Clark, From the Danube to the Yalu, (New York: Harper & Brothers Publishers, 1954), p. 73.

[68] Rosemary Foot, A Substitute for Victory: The Politics of Peacemaking at the Korean Armistice Talks, (Ithaca, N.Y.: Cornell University Press, 1990), pp. 135-137.

[69] Mark Clodfelter, The Limits of Air Power: The American Bombing of North Vietnam, (New York: The Free Press, 1989), pp. 59-61.

[70] Wallace J. Thies, When Governments Collide: Coercion and Diplomacy in the Vietnam Conflict, 1964-1968, (Berkeley, Calif.: University of California Press, 1980), p. 74.

[71] Clodfelter, Limits, p. 102.

[72] Ibid., p. 105.

[73] The Pentagon Papers: The Defense Department History of United States Decision-making in Vietnam, Senator Gravel edition, 5 vols., (Boston: Beacon Press, 1971), IV: 151-153; Clodfelter, Limits, pp. 105-107.

[74] Pentagon Papers, IV: 153, 201. Also see Admiral U. S. Grant Sharp's testimony in United States Senate, Preparedness Investigating Subcommittee of the Committee on Armed Services, Hearings, Air War Against North Vietnam, 90th Congress, 2nd Session, 5 parts, I:105; IV:359-360.

[75] Jon M. Van Dyke, North Vietnam's Strategy for Survival, (Palo Alto, Calif.: Pacific Books Publishers, 1972), p. 144.

[76] Hearings, Air War, IV:364-365.

[77] Deputy Chief of Staff for Intelligence, Headquarters Pacific Air Forces, The Effects of United States Air Operations in Southeast Asia, 1968, 2 vols., I:4-9, HRA file K717.6094.

[78] Deputy Chief of Staff for Intelligence, Headquarters Pacific Air Forces, Effects of Air Operations Southeast Asia, May 1967, 9-10, 127, HRA file K717.6092.

[79] Pentagon Papers, IV:169.

[80] Ibid., IV:153, 201; Van Dyke, p. 207; Clodfelter, pp. 134-136.

[81] Pentagon Papers, IV:225-227; Effects of Air Operations, 1968, I:5-1--5-15.

[82] Lavalle, A.J.C., gen. ed., Airpower and the Spring 1972 Invasion, (Maxwell AFB, Al.: Air University, 1976; reprint ed. Washington, D.C.: Office of Air Force History, 1985), pp. 105-106. M. F. Porter, Linebacker: Overview of the First 120 days, Headquarters Pacific Air Forces, p. 27 September 1973, 35, HRA file K 717.0414-42.

[83] Clodfelter, Limits, pp. 167-169.

[84] Ibid., pp. 177, 182.

[85] Herman L. Gilster and Robert E. M. Frady, Linebacker II USAF Bombing Survey, (Headquarters Pacific Air Forces, April 1973), p. 12, HRA file, K717.64-8.

[86] Ibid, pp. 13-14.

[87] Headquarters United States Air Force, Reaching Globally, Reaching Powerfully: The United States Air Force in the Gulf War, (Washington, D.C.: Department of the Air Force, 1991), p. 12.

[88] Department of Defense, Conduct of the Persian Gulf War: Final Report to Congress, April 1992, p. 96. (Hereafter cited as Title V report).

[89] Colonel John A. Warden, interview with author, Air Command and Staff College, 7 December 1992.

[90] Walid Doleh, Warren Piper, Abdel Qamhieh, and Kamel al Tallaq, "Electrical Facilities Survey," in International Study Team, Health and Welfare in Iraq After the Gulf Crisis: An In-depth Assessment, October 1991, pp. 1-2.

[91] Title V report, p. 159.

[92] Doleh, "Electrical Facilities Survey," p. 1-2; Michael A. Palmer, "The Storm in the Air: One Plan, Two Air Wars?," Air Power History, Vol. 39, No. 4 (Winter 1992), p. 29;

[93] Title V report, p. 150.

[94] The formal names of these locations can be found in the Title V report, p. 619.

[95] For the figure of 70,000 used by William K. Arkin of Greenpeace International who, by all accounts, has presented the most unbiased though critical review of the strategic bombing in Iraq, see "Tactical Bombing of Iraqi Forces Outstripped Value of Strategic Hits, Analyst Contends, Aviation Week & Space Technology, January 27, 1992, pp. 62-63. Beth Osborne Daponte of the U.S. Census Bureau estimated that 100,000 Iraqis died from disease after the war, see Beth Osborne Daponte, "Iraqi Casualties from the Gulf War and Its Aftermath," Defense & Arms Control Studies Program, (Cambridge, Mass.: Center for International Studies, Massachusetts Institute of Technology, 1992). Some estimates are given as high as 170,000 casualties, for other examples of the uproar over this damage see, International Study Team, Health and Welfare in Iraq After the Gulf Crisis: An In-depth Assessment, October 1991; Middle East Watch Report, Needless Deaths in the Gulf War: Civilian Casualties During the Air Campaign and Violations of the Laws of War, (New York: Human Rights Watch, 1991); Nina Burleigh, "Watching Children Starve to Death," Time, June 19, 1991, pp. 56-57; Bernard E. Trainor, "War by Miscalculation," in Joseph S. Nye, Jr. and Roger K. Smith After the Storm: Lessons from the Gulf War, (Lanham, Maryland: Madison Books, 1991), pp. 197-219; Nicholas G. Fotion, "The Gulf War Cleanly Fought," and George A. Lopez, "The Gulf War: Not So Clean," The Bulletin of the Atomic Scientists, Vol. 47, No. 7 (September, 1991), pp. 24-29; 30-35.

[96] Richard I. Brody, Regional Conventional Deterrence and TLAM, unpublished paper, Strategic Policy Analysis Group, Center for Naval Analysis, 31 July 1992.

[97] Richard L. Bean, Nicholas Chackan, Harold R. Moore, and Edward C. Wentz, Transformers for the Electric Power Industry, (New York: McGraw-Hill Book Company, Inc., 1959), p. 8; U.S. Congress, Office of Technology Assessment, Physical Vulnerability of Electric Systems to Natural Disasters

and Sabotage, OTA-E-453, (Washington: GPO, June 1990), p. 4, (hereafter cited as OTA report).

[98] Electricity Transfers and Reliability, (Princeton, N.J.: North American Electric Reliability Council, October 1989). Eugene Gorzelnik, North American Electric Reliability Council, telephone interview with author, 14 April 1993.

[99] OTA report, p. 47; Theodore C. Perry, Executive Director, Planning, Allegheny Power System, telephone interview with author, 8 April 1993.

[100] Linebacker II Bombing Survey, p. 12. There are now methods of attack available to interrupt power without destroying any transformers, one example is the use of carbon fibers reportedly used in Desert Storm, see David A. Fulghum, "Secret Carbon-Fiber Warheads Blinded Iraqi Air Defenses," Aviation Week & Space Technology, April 27, 1992, pp. 18-20.

[101] Fink, pp. 16-2, 16-3. The only two nations with a higher per capita number of kilowatt hours are Canada and Sweden. In Canada, much of the power produced is exported--to the United States.

[102] Quoted in Clodfelter, Limits, p. 136.

[103] Irving L. Janis, Air War and Emotional Stress, RAND series, (New York: McGraw-Hill Book Company, Inc., 1951; reprint ed., Westport, Conn.: Greenwood Press, Publishers, 1976), pp. 145-146.

[104] Ibid., pp. 147-149, 151-152.

[105] Robert A. Pape, Jr., "Coercion and Military Strategy: Why Denial Works and Punishment Doesn't," The Journal of Strategic Studies, Vol. 15, No. 4 (December 1992), pp. 432-433.

[106] Ernest May, Lessons of the Past, (Oxford, England: Oxford University Press, 1976), pp. 125-142; Michael Handel, "The Study of War Termination," The Journal of Strategic Studies, Vol. 1, No. 1 (May 1978), pp. 56-71.

[107] Gilster, Linebacker II, p. 12.

[108] Energy Information Administration, Annual Energy Review 1991, (Washington, D.C.: U.S. Department of Energy, June 1992), pp. 14-14, 30-31, 206-207. According to this source the total amount of electricity consumed in the United States by end users was 9.41 quadrillion Btu. Using a standard conversion factor of 3412 Btu per kilowatt-hour this equates to 2.8 trillion kilowatt-hours. DOD use was 120.6 trillion Btu or 3.5 billion kilowatt-hours, approximately 1.3 percent of the total amount of electricity consumed in the country. Major James Mandziara, Material and Resource Management Policy Directorate, Office of the Assistant Secretary of Defense (Production & Logistics), telephone interview with author, 4-5 May 1993.

[109] Interview with Laura Gosline; Gilster, Linebacker II, pp. 12-14.

[110]Robert R. Ploger, U.S. Army Engineers, 1965-1970, (Washington, D.C.: Department of the Army, 1974), pp. 194-195.

[111]Headquarters Far Eastern Air Forces, FEAF Report on the Korean War (draft), 15 February 1954, book 3 of 3, section 20, pp. 13-14, HRA file K720.04D.

[112]Ploger, pp. 60, 194-195; John Schlight, The War in South Vietnam: The Years of the Offensive, 1965-1968, (Washington: Office of Air Force History, 1988), p. 171; Richard Tregaskis, Southeast Asia: Building the Bases, (Washington: GPO, 1975), pp. 209-210, 224, 250, 257, 284-285, 370.

[113]United States Department of Defense, Conduct of the Persian Gulf War: Final Report to Congress, April 1992, pp. 442-444. This report notes that the U.S. Air Force maintains a bare base construction package, nicknamed Harvest Eagle, which contains its own power generation and distribution equipment. This equipment is capable of supporting 55,000 people and 750 aircraft at 14 different airfields.

[114]Interviews with Gosline, Warden.

[115]USSBS, Summary, p. 14; USSBS, German Electric Industry, pp. 3, 46-51.

[116]Because dams and nuclear power plants contain what are termed "dangerous forces" the issue of attacking these targets is complicated by international law constraints. Article 56 of the 1977 Protocol I Addition to the Geneva Conventions of 12 August 1949 lists the criteria involved with attacking these targets. Although the United States is not a signatory to this document, such guidance could affect future air attacks, see W. Hays Parks, "Air War and the Law of War," The Air Force Law Review, Vol. 32, No. 1 (1990), pp. 202-218. Official Air Force guidance states that, "Target selection of such objects [dams and nuclear power plants] is accordingly a matter of national decision at appropriate high policy levels." see AFP 110-31, International Law--The Conduct of Armed Conflict and Air Operations, 19 November 1976, p. 5-11.

[117]"Strategic Campaign Focused on Targets and Cut Casualties, Pentagon Maintains, Aviation Week & Space Technology January 27, 1992, pp. 64-65.

[118]I am not arguing that the number of post-war casualties is correct, in fact I believe they are well above the number actually caused by the loss of electricity. These numbers are based on a survey of 9,034 households, not be the actual number of cases in hospitals, this methodology is in International Study Team, Health and Welfare in Iraq. This study also did not take into account the restoration of electricity, which, according to the Gulf War Airpower Survey, occurred, despite the UN sanctions, by the summer of 1991. The numbers also seem high in comparison with the figures from World War II. For example, in Japan during 1944 approximately 4600 people died of dysentery and typhoid (based on a population of 13 million, and death rates per 100,000 per year, of 14.3 and 20.8), in the same year there were a total of 33,000 cases of dysentery and typhoid, see USSBS, Health and Medical Services in Japan, pp. 159-164. Based on an Iraqi population of 18 million, 70,000 deaths would equal a death rate of 388 per 100,000--almost twenty times that of Japan

in 1944. Regardless of the accuracy of the figures from the Gulf War, the fact remains that the perception among many people is that these deaths were preventable.

[119] Lawrence Freedman and Efraim Karsh, The Gulf Conflict and the New World Order, (Princeton, N.J.: Princeton University Press, 1993), p. 437.